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UP-TO DATE REVIEW AND CASE REPORT • LOWER LIMB - FRACTURES

Short versus long intramedullary nails for treatment of intertrochanteric femur fractures (AO 31-A1 and AO 31-A2): a systematic review

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Abstract

Objectives Intramedullary nails are used increasingly in the surgical treatment of intertrochanteric femur fractures (IFFs). However, controversy has developed regarding the length of the nail itself. The purpose of this study is to investigate differences in reoperation rate, as well as operating time, length of hospital stay and 1-year mortality between short and long intramedullary nails in IFF-type AO 31-A1 and AO 31-A2.
Data sources A search was conducted using PUBMED, Embase and Cochrane Central (January 1, 2000–August 1, 2018). Articles written in English, German or Scandinavian language were included.
Study selection Studies with patients > 18 years having an IFF comparing short nail with long nail and a least one of the clinical outcomes on interest (reoperation rate, operating time, length of hospital stay, 1-year mortality) were included.
Data extraction A total of 2680 studies were identified and screened according to PRISMA guidelines. Cochrane risk of bias tool for RCTs and non-randomized studies was used to assess the risk of bias.
Data synthesis Odds ratio and 95% confidence interval were calculated.
Conclusions No difference in complication rate leading to reoperation was found in the individual studies or in the meta-analysis [OR 0.89 (0.49; 1.16)]. There is no difference in the length of hospital stay between the two nail cohorts; a shorter operating time inserting a short nail compared to inserting a long nail was found ($p < 0.0001$). In the meta-analysis, we found no difference in 1-year mortality [OR 1.20 (0.80; 1.79)].

Keywords Intertrochanteric fracture · Intramedullary nail · Complications

Introduction

Intertrochanteric femur fractures (IFFs) are becoming increasingly common with the development of global aging. In the year 2000, 1.6 millions out of 9 million osteoporosis fractures in the elderly were hip fractures and the number is expected to increase [1, 2]. One study also shows that the incidence of IFF is increasing more than the incidence of femoral neck fractures in the elderly [3].

Intramedullary nails are used more and more often in the surgical treatment of IFF in adults, since it is less invasive and has a shorter working arm of force compared to sliding hip screws [4–6]. However, controversy has developed regarding the length of the nail itself [7]. It is widely accepted that for AO 31-A3 fractures long intramedullary nails are the treatment of choice, but there is no consensus when it comes to AO 31-A1 and AO 31-A2. To our knowledge, there is no systematic review comparing outcome and reoperation rate due to secondary femur fracture, blade or screw cutout/hardware failure/avascular necrosis, infection and non-union, as well as operating time, length of hospital stay and 1-year mortality of different nail lengths in IFF-type AO 31-A1 and AO 31-A2. Therefore, we wanted

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to compare short and long nails using a meta-analysis and hypothesized that there is no difference regarding the analyzed key parameters. The analysis does not focus on a special implant design, but rather compares the biomechanical principles of short versus long intramedullary nail.

Objectives (PICO)

The research question of this systematic review was: In patients with an IFF (P), how does a short intramedullary nail (I) compared to a long intramedullary nail (C) affect reoperation rate due to secondary femur fracture, blade or screw cutout/hardware failure/avascular necrosis, infection and non-union, operating time, length of hospital stay and 1-year mortality (O)?

Methods

Protocol and registration

This systematic review is planned, conducted and reported according to the PRISMA guidelines (preferred reporting items for systematic reviews and meta-Analysis) [8]. The study protocol, prior to data abstraction and data analysis, was registered at the PROSPERO trial registration site (registration number: CRD42017059458).

Eligibility criteria

Inclusion criteria are: (1) articles involving IFF AO 31-A1 and AO 31-A2, (2) articles written in English, German or Scandinavian language, (3) report of at least one of the clinical outcomes of interest: (A) reoperation rate, (B) operating time, (C) length of hospital stay and D) 1-year mortality.

Studies with level of evidence I–III according to Oxford Centre for Evidence-based Medicine CEBM, 2011 (www.cebm.net), was included. This includes RCTs, cohort and case–control studies evaluating or comparing operative treatment [short nail and long nail] of IFFs in adults.

Exclusion criteria are: (1) articles including patients < 18 years, (2) systematic reviews, (3) pathological fractures due to tumor and (4) multiple injured patients ($ISS \geq 15$).

Information source

Studies were identified by using a systematic research in electronic databases and by scanning reference lists of articles. This search was applied for PUBMED/Medline (January 1, 2000–August 1, 2018), EMBASE (January 1, 2000–August 1, 2018) and COCHRANE (January 1, 2000–August 1, 2018) databases.

Search

(Hip fracture (MESH) OR pertrochanteric fracture OR pertrochanteric fractures) AND (Fracture Fixation, Intramedullary (MeSH) OR cephalo medullary nail OR cephalo medullary nails OR cephalomedullary nail OR cephalomedullary nails OR intermedullary nail OR intramedullary nails).

Study selection

Duplicate studies were identified using Covidence and removed from the search results. Then, title and abstracts of all retrieved studies were reviewed for relevant articles by two unblinded co-authors (LF and PB). LF and PB independently reviewed each article and determined eligibility. Any disagreement regarding inclusion of an article was clarified by the input of a third co-author (HS).

Data collection process

All eligible studies were read in full length by LF and PB, and data extraction was performed based on type of study, type of participants (including age, gender and ASA score), type of intervention and outcomes. One review author PB entered the data extracted, and LF rechecked the data registration.

Data items

Reoperation rate due to postoperative ipsilateral femoral fracture, blade or screw cutout/hardware failure/avascular necrosis, infection or non-union was the primary outcome. The secondary outcomes were operating time, length of hospital stay and 1-year mortality.

Summary measures

A meta-analysis was performed on complications, leading to reoperation and 1-year mortality.

Risk of bias

To assess the study quality, revised Cochrane risk of bias tool for randomized trials was used [9]. Each study was judged as being at low risk of bias, some concerns or high risk of bias.

The risk of bias in non-randomized studies of interventions (ROBINS-I) assessment tool was used to evaluate non-randomized cohort studies [10]. We assessed bias due to confounding, deviation from intended interventions and missing data, as well as bias in selection of participants for the study, classification of interventions, measurement of outcomes and selection of the reported result. Each study was judged as being at low risk, moderate risk, serious risk, critical risk or no information.

Statistics

Statistical analyses were performed using MedCalc for Windows, version 12.7.7.0 (MedCalc Software, Ostend, Belgium). Odds ratio with 95% confidence interval is calculated.

Results

Study selection

The search in the databases retrieved 2741 studies, of which six met the inclusion criteria (Fig. 1).

Study characteristics

Left for review were six retrospective cohort studies [11–16]. All studies compared a short intramedullary nail with a long intramedullary nail. The studies reported on 1244 participants (486 males, 502 females and 256 unknown genders). Totally, 513 patients had a short nail, and in 731 patients a

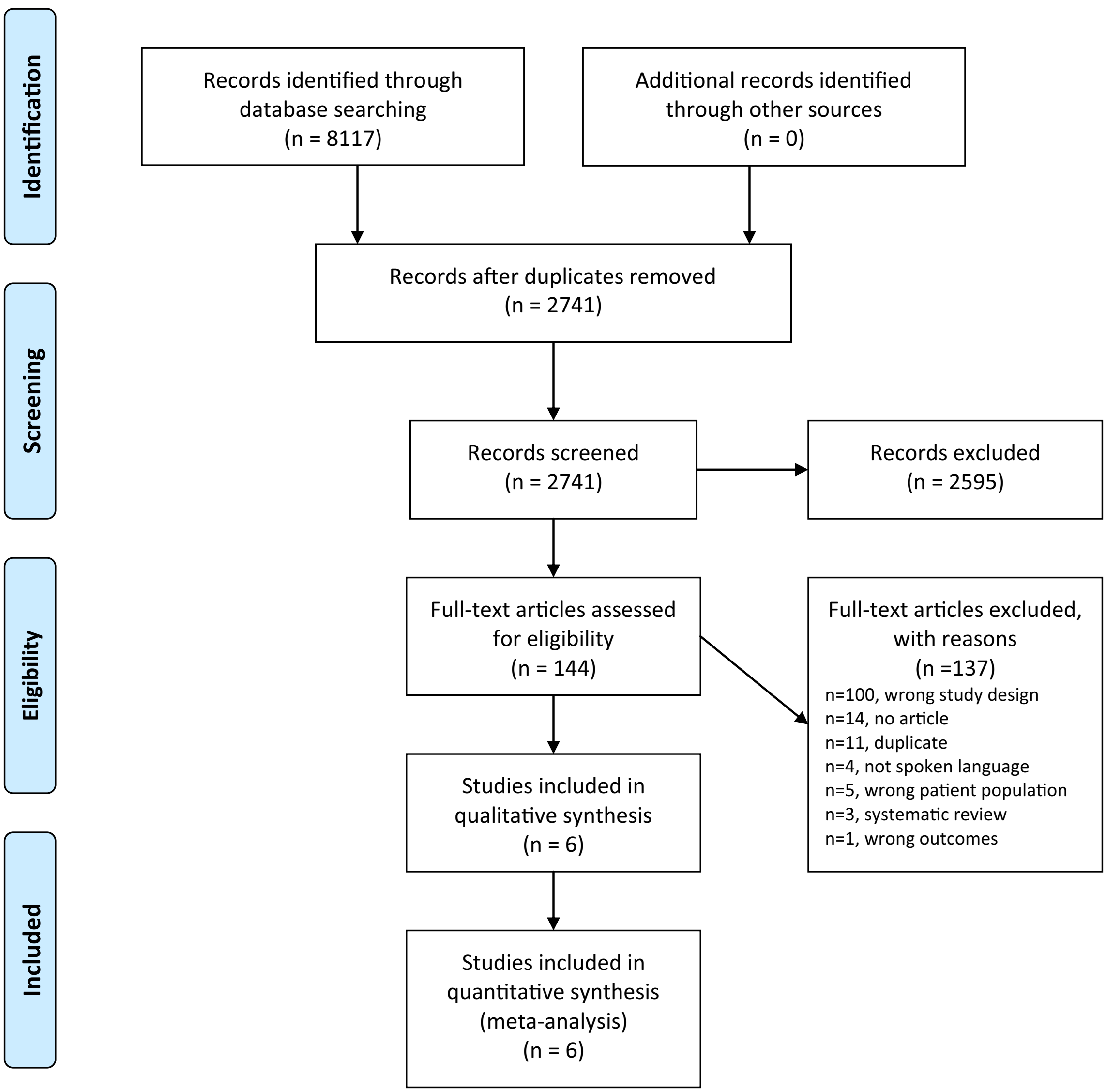

Fig. 1 PRISMA 2009 flow diagram

long nail was inserted. Study characteristics (Table 1), operating time, length of hospital stay and 1-year mortality are listed in Table 2. Table 3 shows complications leading to reoperation.

Risk of bias

All studies included were retrospective, and three studies reported level of evidence III. In the remaining three studies, level of evidence was estimated (Table 1). The overall risk of bias in individual studies as well as across studies was judged as serious or critical.

Results of individual studies

We assessed differences in reoperation rate due to secondary fracture, blade or screw cutout/ hardware failure/avascular necrosis, infection and non-union as well as the all-cause reoperation rate in all studies and found no difference between patients having a short or a long intramedullary nail (Table 3). The studies reporting on the length of hospital stay and 1-year mortality reported no difference between the two groups as well (Table 2). Five out of six studies described operating time. Three studies demonstrated a shorter operating time inserting a short nail compared to inserting a long nail (Table 2).

Table 1 Characteristics of included studies

Study	Inclusion period	Level of evidence	Mean age (SD)	ASA score	Gender male/female (*N*)	Mean follow-up period (SD)
Hou [11]	2004–2009	III	NI	1: 1 2: 35 3: 165 4: 46 NI: 36	73/210	Min. 12.0 months
Boone [12]	2008–2011	III	81.1 years (9.2)	NI	57/144	25.2 months (range 12–54)
Guo [14]	2008–2013	NI (Estimated III)	70.2 years (10.8)	NI	85/93	21.3 months (6.8)
Vaughn [13]	2006–2011	NI (Estimated III)	NI	NI	NI	Min 12.0 months
Krigbaum [15]	2001–2010	III	NI	≤ 2: 12 3: 121 ≥ 4: 68	252/10	Short: 24 months (31.2) Long: 24 months (26.4)
Hong [16]	2009–2012	NI (Estimated III)	79.9 years (range 56–97)	1: 2 2: 31 3: 31	19/45	Min. 12.0 months

All studies comparing a short intramedullary nail with a long intramedullary nail

NI No information, *ASA* American Society of Anesthesiologists

Table 2 Data reporting operating time, length of hospital stay and 1-year mortality in the included studies

Study	Nail	Operating time mean (SD)	*p* value	Hospital stay Mean (SD)	*p* value	One-year mortality N	OR (95% CI)
Hou [11]	Short	41 min (range 19–106)	0.000	6.4 days	0.838	22 (22%)	1.06 (0.53–1.90)
	Long	61 min (range 16–216)		6.8 days		42 (23%)	
Boone [12]	Short	44.0 min (10.7)	< 0.0001	7.7 days (4.1)	0.63	NI	
	Long	56.8 min (19.4)		8 days (4.5)		NI	
Guo [14]	Short	43.5 min (12.3)	< 0.0001	12.9 days (6.5)	0.84	NI	
	Long	58.5 min (20.3)		12.7 days (6.2)		NI	
Vaughn [13]	Short	NI		NI		NI	
	Long	NI		NI		NI	
Krigbaum [15]	Short	66 min (30)	< 0.0001	6.9 days	NC	35 (28%)	1.34 (0.79–2,27)
	Long	90 min (48)		9.1 days		47 (34%)	
Hong [16]	Short	73.0 min (range 40–141)	NC	15.5 days (range 4–53)	NC	2 (5%)	0.42 (0.02–9.04)
	Long	78.2 min (range 29–315)		14.0 days (range 3–30)		0 (0%)	

Ni no information, *NC* not possible to calculate

Table 3 Complications leading to reoperation

Study	Nail	Total number of patients (*n*)	Infection (*n*)	Non-union (*n*)	Secondary fracture (*n*)	Blade or screw cutout/hardware failure/avascular necrosis (*n*)	All causes (*n*)
Hou [11]	Short	100	1 (1%)	0	0	4 (4%)	5 (5%)
	Long	183	2 (1.1%)	0	2 (1.1%)	4 (2.2%)	8 (4.4%)
Boone [12]	Short	82	0	1 (1.2%)	0	2 (2.4%)	3 (3.7%)
	Long	119	2 (1.7%)	0	1 (0.8%)	3 (2.5%)	6 (5%)
Guo [14]	Short	102	NI	1 (1%)	1 (1%)	1 (1%)	3 (2.9%)
	Long	76	NI	0	1 (1.3%)	0	1 (1.3%)
Vaughn [13]	Short	60	NI	NI	2 (3.3%)	1 (1.7%)	3 (5%)
	Long	196	NI	NI	0	5 (2.6%)	5 (2.6%)
Krigbaum [15]	Short	125	0	0	2 (1.6%)	2 (1.6%)	4 (3.2%)
	Long	137	1 (0.7%)	0	0	4 (2.9%)	5 (3.7%)
Hong [16]	Short	44	0	1 (2.3%)	3 (6.8%)	0	4 (9.1%)
	Long	20	0	1 (55)	0	1 (5%)	2 (10%)
Total	Short	513	1 (0.2%)	3 (0.6%)	8 (1.6%)	10 (1.9%)	22 (4.3%)
	Long	731	5 (0.7%)	1 (0.1%)	4 (0.5%)	17 (2.3%)	27 (3.79%)

NI no information

Synthesis of results

Meta-analysis

We performed a forest plot of all causes for reoperation and showed no difference between the two nail cohorts (Fig. 2). The two major groups of complications leading to reoperation were secondary fracture and hardware failure/cutout/avascular necrosis. Performing a forest plot on these two subgroups showed no difference either (Fig. 2).

For the secondary fractures around short nails, four had a longer nail, one cerclage wiring, one distal plate osteosynthesis, one non-operative treatment and one unknown treatment modality. For the secondary fractures around a long nail, three had distal plate osteosynthesis and one unknown treatment modality. None of the authors describe the AO classification at index operation. Three studies reported on 1-year mortality, and we found no difference between the two groups in the meta-analysis (Fig. 3).

Discussion

The main finding of our comparison for the treatment of IFF with short or long nails was that there is no difference for the incidence of secondary femur fractures, blade or screw cutout/ hardware failure/avascular necrosis of the femoral head, and the incidence of infection requiring reoperation or non-unions. However, the operating time was shorter using short nails. Furthermore, no difference for the length of hospital stay or 1-year mortality was demonstrated. Based on our literature review, only six studies have attempted to compare the outcomes of short intramedullary nails with the use of long intramedullary nails in the management of AO 31-A1 and AO 31-A2 fractures. None of the individual studies, as well as the meta-analysis in the present review, demonstrated a significant difference regarding complications leading to reoperation in the two nail cohorts. This is in contrast to previous studies, describing stress accumulation at the tip of short nails, thus predisposing to ipsilateral fractures [17, 18]. It is possible that design modifications have decreased the incidence of such fractures, thereby leading to the different conclusions [19]. A comparison of intra- and postoperative complications as secondary femoral fractures and lag screw cutouts in patients treated with a Gamma3 nail compared to a historical cohort treated with the trochanteric gamma nail showed less intra- and postoperative complications after using the new nail design. Furthermore, the reoperation rate was significantly less in the group operated with a Gamma3 nail [20]. An argument can be made that IFFs in the elderly population are the result of pathologic osteoporotic or osteopenic bone, thus requiring the full protection afforded by the use of longer intramedullary devices. However, Curtis et al. found a higher risk for osteoporotic fractures in the metaphysis compared to the diaphysis, suggesting that the placement of the long nails tip deep into the metaphysis might additionally weaken this region [21]. Although each nail design might predispose for a certain type of secondary fracture, our meta-analysis could not support any of these arguments and documented no difference regarding the total rate of postoperative complications including the number of consecutive fractures. Overall, the incidence of secondary fractures is with $<2\%$ very low compared to other complications and a 1-year mortality of $>20\%$.

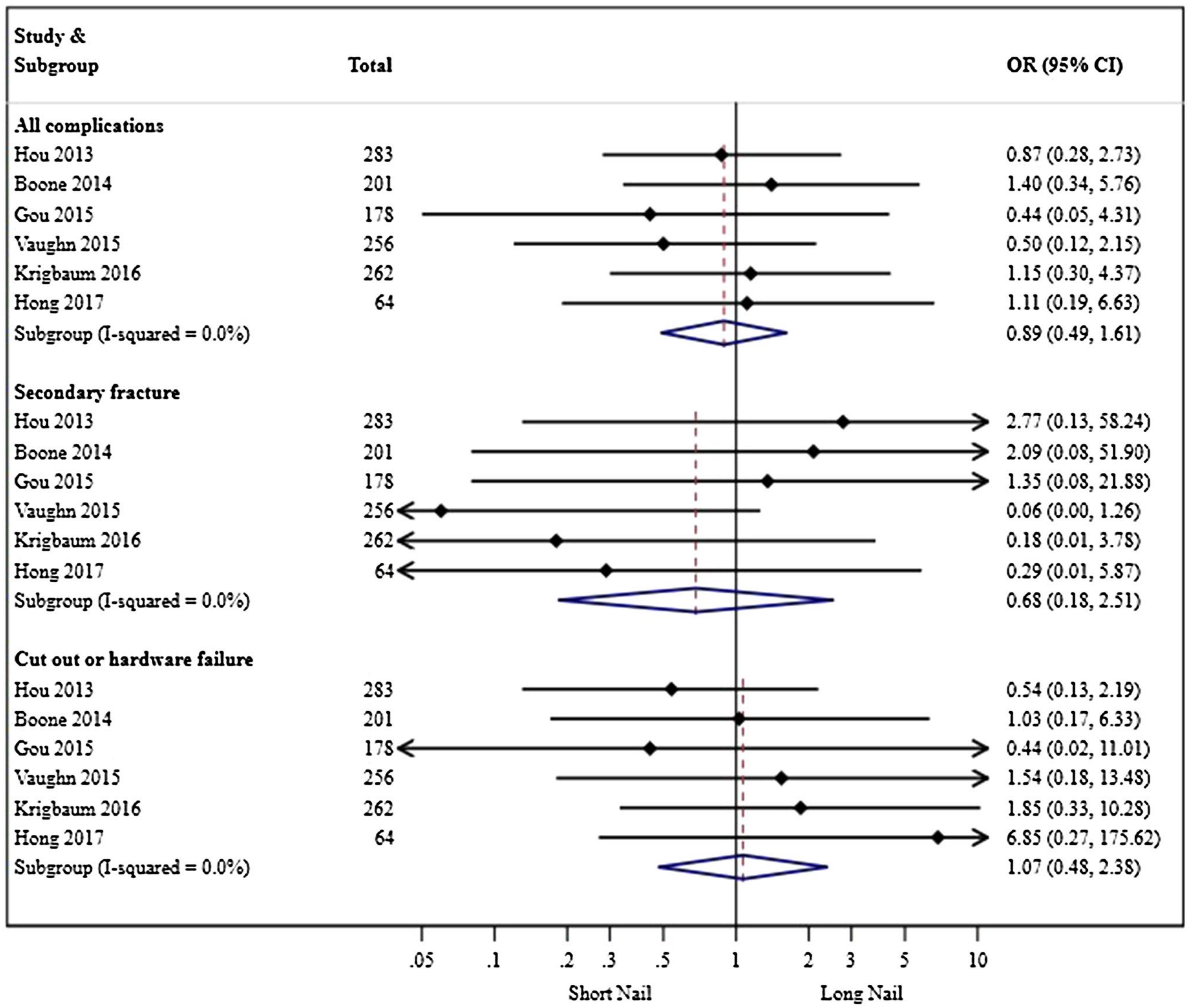

Fig. 2 Meta-analysis; complications

Since the insertion of long nails is usually technically more demanding and includes risk such as reaming with potential iatrogenic damage of the diaphyseal cortex, or difficult or inaccurate distal interlocking, the use of short nails might be preferable in AO 31-A1 and AO 31-A2 fractures [7, 15]. This conclusion is supported by economic considerations, because implantations of longer nails are usually associated with higher expenses. Furthermore, the aspect of potential revision surgery needs to be considered. A fracture around a short nail typically requires removal of the original device and insertion of a longer nail, while fracture distal to a long nail results in a periarticular fracture, which often requires technically difficult plate fixation, cerclage wiring and eventually locking attachment plates.

The need for distal interlocking in long nail insertion was determined in four studies by the surgeon using none, one or two distal locking screws [11–13, 16]. Krigbaum et al. did not report on this issue, while Guo et al. describes the use of distal interlock, but not the number of screws inserted [14, 15]. Anyhow, this is certainly one reason for the higher operating time expenditure, when implanting long nails. This is in concordance with the previous studies [22, 23]. Here, the reasons are summarized: (1) If needed, additional time is spent reaming the canal for a long nail, (2) distal interlocking screw insertion in the long nail requires a free-hand technique under fluoroscopic guidance. In contrast, a jig is used to direct the distal interlocking screw insertion in the short nail, making distal screw insertion fast and easy, (3) short nails receive a single screw, whereas long nails have the opportunity to receive one or two screws.

The difference between the lengths of stay in hospital was not significant between the long and the short nail cohorts.

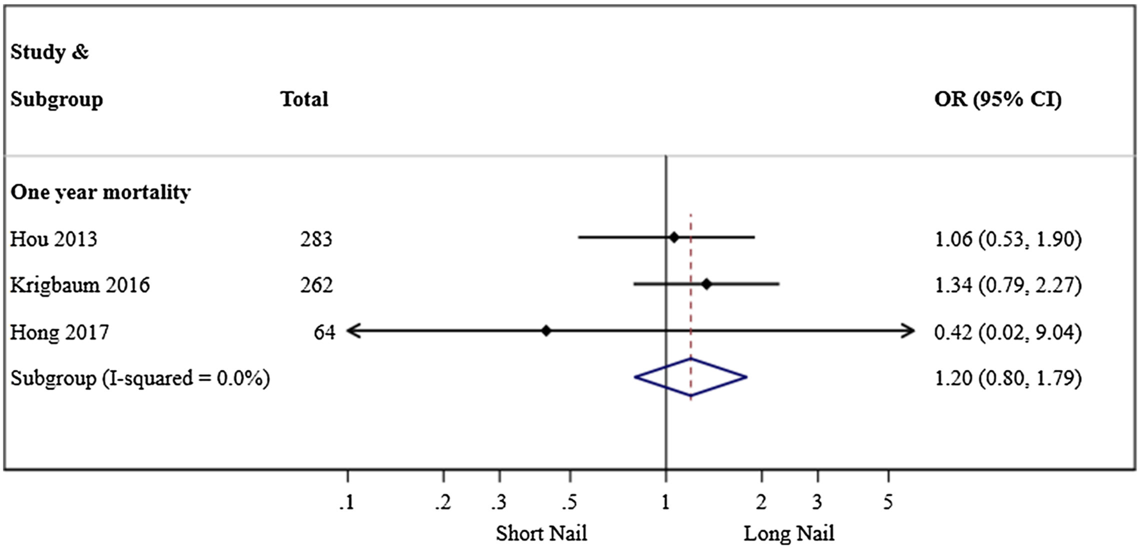

Fig. 3 Meta-analysis; one year mortality

However, the length of hospital stay varied from 6.4 to 15.5 days for the short nail, and from 6.8 to 14.0 days for the long nail [11, 16]. It is well known that a large proportion of patients, who undergo hip fracture surgeries, have poor functional status and impaired activities of daily living after the surgery. The difference in the length of hospital stay might reflect the local ability to gain access to rehabilitation, nursing home or help at home and very much depend on the organization of local healthcare systems.

One-year mortality after sustaining a hip fracture has been reported as high as 58% [24]. The first year after a hip fracture appears to be the most critical time with regard to mortality, but even though the relative hazards decrease substantially over the first 2 years after fracture, it never returns to the mortality rate of a sex- and age-matched control group [25, 26]. Patients with dementia are known to have higher mortality rates after hip fractures as well as a delay in surgery for 2 days or more from admission and male gender [25, 27–30]. The reason for this disparity in mortality between genders is unclear. However, males are more likely to have more medical comorbidities [31, 32]. In contrast, comanaged care between orthopedic surgeons and geriatricians has shown a lower 1-year mortality rate compared to usual care [25, 33]. In the present study, the mortality rate varies from 3% (2/64) to 31% (82/262) with no statistically significant difference between nail length in individual studies. The mortality rate on 3% reported by Hong et al [16] is low compared to the literature and the two other studies in this review, but is not explained further in their article. Two hundred and fifty-four out of 451 (56%) males had a long nail compared to 265/501 (53%) females, which might affect the mortality. However, three of the included studies describe the ASA score without a significant difference in the two nail cohorts [11, 15, 16]. The patient's mental status, time to surgery and whether the patients attended a hip program with geriatrics care were not noted in any of the study included. Since several confounders affect the mortality, so it is likely that preoperative care and activity status or deterioration of coexistent diseases affects the mortality rather than the length of the nail.

The strength of this study is the inclusion of only intertrochanteric AO 31-A1 and AO 31-A2 fractures, where earlier review on this topic includes AO 31-A1, AO 31-A2 and AO 31-A3 fractures. Several limitations are present: (1) Number of studies for review was only six. All of them were retrospective and with an overall risk of bias judged as serious or critical. (2) One study did not describe how the decision to use either a long or a short nail was reached [15]. In the remaining studies, the surgeon decided which nail to use on an individual basis; hence, bias toward use of either a short or a long nail in certain fracture patterns or patient subgroups may have occurred [11–14, 16]. (3) Three studies reported on intraoperative fracture occurrence, which might have led to a longer operating time or change in implant [12–14]. (4) The mean follow-up period varied in the studies from minimum 12.0 months to 25.2 months, which might have biased the rate of complications. (5) Finally, only studies reported in English, Scandinavian and German were accepted in this review. Hence, there might be a risk for publication bias.

Conclusion

Our review showed no increased risk of secondary femoral fracture, blade or screw cutout/hardware failure/avascular necrosis, infection requiring reoperation or non-union in patients having a short nail compared to a long nail. A shorter operating time inserting a short nail compared to a long nail was demonstrated. There was no difference in the length of hospital stay or 1-year mortality.

Compliance with ethical standards

Conflict of interest Dr. Bovbjerg, Dr. Froberg and Dr. Schmal have nothing to disclose.

References

1. Johnell O, Kanis JA (2006) An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int 17(12):1726–1733. https://doi.org/10.1007/s00198-006-0172-4
2. Kannus P, Parkkari J, Sievanen H, Heinonen A, Vuori I, Jarvinen M (1996) Epidemiology of hip fractures. Bone 18(1 Suppl):57s–63s
3. Veronese N, Maggi S (2018) Epidemiology and social costs of hip fracture. Injury 49(8):1458–1460. https://doi.org/10.1016/j.injury.2018.04.015
4. Anglen JO, Weinstein JN (2008) Nail or plate fixation of intertrochanteric hip fractures: changing pattern of practice. A review of the American board of orthopaedic surgery database. J Bone Jt surg Am 90(4):700–707. https://doi.org/10.2106/jbjs.g.00517
5. Forte ML, Virnig BA, Eberly LE, Swiontkowski MF, Feldman R, Bhandari M, Kane RL (2010) Provider factors associated with intramedullary nail use for intertrochanteric hip fractures. J Bone Jt surg Am 92(5):1105–1114. https://doi.org/10.2106/jbjs.I.00295
6. Gjertsen JE, Dybvik E, Furnes O, Fevang JM, Havelin LI, Matre K, Engesaeter LB (2017) Improved outcome after hip fracture surgery in Norway. Acta Orthop 88(5):505–511. https://doi.org/10.1080/17453674.2017.1344456
7. Baldwin PC 3rd, Lavender RC, Sanders R, Koval KJ (2016) Controversies in intramedullary fixation for intertrochanteric hip fractures. J Orthop Trauma 30(12):635–641. https://doi.org/10.1097/bot.0000000000000652
8. Moher D, Liberati A, Tetzlaff J, Altman DG (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ (Clin Res Ed) 339:b2535. https://doi.org/10.1136/bmj.b2535
9. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, Cates CJ, Cheng H-Y, Corbett MS, Eldridge SM, Hernán MA, Hopewell S, Hróbjartsson A, Junqueira DR, Jüni P, Kirkham JJ, Lasserson T, Li T, McAleenan A, Reeves BC, Shepperd S, Shrier I, Stewart LA, Tilling K, White IR, Whiting PF, Higgins JPT. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ (**in press**)
10. Sterne JAC, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, Henry D, Altman DG, Ansari MT, Boutron I, Carpenter JR, Chan AW, Churchill R, Deeks JJ, Hróbjartsson A, Kirkham J, Jüni P, Loke YK, Pigott TD, Ramsay CR, Regidor D, Rothstein HR, Sandhu L, Santaguida PL, Schünemann HJ, Shea B, Shrier I, Tugwell P, Turner L, Valentine JC, Waddington H, Waters E, Wells GA, Whiting PF, Higgins JPT (2016) ROBINS-I: a tool for assessing risk of bias in non-randomized studies of interventions. BMJ 355:i4919. https://doi.org/10.1136/bmj.i4919
11. Hou Z, Bowen TR, Irgit KS, Matzko ME, Andreychik CM, Horwitz DS, Smith WR (2013) Treatment of pertrochanteric fractures (OTA 31-A1 and A2): long versus short cephalomedullary nailing. J Orthop Trauma 27(6):318–324. https://doi.org/10.1097/BOT.0b013e31826fc11f
12. Boone C, Carlberg KN, Koueiter DM, Baker KC, Sadowski J, Wiater PJ, Nowinski GP, Grant KD (2014) Short versus long intramedullary nails for treatment of intertrochanteric femur fractures (OTA 31-A1 and A2). J Orthop Trauma 28(5):e96–e100. https://doi.org/10.1097/BOT.0b013e3182a7131c
13. Vaughn J, Cohen E, Vopat BG, Kane P, Abbood E, Born C (2015) Complications of short versus long cephalomedullary nail for intertrochanteric femur fractures, minimum 1 year follow-up. Eur J Orthop Surg Traumatol Orthop Traumatol 25(4):665–670. https://doi.org/10.1007/s00590-014-1557-2
14. Guo XF, Zhang KM, Fu HB, Cao W, Dong Q (2015) A comparative study of the therapeutic effect between long and short intramedullary nails in the treatment of intertrochanteric femur fractures in the elderly. Chin J Traumatol 18(6):332–335
15. Krigbaum H, Takemoto S, Kim HT, Kuo AC (2016) Costs and complications of short versus long cephalomedullary nailing of OTA 31-A2 proximal femur fractures in U.S. veterans. J Orthop Trauma 30(3):125–129. https://doi.org/10.1097/bot.0000000000000521
16. Hong CC, Nashi N, Makandura MC, Tan JH, Peter L, Murphy D (2017) The long and short of cephalomedullary nails in the treatment of osteoporotic pertrochanteric fracture. Singap Med J 58(2):85–91. https://doi.org/10.11622/smedj.2016048
17. Hesse B, Gachter A (2004) Complications following the treatment of trochanteric fractures with the gamma nail. Arch Orthop Trauma Surg 124(10):692–698. https://doi.org/10.1007/s00402-004-0744-8
18. Lorich DG, Geller DS, Nielson JH (2004) Osteoporotic pertrochanteric hip fractures: management and current controversies. Instr Course Lect 53:441–454
19. Norris R, Bhattacharjee D, Parker MJ (2012) Occurrence of secondary fracture around intramedullary nails used for trochanteric hip fractures: a systematic review of 13,568 patients. Injury 43(6):706–711. https://doi.org/10.1016/j.injury.2011.10.027
20. Georgiannos D, Lampridis V, Bisbinas I (2014) Complications following treatment of trochanteric fractures with the gamma3 nail: Is the latest version of gamma nail superior to its predecessor? Surg Res Pract 2014:143598. https://doi.org/10.1155/2014/143598
21. Curtis R, Goldhahn J, Schwyn R, Regazzoni P, Suhm N (2005) Fixation principles in metaphyseal bone—a patent based review. Osteoporos Int 16(Suppl 2):S54–S64. https://doi.org/10.1007/s00198-004-1763-6
22. Haidukewych GJ (2009) Intertrochanteric fractures: ten tips to improve results. J Bone Jt surg Am 91(3):712–719
23. Dunn J, Kusnezov N, Bader J, Waterman BR, Orr J, Belmont PJ (2016) Long versus short cephalomedullary nail for trochanteric femur fractures (OTA 31-A1, A2 and A3): a systematic review. J Orthop Traumatol 17(4):361–367. https://doi.org/10.1007/s10195-016-0405-z
24. Rapp K, Becker C, Lamb SE, Icks A, Klenk J (2008) Hip fractures in institutionalized elderly people: incidence rates and excess mortality. J Bone Miner Res 23(11):1825–1831. https://doi.org/10.1359/jbmr.080702
25. Schnell S, Friedman SM, Mendelson DA, Bingham KW, Kates SL (2010) The 1-year mortality of patients treated in a hip fracture program for elders. Geriatr Orthop Surg Rehabil 1(1):6–14. https://doi.org/10.1177/2151458510378105
26. Haentjens P, Magaziner J, Colon-Emeric CS, Vanderschueren D, Milisen K, Velkeniers B, Boonen S (2010) Meta-analysis: excess mortality after hip fracture among older women and men. Ann Intern Med 152(6):380–390. https://doi.org/10.7326/0003-4819-152-6-201003160-00008

27. Khan R, Fernandez C, Kashifl F, Shedden R, Diggory P (2002) Combined orthogeriatric care in the management of hip fractures: a prospective study. Ann R Coll Surg Engl 84(2):122–124
28. Hershkovitz A, Polatov I, Beloosesky Y, Brill S (2010) Factors affecting mortality of frail hip-fractured elderly patients. Arch Gerontol Geriatr 51(2):113–116. https://doi.org/10.1016/j.archger.2009.09.003
29. McGuire KJ, Bernstein J, Polsky D, Silber JH (2004) The 2004 Marshall Urist award: delays until surgery after hip fracture increases mortality. Clin Orthop Relat Res 428:294–301
30. Moja L, Piatti A, Pecoraro V, Ricci C, Virgili G, Salanti G, Germagnoli L, Liberati A, Banfi G (2012) Timing matters in hip fracture surgery: patients operated within 48 hours have better outcomes. A meta-analysis and meta-regression of over 190,000 patients. PLoS ONE 7(10):e46175. https://doi.org/10.1371/journal.pone.0046175
31. Endo Y, Aharonoff GB, Zuckerman JD, Egol KA, Koval KJ (2005) Gender differences in patients with hip fracture: a greater risk of morbidity and mortality in men. J Orthop Trauma 19(1):29–35
32. Holt G, Smith R, Duncan K, Finlayson DF, Gregori A (2008) Early mortality after surgical fixation of hip fractures in the elderly: an analysis of data from the scottish hip fracture audit. J Bone Jt Surg Br 90(10):1357–1363. https://doi.org/10.1302/0301-620x.90b10.21328
33. Prestmo A, Hagen G, Sletvold O, Helbostad JL, Thingstad P, Taraldsen K, Lydersen S, Halsteinli V, Saltnes T, Lamb SE, Johnsen LG, Saltvedt I (2015) Comprehensive geriatric care for patients with hip fractures: a prospective, randomised, controlled trial. Lancet 385(9978):1623–1633. https://doi.org/10.1016/s0140-6736(14)62409-0