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ORIGINAL ARTICLE • HIP - FRACTURES

Comparative outcome of PFNA, Gamma nails, PCCP, Medoff plate, LISS and dynamic hip screws for fixation in elderly trochanteric fractures: a systematic review and network meta-analysis of randomized controlled trials

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Abstract The ideal implant for the treatment of an unstable intertrochanteric femoral fracture is still a matter of discussion. The aim of this systematic review is to conduct a network meta-analysis of randomized controlled trials (RCTs) comparing clinical outcomes between dynamic hip screws (DHS), Medoff sliding plating, percutaneous compression plating (PCCP), proximal femoral nails (PFN), Gamma nails and less invasive stabilization system fixation in femoral trochanteric fractures in the elderly. These clinical outcomes consist of total intra-operative time, intra-operative fluoroscopy time, intra-operative blood loss, blood component transfusion, length of hospital stay, postoperative general complications, wound complications, late complications and reoperation rates. This systematic review was conducted using PubMed and Scopus search engines for RCTs comparing clinical outcomes between treatments from inception to February 22, 2015. Thirty-six of 785 studies identified were eligible. Compared to the other implants, PCCP showed the lowest total operative time and units of blood transfusion with an unstandardized mean difference (UMD) of 29.27 min (95% CI 5.24, 53.50) and 0.89 units (95% CI 0.52, 1.25). The lowest incidence of general complications, wound complications and late complications of PCCP was 0.09 (95% CI 0.04, 0.18), 0.01 (95% CI 0.01, 0.04) and 0.05 (95% CI 0.02, 0.11), respectively, when compared to others. The lowest fluoroscopic time was with DHS with an UMD of 0.24 min (95% CI 0.16, 0.32), whereas the lowest blood loss and shortest hospital stay were with PFN with an UMD of 233.61 ml of blood loss (95% CI 153.17, 314.04) and 7.23 days of hospital stay (95% CI 7.15, 7.31) when compared to all other fixation methods. Reoperation rates of all implants had no statistically significant difference. The network meta-analysis suggested that fixation with PCCP significantly shortens operative time and decreases the units of blood transfusion required, while also lowering risks of general complications, wound complications and late complications when compared to fixation. Use of PFN showed the least intra-operative blood loss and shortest hospital stay. Multiple active treatment comparisons indicate that PCCP fixation in trochanteric fractures in the elderly is the treatment of choice in terms of intra-operative outcomes and postoperative complications.

Keywords DHS · Medoff sliding plate · PCCP · PFN · Gamma nail · LISS · Trochanteric fractures

Abbreviations

RCTs	Randomized controlled trials
DHS	Dynamic hip screws

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PCCP Percutaneous compression plating
PFN Proximal femoral nails
LISS Less invasive stabilization system

Introduction

Options for treating intertrochanteric fractures include extramedullary fixation [dynamic hip screw (DHS), percutaneous compression plate (PCCP), Medoff sliding plate (MSP), less invasive stabilization system (LISS)] and intramedullary fixation [Gamma nail and proximal femoral nail with anti-rotating (PFNA)]. The ideal implant for the treatment is still a matter of discussion. DHS, the most representative implant of extramedullary fixation, has been considered the gold standard for treatment of intertrochanteric fractures. However, the failure rate of DHS is higher [10, 21] in the unstable and reverse oblique fracture, which limits its clinical use [11, 16]. Gotfried developed the PCCP technique; however, the PCCP lengthens operation time and increases biomechanical complications [12]. The MSP evolved from the DHS has produced remarkably good results in prospective trials in both unstable trochanteric and subtrochanteric fractures with a rate of failure of 2–4% [27]. LISS (the use of the distal femoral LISS in the proximal femur) has some advantages in the treatment of complex proximal femoral fractures in a more stable construct with higher pullout resistance [26]. Gamma nail has been widely used for many years because of its inspiring clinical results [2, 5]. Long-term studies, however, revealed that Gamma nail might cause higher intra-operative and late complications that often require revision surgery [4, 6]. PFNA provides angular and rotational stability, which is especially important in osteoporotic bone, and allows early mobilization and weight bearing on the affected limb [13, 17]. From literature review, we found 8 systematic reviews were published and dealing with the type of fixation of intertrochanteric fracture [7, 8, 15, 19, 22, 28–30]. However, none of the reviews compared all the implants, and none incorporated their comparative effectiveness using a network meta-analysis approach. The objective of the study was to assess the comparative effectiveness of different types of implants for intertrochanteric fracture fixation by combining direct and indirect evidence in a systematic review and network meta-analysis of RCTs with the aim of comparing relevant clinical outcomes between all implants.

Materials and methods

This systematic review and network meta-analysis were conducted following guideline in the preferred reporting items for systematic reviews and meta-analyses (PRISMA), extension of network meta-analyses [9].

Search strategy

The MEDLINE and Scopus databases were used to identify relevant studies published in English from the date of inception to February 22, 2015. The PubMed and Scopus search engines were used to locate studies using the following search terms: ((fracture intertrochanteric) (elder) OR (fracture femur)) AND ((proximal femural nail) OR (dynamic hip screw) OR (Gamma nail) OR (proximal femural nail anti rotation)) AND ((blood loss) OR (hospital stay) OR (failure rate) OR (femeral shaft fracture) OR (operative time) OR (complication)) AND (clinical trial or randomized controlled trial). Search strategies for MEDLINE and Scopus are described in "Appendix." Relevant studies from the reference lists of identified studies and previous systematic reviews were also explored.

Selection of studies

Identified studies were selected by one author (JK) and randomly checked by (AA). Their titles and abstracts were initially screened, and full papers were retrieved if a decision could not be made from the abstracts. The reasons for ineligibility or exclusion of studies were recorded (Fig. 1).

Inclusion criteria

Randomized controlled trials or quasi-experimental designs that compared clinical outcomes between proximal femoral nail with anti-rotating, Gamma nails, percutaneous compression plate, Medoff sliding plate, less invasive stabilization system and dynamic hip screws for fixation in elderly trochanteric fractures were eligible if they met following criteria:

- Compared clinical outcomes between proximal femoral nail with anti-rotating, Gamma nails, percutaneous compression plate, Medoff sliding plate, less invasive stabilization system and dynamic hip screws.
- Compared at least one of following outcomes: operative time, fluoroscopy time, operative blood loss, length of hospital stays, wound complication (hematoma, infection and dehiscent), general complication (pneumonia, thromboembolic complications, fixation failure and fracture), late complication (fracture, malunion and nonunion) and reoperation.
- Had sufficient data to extract and pool, i.e., the reported mean, standard deviation (SD), the number of subjects according to treatments for continuous outcomes, and the number of patients according to treatment for dichotomous outcomes.

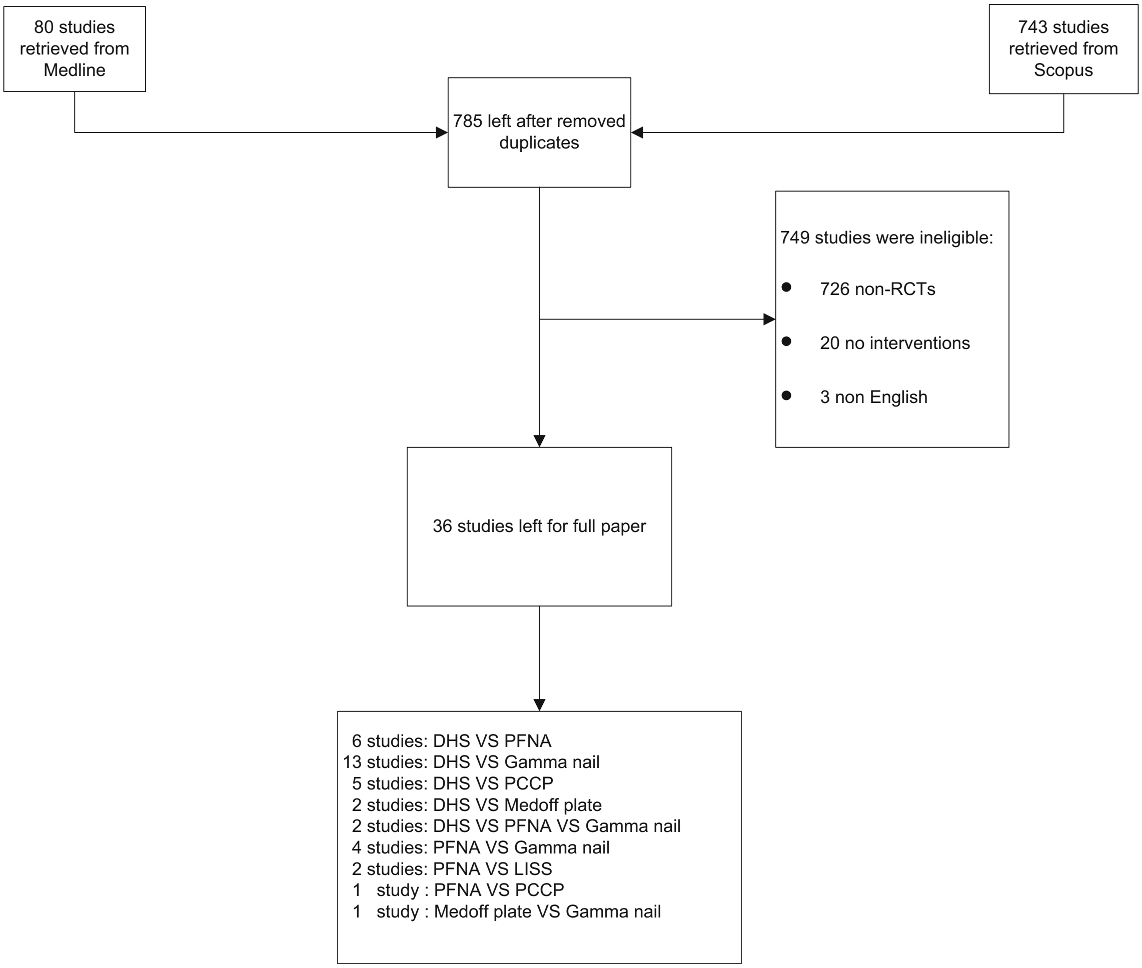

Fig. 1 Flow of study selection

Data extraction

Two reviewers (JK and AA) independently performed data extraction using standardized data extraction forms. General characteristics of the study (e.g., mean age, gender, body mass index (BMI), ASA status and mean follow-up time at baseline) were extracted. The number of subjects, mean, and SD of continuous outcomes (i.e., operative time, fluoroscopy time, operative blood loss and length of hospital stays) between groups were extracted. Cross-tabulated frequencies between treatment and all dichotomous outcomes (wound complication (hematoma, infection and dehiscent), general complication (pneumonia, thromboembolic complications, fixation failure, and fracture), late complication (fracture, malunion and nonunion) and reoperation) were also extracted. Any disagreements were resolved by discussion and consensus with a third party (TA).

Risk of bias assessment

Two authors (JK and AA) independently assessed risk of bias for each study. Six study quality domains were considered, consisting of sequence generation, allocation concealment, blinding (participant, personnel and outcome assessors), incomplete outcome data, selective outcome reporting and other sources of bias [28]. Disagreements between two authors were resolved by consensus and discussion with a third party (TA).

Outcomes

The outcomes of interest were operative time (OT), fluoroscopic time (FT), blood loss (BL), unit transfusion (UT), early postoperative (general complications and wound complications), hospital stay (HS), late postoperative complication and reoperation due to failure fixation.

Methods of measure for these outcomes were used according to the original studies. Briefly, the operative time (min), fluoroscopic time (min), blood loss (ml), unit transfusion (unit), early postoperative [general complications (cut though, fracture, malposition, DVT) and wound complications (dehiscent and infection)], hospital stay (days), late postoperative complication (nonunion, fracture and failure fixation) and reoperation due to failure fixation were considered.

Statistical analysis

Direct comparisons of continuous outcomes measured at the end of each study between proximal femoral nail with anti-rotating, Gamma nails, percutaneous compression plate, Medoff sliding plate, less invasive stabilization system and dynamic hip screws were pooled using an unstandardized mean difference (UMD). Heterogeneity of the mean difference across studies was checked using the Q-statistic, and the degree of heterogeneity was quantified using the I^2 statistic. If heterogeneity was present as determined by a statistically significant Q-statistic or by $I^2 > 25\%$, the UMD was estimated using a random effects model; otherwise, a fixed effects model was applied.

For dichotomous outcomes, a relative risk (RR) of postoperative complication of treatment comparisons at the end of each study was estimated and pooled. Heterogeneity was assessed using the previous method. If heterogeneity was present, the Dersimonian and Laird method [1] was applied for pooling. If not, the fixed effects model by inverse variance method was applied. Meta-regression was applied to explore the source of heterogeneity [e.g., mean age, percentage of females, body mass index (BMI), follow-up time and ASA status] if data were available. Publication bias was assessed using contour-enhanced funnel plots [18, 20] and Egger tests [3].

For indirect comparisons, network meta-analyses were applied to assess all possible effects of treatment if summary data were available for pooling [14, 23]. A linear regression model, weighted by inverse variance, was applied to assess the treatment effects for continuous outcomes. For postoperative complications (early and late) and reoperation, a mixed-effect Poisson regression was applied to assess treatment effects [14]. Summary data were expanded to individual patient data using the "expand" command in STATA. Treatment was considered as a fixed effect, whereas the study variable was considered as a random effect in a mixed-effect model. The pooled RR and its 95% confidence intervals (CIs) were estimated by exponential coefficients of treatments. All analyses were performed using STATA version 14.0 [25]. A p value <0.05 was considered statistically significant, except for the test of heterogeneity where <0.10 was used.

Results

Eighty and 743 studies from MEDLINE and Scopus were identified, respectively; 38 studies were duplicate, leaving 785 studies for review of titles and abstracts. Of these, 36 studies were reviewed and extracted. Characteristics of the 36 studies are described in Table 1. Among 28 dynamic hip screws studies, the comparators included proximal femoral nail with anti-rotating in 8 studies, Gamma nails in 14 studies, percutaneous compression plate in 5 studies and Medoff sliding plate in 2 studies. Comparing to proximal femoral nail with anti-rotating, the comparators included Gamma nail in 4 studies, LISS in 2 studies and PCCP in 1 study. Only one study compared Gamma nail to Medoff plate. Most studies included proximal femoral fracture type 31-A1–A3, followed by type 31-A2–A3 and type 31-A2. Mean age, BMI, type 3–4/1–2 ASA status ratio and follow-up time after surgery varied from 54 to 84 years, 21.8 to 24.3 kg/m^2, 0.2 to 0.95 and 3 to 40 months, respectively. Percentage of females ranged from 30 to 88%. Various outcomes were compared between treatment groups (Fig. 1).

Risk of bias in included studies

Risk of bias assessment is described in Table 2.

Direct comparisons

Data for direct comparisons of all treatments and outcomes measured at the end of each study are described in Table 1. Pooling according to outcomes was performed if there were at least two studies for each comparison, as clearly described below.

Operative time

The mean operative time of PFNA was −22.6 min (95% CI −37.9, −7.3) statistically significant lower than LISS, whereas PFNA was 13.5 min (95% CI 7.54, 19.45) statistically significant higher than PCCP. There were no significant differences between Gamma nail, PFNA, PCCP and Medoff when compared to DHS. Comparing to Gamma nail, PFNA and Medoff were no statistically significant different (Table 3).

Fluoroscopic time

The mean fluoroscopic time of DHS was −0.50 (95% CI −0.79, −0.21) statistically significant lower than PFNA, while PFNA was −0.21 (95% CI −0.35, −0.08) statistically significant lower than LISS. There were no significant differences between DHS and PFNA when compared to Gamma nail (Table 3).

Table 1 Characteristics of included studies

Authors	Years	Intervention	Comparator	Follow-up (months)	Type of fracture	Age	Sex (Female %)	Mean BMI	Preoperative ASA grading (I–II/III–IV %)	Outcomes
Saudan M	2002	DHS	PFNA	12	31-A1–A3	83.35	77.7	–	0.31	OT, FT, UT, GC, WC, HS, GC, WC, RO
Pajarinen J	2005	DHS	PFNA	4	31-A1–A3	80.6	75	21.8	0.20	OT, BL, UT WC, HS, LC, RO
Papasimos S	2005	DHS	PFNA and Gamma nail	12	31-A2–A3	81.2	60.8	–	0.62	OT, FT, GC, WC, LC, RO
Zou J	2009	DHS	PFNA	12	31-A1–A3	65	79	–	–	OT, BL, WC, LC, RO
Xu YZ	2010	DHS	PFNA	12	31-A2	78.5	70.8	–	0.65	OT, FT, BL, GC, WC, HS, GC, WC
Garg B	2011	DHS	PFNA	40	31-A2–A3	62.25	31	–	–	OT, FT, LC, RO
Parker MJ	2012	DHS	PFNA	12	31-A1–A3	81.9	80	–	0.35	OT, FT, UT, WC, HS, LC, RO
Bridle SH	1991	DHS	Gamma nail	6	–	81.85	84	–	–	GC, WC, RO
Leung KS	1992	DHS	Gamma nail	7.2	31-A1–A3	79.6	70.4	–	61.3	OT, BL, GC, WC, HS, LC
Radford PJ	1993	DHS	Gamma nail	12	–	80.5	75	–	–	WC, LC, RO
O'Brien PJ	1995	DHS	Gamma nail	13	31-A1–A3	80	74.3	–	–	OT, GC, WC, HS, LC, RO
Butt MS	1995	DHS	Gamma nail	6	31-A1–A3	78.5	69.5	–	–	OT, BL, GC, WC, HS, LC, RO
Kukla C	1997	DHS	Gamma nail	6	31-A1–A3	83	85	–	–	OT, WC, HS, LC, RO
Park SR	1998	DHS	Gamma nail	12	–	72.95	60	–	0.7	WC, LC, RO
Madsen JE	1998	DHS	Gamma nail	6	31-A1–A3	80	88.2	–	0.75	OT, UT, GC, WC, HS, LC, RO
Adam CI	2001	DHS	Gamma nail	12	31-A1–A3	80.95	78	–	–	OT, BL, WC, LC, RO
Utrilla AL	2005	DHS	Gamma nail	12	31-A1–A3	80.2	68.6	–	0.48	OT, FT, UT, GC, WC, LC, RO
Verettas DJ	2009	DHS	Gamma nail	10 days	31-A2	80.125	82.5	–	–	OT, BL, UT, GC, WC, HS
Barton TM	2010	DHS	Gamma nail	12	31-A2	83.2	79	–	0.45	HS, RO
Stern	2011	DHS	PFNA and Gamma nail	12	31-A1–A3	76.2	76.7	–	0.30	RO
Aktselis	2014	DHS	Gamma nail	12	31-A2–A3	83	70	–	0.64	OT, HS, LC, RO
Brandt SE	2002	DHS	PCCP	3	31-A2–A3	80.85	–	–	–	OT, GC, WC, HS, LC, RO
Kosygan KP	2002	DHS	PCCP	19	31-A1–A3	82.9	81.1	–	–	OT, UT, GC, WC, HS, LC, RO
Janzing HMJ	2002	DHS	PCCP	12	31-A1–A2	82.5	83.1	–	0.48	OT, UT, LC, RO
Peyser A	2005	DHS	PCCP	12	31-A1–A2	80.65	67	–	0.46	OT, BL, UT, WC, HS, LC, RO
Yang E	2011	DHS	PCCP	12	31-A1–A2	76.5	71.2	–	–	OT, BL, UT
Guo Q	2013	PFNA	PCCP	12	31-A1–A2	72.9	61.1	–	0.42	OT, BL, GC, WC, HS, RO
Schipper IB	2004	PFNA	Gamma nail	12	31-A2–A3	82.4	82.3	–	0.56	OT, BL, GC, WC, LC, RO
Yaozeng X (injury)	2010	PFNA	Gamma nail	12	31-A1–A3	76.7	64.5	–	0.47	OT, FT, BL, GC, WC, HS, LC, RO
Yaozeng X (orthopedic)	2010	PFNA	Gamma nail	12	31-A2–A3	75.7	60.3	–	0.68	OT, FT, BL, UT, GC, WC, HS, LC, RO
Voquero 2012	2012	PFNA	Gamma nail	12	31-A2–A3	83.55	82.8	24.25	0.52	OT, FT, WC, HS, LC, RO
Lunsjo K	2001	DHS	Medoff	12	31-A2–A3	81	72.7	–	–	OT, BL, GC, WC, HS, LC, RO
Miedel R	2004	Gamma nail	Medoff	12	31-A2–A3	81.65	88	–	–	OT, BL, GC, LC, RO
McCormack R	2013	DHS	Medoff	6	31-A2	83.3	76.1	–	–	LC, RO

Table 1 continued

Authors	Years	Intervention	Comparator	Follow-up (months)	Type of fracture	Age	Sex (Female %)	Mean BMI	Preoperative ASA grading (I–II/III–IV %)	Outcomes
Zhou F	2012	PFNA	LISS	12	31-A1–A3	71.97	53.1	–	0.61	OT, BL, GC, WC, HS, LC, RO
Haq RU	2014	PFNA	LISS	12	31-A2–A3	54.75	30	–	0.95	OT, FU, BL, LC, RO

DHS dynamic hip screw, *PFNA* proximal femoral nail anti-rotating, *PCCP* percutaneous compression plate, *LISS* less invasive stabilization system, *OT* operative time, *FT* fluoroscope time, *BL* blood loss, *UT* unit transfusion, *GC* general complication, *WC* wound complication, *HS* hospital stay, *LC* late complication, *RO* reoperation

Blood loss

The mean blood loss of DHS was 30.12 (95% CI 1.30, 58.94) and 136.03 (95% CI 6.69, 265.37) statistically significant higher than Gamma nail and PFNA, whereas DHS was −195 (95% CI −312.16, −77.84) statistically significant lower than Medoff. Mean blood loss of PFNA was −60.67 (95% CI −71.55, 49.79) and −80.47 (95% CI −160.97, 0.04) statistically significant lower than Gamma nail and LISS (Table 3).

Unit transfusion

The mean unit transfusion of DHS was 0.34 unit (0.07, 0.61) statistically significant higher than PCCP. However, there were no significant differences between Gamma nail and PFNA groups when compared to DHS (Table 3).

Hospital stay

The mean hospital stay of DHS was 0.87 days (95% CI 0.28, 1.45) statistically significant longer than Gamma nail. When compared to PFNA, Gamma nail was longer hospital stay for more 0.20 days (0.13, 0.27), while LISS has statistically significant shorter hospital stay of 2.72 days (1.47, 3.97) when compared to PFNA.

Complications (general, wound and late) and reoperation

In terms of (general, wound and late) complications and reoperation, there were no significant differences risk between Gamma nail, PFNA and Medoff when compared to DHS (Table 3). And, there were no significant differences in risk between PCCP and LISS when compared to PFNA (Table 3). Three studies were pooled wound complication of DHS was 2.78 (95% CI 1.58, 4.89) which showed a significantly higher risk when compared with PCCP, and no heterogeneity ($I^2 = 0$) was present (Table 3), while five studies were pooled late complication of Gamma nail was 0.72 (95% CI 0.54, 0.97) which showed a significantly lower risk when compared with PFNA, and no heterogeneity ($I^2 = 0$) was present (Table 3).

Network meta-analysis

Operative time

Data from 31 studies: the regression analysis suggested that the mean operative time was lowest in the PCCP with an overall mean of 29.3 (95% CI 5.24, 53.3) followed by DHS

Table 2 Risk of bias assessment

Authors	Adequate sequence generation	Adequate allocation concealment	Blinding	Address incomplete outcome data	Selective outcome report	Free of other bias	Description of other bias
Saudan M	U	N	N	N	Y	N	Per protocol analysis
Pajarinen J	Y	Y	Y	N	Y	N	Per protocol analysis
Papasimos S	U	N	N	N	Y	N	Per protocol analysis
Zou J	U	N	N	N	Y	N	Per protocol analysis
Xu YZ	Y	Y	N	N	Y	N	Per protocol analysis
Garg B	Y	N	N	N	Y	N	Per protocol analysis Did not mention to ITT
Parker MJ	Y	Y	Y	Y	Y	Y	–
Bridle SH	U	N	N	N	Y	N	Per protocol analysis Did not mention to ITT
Leung KS	U	N	Y (assessor)	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Radford PJ	U	N	N	N	Y	N	Per protocol analysis Did not mention to ITT
O'Brien PJ	U	N	N	N	Y	N	Per protocol analysis
Butt MS	Y	N	N	N	Y	N	Per protocol analysis Did not mention to ITT
Kukla C	U	Y	Y	N	Y	N	Per protocol analysis Did not mention to ITT
Park SR	Y	N	N	N	Y	N	Per protocol analysis Did not mention to ITT
Madsen JE	U	N	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Adam CI	U	Y	Y (assessor)	N	Y	N	Per protocol analysis
Utrilla AL	Y	Y	N	N	Y	N	Per protocol analysis
Verettas DJ	U	N	Y (assessor)	Y	Y	Y	–
Barton TM	U	Y	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Stern R	Y	Y	N	Y	Y	Y	–
Aktselis I	U	Y	N	N	Y	N	Per protocol analysis
Brandt SE	U	Y	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Kosygan KP	U	Y	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Janzing HMJ	Y	Y	N	N	Y	N	Per protocol analysis
Peyser A	Y	Y	Y (assessor)	Y	Y	Y	–

Table 2 continued

Authors	Adequate sequence generation	Adequate allocation concealment	Blinding	Address incomplete outcome data	Selective outcome report	Free of other bias	Description of other bias
Yang E	Y	Y	Y (assessor)	N	Y	N	Per protocol analysis
Guo Q	U	Y	Y (assessor)	N	Y	N	Per protocol analysis
Schipper IB	Y	Y	Y	Y	Y	Y	–
Yaozeng X (injury)	Y	Y	N	N	Y	N	Per protocol analysis
Yaozeng X (orthopedic)	Y	Y	N	N	Y	N	Per protocol analysis
Vaquero J	Y	Y	Y	Y	Y	Y	–
Lunsjo K	U	Y	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Miedel R	U	Y	N	Y	Y	N	Did not mention to randomization technique
McCormack R	U	Y	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Zhou F	U	Y	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT
Haq RU	U	Y	N	N	Y	N	Did not mention to randomization technique Did not mention to ITT

(53.7, 95% CI 40.1, 67.3), PFN (60.6, 95% CI 56.6, 64.6), Gamma nail (62.3, 95% CI 56.3, 64.6) and LISS (84.2, 95% CI 76.1, 92.2) (as given in Table 4; Fig. 2). Multiple comparisons indicated that there was statistically significant higher operative time of DHS, Medoff, Gamma nail, PFN and LISS when compared to PCCP. While LISS was statistically significant lower operative time of DHS, Medoff, Gamma nail, PFN and PCCP when compared to LISS.

Fluoroscopic time

Data from 12 studies: the regression analysis suggested that the mean fluoroscopic time was lowest in the DHS with an overall mean of 0.24 min (95% CI 0.16, 0.32), while Gamma nail was highest with an overall mean of 1.83 min (95% CI −0.71, 4.37) (as given in Table 4; Fig. 2). Multiple comparisons indicated that there was no statistically significant difference in operative time of DHS, Gamma nail, PFN and LISS.

Blood loss

Data from 15 studies: the regression analysis suggested that the mean blood loss was lowest in the PFN with an overall mean of 233.6 (95% CI 153.2, 314.0) followed by DHS (266.8, 95% CI 256.6, 277), Gamma nail (276, 95% CI 264.1, 287.9), LISS (279.2, 95% CI 43.5, 514.9), PCCP (432.9, 95% CI −270.7, 1136.5) and Medoff (611.9, 95% CI 242.7, 981.5) (as given in Table 4; Fig. 2). Multiple comparisons indicated that there was no statistically significant blood loss of DHS, PCCP, Medoff, Gamma nail, PFN and LISS.

Unit transfusion

Data from 11 studies: the regression analysis suggested that the mean unit transfusion was lowest in the PCCP with an overall mean of 0.89 unit (95% CI 0.52, 1.25) followed by DHS (1.31, 95% CI 0.74, 1.88), PFN (1.54, 95% CI 0.52,

Table 3 Summarized results of direct comparisons according to type of interventions

Clinical outcomes	No. of studies	I^2	No. of subjects	UMD (95% CI)	*p* value
Operative time					
DHS versus Gamma	9	84.6	634 versus 656	5.21 (−1.26, 11.68)	0.114
DHS versus PFNA	7	98.2	657 versus 645	−2.60 (−13.93, 8.73)	0.653
DHS versus PCCP	5	93.3	223 versus 211	9.31 (−7.07, 25.69)	0.265
DHS versus Medoff	1	–	238 versus 268	7.5 (−2.92, 17.92)	0.158
Gamma versus PFNA	5	96.7	455 versus 444	3.12 (−0.39, 6.62)	0.081
Gamma versus Medoff	1	–	108 versus 109	−4 (−12.05, 4.05)	0.330
PFNA versus PCCP	1	–	45 versus 45	13.5 (7.54, 19.45)	<0.001
PFNA versus LISS	2	36.4	56 versus 48	−22.58 (−37.91, −7.26)	0.004
Fluoroscopic time					
DHS versus Gamma	2	91.4	146 versus 144	0.19 (−0.37, 0.75)	0.500
DHS versus PFNA	5	97.4	540 versus 533	−0.50 (−0.79, −0.21)	0.001
Gamma versus PFNA	4	98.5	193 versus 195	−0.08 (−0.49, 0.33)	0.711
PFNA versus LISS	1	–	20 versus 20	−0.21 (−0.35, −0.08)	0.002
Blood loss					
DHS versus Gamma	3	0	304 versus 309	30.12 (1.30, 58.94)	0.041
DHS versus PFNA	3	94.2	172 versus 163	136.03 (6.69, 265.37)	0.039
DHS versus PCCP	2	90.5	86 versus 83	131.17 (−18.41, 280.74)	0.086
DHS versus Medoff	1	–	238 versus 268	−195 (−312.16, −77.84)	0.001
Gamma versus PFNA	3	88.2	335 versus 398	60.67 (49.79, 71.55)	<0.001
Gamma versus Medoff	1	–	109 versus 108	−126.00 (−274.49, 22.48)	0.096
PFNA versus LISS	2	52.2	56 versus 48	−80.47 (−160.97, 0.04)	0.050
Unit transfusion					
DHS versus Gamma	3	14.9	200 versus 213	0.15 (−0.12, 0.42)	0.281
DHS versus PFNA	3	0	460 versus 454	−0.04 (−0.20, 0.12)	0.617
DHS versus PCCP	4	0	185 versus 178	0.34 (0.07, 0.61)	0.015
Gamma versus PFNA	1	–	70 versus 66	0.08 (−0.24, 0.40)	0.620
Hospital stay					
DHS versus Gamma	8	2.8	494 versus 502	0.87 (0.28, 1.45)	0.004
DHS versus PFNA	4	13.1	515 versus 505	0.15 (−0.51, 0.82)	0.649
DHS versus PCCP	3	0	146 versus 139	0.24 (−1.66, 2.14)	0.802
DHS versus Medoff	1	–	238 versus 268	0 (−2.41, 2.41)	1.000
Gamma versus PFNA	3	0	153 versus 154	0.20 (0.13, 0.27)	<0.001
PFNA versus PCCP	1	–	45 versus 45	0.8 (−0.84, 2.44)	0.339
PFNA versus LISS	1	–	36 versus 28	2.72 (1.47, 3.97)	<0.001

Clinical outcomes	No. of studies	I^2	No. of subjects	RR	*p* value
General complication					
DHS versus Gamma	7	33.2	481 versus 495	1.01 (0.68, 1.50)	0.951
DHS versus PFNA	3	35.9	201 versus 191	1.08 (0.73, 1.60)	0.704
DHS versus PCCP	2	21	93 versus 89	2.07 (1.00, 4.31)	0.051
DHS versus Medoff	1	–	238 versus 268	3.38 (0.14, 82.49	0.455
Gamma versus PFNA	4	0	375 versus 372	0.97 (0.82, 1.16)	0.752
Gamma versus Medoff	1	–	108 versus 109	1.49 (0.84, 2.64)	0.176
PFNA versus PCCP	1	–	45 versus 45	0.89 (0.38, 2.10)	0.788
PFNA versus LISS	1	–	36 versus 28	0.78 (0.25, 2.43)	0.665
Wound complication					
DHS versus Gamma	12	0	868 versus 888	1.24 (0.79, 1.96)	0.345

Table 3 continued

Clinical outcomes	No. of studies	I^2	No. of subjects	RR	p value
DHS versus PFNA	6	0	618 versus 603	1.03 (0.58, 1.83)	0.917
DHS versus PCCP	3	0	146 versus 139	2.78 (1.58, 4.89)	<0.001
DHS versus Medoff	1	–	238 versus 268	2.25 (0.42, 12.19)	0.346
Gamma versus PFNA	5	0	406 versus 405	1.32 (0.89, 1.95)	0.172
PFNA versus PCCP	1	–	45 versus 45	0.73 (0.05, 11.30)	0.824
PFNA versus LISS	1	–	36 versus 28	0.79 (0.05, 12.11)	0.865
Late complication					
DHS versus Gamma	10	0	798 versus 820	0.77 (0.54, 1.10)	0.146
DHS versus PFNA	7	30	657 versus 645	0.89 (0.42, 1.89)	0.765
DHS versus PCCP	4	0	190 versus 178	1.23 (0.51, 2.96)	0.648
DHS versus Medoff	2	0	324 versus 345	0.62 (0.34, 1.13)	0.117
Gamma versus PFNA	5	0	193 versus 194	0.72 (0.54, 0.97)	0.028
Gamma versus Medoff	1	–	108 versus 109	0.43 (0.11, 1.60)	0.206
PFNA versus LISS	2	24.9	56 versus 48	0.51 (0.13, 1.93)	0.318
Reoperation					
DHS versus Gamma	13	0	1033 versus 965	0.75 (0.44, 1.27)	0.284
DHS versus PFNA	6	41.8	706 versus 615	1.21 (0.47, 2.09)	0.691
DHS versus PCCP	4	0	190 versus 178	1.25 (0.49, 3.23)	0.640
DHS versus Medoff	2	65.1	324 versus 345	0.86 (0.15, 4.91)	0.863
Gamma versus PFNA	6	0	485 versus 494	0.74 (0.47, 1.19)	0.213
Gamma versus Medoff	1	–	108 versus 109	0.33 (0.09, 1.19)	0.090
PFNA versus PCCP	1	–	45 versus 45	1.00 (0.02, 49.33)	1.000
PFNA versus LISS	2	0	56 versus 48	0.68 (0.14, 3.35)	0.635

2.56), Gamma nail (1.6, 95% CI 0.58, 2.62) (as given in Table 4; Fig. 2). Multiple comparisons indicated that there was no statistically significant difference in unit transfusion of PCCP, DHS, PFN and Gamma nail.

Hospital stay

Data from 20 studies: the regression analysis suggested that the mean hospital stay was lowest in the PFN with an overall mean of 7.23 days (95% CI 7.15, 7.31), while DHS was highest with an overall mean of 10.31 days (95% CI 7.54, 13.08) (as given in Table 4; Fig. 2). Multiple comparisons indicated that there was statistically significant lower hospital stay of PCCP, Gamma nail and PFN when compared to Medoff.

Complications (general, wound and late) and reoperation

The regression analysis suggested that the incidence of having complications (general, wound and late) was lowest in the PCCP with an overall incidence of 0.09 (95% CI 0.04, 0.18), 0.01 (95% CI 0.01, 0.04) and 0.05 (95% CI 0.02, 0.11), respectively. The incidence of having general and late complications was highest in the LISS with an overall incidence of (0.21, 95% CI 0.06, 0.72 and 0.18, 95% CI 0.07, 0.11), while DHS has an incidence of wound complications of 0.05 (95% CI 0.04, 0.08). In terms of reoperation, there was no statistically significant difference between all implants.

Discussion

We have performed a systematic review and a network meta-analysis comparing effects of proximal femoral nail with anti-rotating, Gamma nails, percutaneous compression plate, Medoff sliding plate, less invasive stabilization system and dynamic hip screws for fixation in elderly trochanteric fractures. Relevant clinical outcomes included operative time, fluoroscopic time, blood loss, unit transfusion, early postoperative (general complications) and wound complications), hospital stay, late postoperative complications and reoperation due to failure fixation were pooled. Our results indicate that PCCP was the lowest operative time, unit transfusion and the chance of complications (general, wound and late) when compared to the other treatments. PFN was the lowest blood loss and hospital stay when compared to the other treatments, while the lowest fluoroscopic time was DHS fixation. Medoff plate was the highest blood loss and hospital stay when

Table 4 Comparisons of treatment effects: a network meta-analysis

Treatment	Operative time			
	N	*β*	*p* value	95% CI
DHS	1712	53.70	<0.001	40.08, 67.32
PCCP	256	29.27	0.02	5.24, 53.30
Medoff	376	68.98	<0.001	61.06, 76.90
Gamma	1131	62.28	<0.001	56.25, 64.60
PFN	1111	60.62	<0.001	56.63, 64.60
LISS	48	84.16	<0.001	76.11, 92.22
PCCP versus DHS	–	−24.43	0.010	−42.44, −6.42
Medoff versus DHS	–	15.28	0.056	−0.44, 30.99
Gamma versus DHS	–	8.58	0.247	−6.29, 23.44
PFN versus DHS	–	6.92	0.355	−8.63, 21.98
LISS versus DHS	–	30.46	<0.001	14.63, 46.32
PCCP versus Medoff	–	−39.71	0.003	−65.01, −14.41
PCCP versus Gamma	–	−33.01	0.011	−57.78, −8.23
PCCP versus PFN	–	−31.35	0.013	−55.68, −7.02
PCCP versus LISS	–	−54.89	<0.001	−80.23, −29.55
Medoff versus Gamma	–	6.70	0.179	−3.25, 16.65
Medoff versus PFN	–	8.36	0.064	−0.50, 17.23
Medoff versus LISS	–	−15.18	0.010	−26.48, −3.89
Gamma versus PFN	–	1.66	0.338	−1.83, 5.15
Gamma versus LISS	–	−21.88	<0.001	−31.94, −11.82
PFN versus LISS	–	−23.54	<0.001	−32.54, −14.55
Fluoroscopic time				
DHS	646	0.24	<0.001	0.16, 0.32
Gamma	297	1.83	0.138	−0.71, 4.37
PFN	707	1.39	0.110	−0.38, 3.15
LISS	20	0.59	<0.001	0.59, 0.59
Gamma versus DHS	–	1.59	0.183	−0.90, 4.08
PFN versus DHS	–	1.14	0.168	−0.58, 2.87
LISS versus DHS	–	0.35	<0.001	0.27, 0.43
Gamma versus PFN	–	0.44	0.317	−0.50, 1.39
Gamma versus LISS	–	1.24	0.299	−1.30, 3.78
PFN versus LISS	–	0.80	0.335	−0.97, 2.56
Treatment	Operative time			
	N	*B*	*p* value	95% CI
Blood loss				
DHS	800	266.81	<0.001	256.62, 276.99
PCCP	128	432.90	0.209	−270.73, 1136.53
Medoff	376	611.91	0.003*	242.73, 981.54
Gamma	753	275.99	<0.001	264.10, 287.89
PFN	596	233.61	<0.001	153.17, 314.04
LISS	48	279.21	0.023	43.50, 514.93
PCCP versus DHS	–	166.10	0.620	−532.22, 864.42
Medoff versus DHS	–	345.10	0.065	−24.37, 714.58
Gamma versus DHS	–	9.19	0.222	−6.19, 24.57
PFN versus DHS	–	−33.20	0.413	−117.29, 50.89
LISS versus DHS	–	12.41	0.912	−223.53, 248.35
PCCP versus Medoff	–	−179.01	0.638	−973.82, 615.8

Table 4 continued

Treatment	Operative time			
	N	*B*	*p* value	95% CI
PCCP versus Gamma	–	156.91	0.641	−546.82, 860.64
PCCP versus PFN	–	199.29	0.529	−459.55, 858.15
PCCP versus LISS	–	153.69	0.665	−588.37, 895.75
Medoff versus Gamma	–	335.91	0.072	−33.90, 705.73
Medoff versus PFN	–	378.30	0.050	0.03, 756.58
Medoff versus LISS	–	332.70	0.127	−105.69, 771.09
Gamma versus PFN	–	42.39	0.288	−39.61, 124.40
Gamma versus LISS	–	−3.22	0.997	−239.23, 232.80
PFN versus LISS	–	−45.61	0.701	−293.99, 202.78
Unit transfusion				
DHS	739	1.31	0.001	0.74, 1.88
PCCP	178	0.89	<0.001	0.52, 1.25
Gamma	283	1.60	0.006	0.58, 2.62
PFN	420	1.54	0.008	0.52, 2.56
PCCP versus DHS	–	−0.42	0.143	−1.01, 0.17
Gamma versus DHS	–	0.29	0.500	−0.65, 1.23
PFN versus DHS	–	0.23	0.542	−0.59, 1.06
PCCP versus Gamma	–	−0.71	0.169	−1.79, 0.37
PCCP versus PFN	–	−0.65	0.207	−1.74, 0.43
Gamma versus PFN	–	0.61	0.915	−1.21, 1.33
Hospital stay				
DHS	1315	10.31	<0.001	7.54, 13.08
PCCP	184	9.29	<0.001	12.27, 12.31
Gamma	268	7.55	<0.001	7.14, 7.97
PFN	562	7.23	<0.001	7.15, 7.31
PCCP versus DHS	–	−1.02	0.598	−4.99, 2.96
Medoff versus DHS	–	5.44	0.001	2.67, 8.21
Gamma versus DHS	–	−2.76	0.045	−5.46, −0.07
PFN versus DHS	–	−3.08	0.031	−5.47, −0.32
LISS versus DHS	–	−2.70	0.055	−5.47, 0.07
PCCP versus Medoff	–	−6.46	<0.001	−9.48, −3.44
PCCP versus Gamma	–	1.74	0.246	−1.31, 4.79
PCCP versus PFN	–	2.07	0.169	−0.96, 5.09
PCCP versus LISS	–	1.68	0.258	−1.34, 4.70
Medoff versus Gamma	–	8.20	<0.001	7.78, 8.61
Medoff versus PFN	–	8.52	<0.001	8.44, 8.60
Gamma versus PFN	–	0.32	0.084	−0.05, 0.69
Gamma versus LISS	–	−0.06	0.772	−0.47, 0.36
PFN versus LISS	–	−0.38	<0.001	−0.46, −0.30
Treatment	Operative time			
	N	RR	*p* value	95% CI
General complication				
DHS	880	0.18	<0.001	0.11, 0.29
PCCP	134	0.09	<0.001	0.04, 0.18
Medoff	376	0.10	<0.001	0.05, 0.22
Gamma	846	0.16	<0.001	0.10, 0.28
PFN	604	0.17	<0.001	0.10, 0.28

Table 4 continued

Treatment	Operative time			
	N	RR	*p* value	95% CI
LISS	28	0.21	0.014	0.06, 0.72
PCCP versus DHS	–	0.51	0.013*	0.30, 0.86
Medoff versus DHS	–	0.60	0.120	0.31, 1.14
Gamma versus DHS	–	0.93	0.576	0.72, 1.20
PFN versus DHS	–	0.94	0.624	0.73, 1.21
LISS versus DHS	–	1.09	0.884	0.33, 3.60
PCCP versus Medoff	–	0.85	0.691	0.37, 1.92
PCCP versus Gamma	–	0.55	0.036*	0.31, 0.96
PCCP versus PFN	–	0.54	0.029*	0.31, 0.94
PCCP versus LISS	–	0.46	0.244	0.13, 1.69
Medoff versus Gamma	–	0.64	0.154	0.35, 1.18
Medoff versus PFN	–	0.64	0.166	0.34, 1.20
Medoff versus LISS	–	0.55	0.374	0.15, 2.06
Gamma versus PFN	–	0.99	0.927	0.80, 1.22
Gamma versus LISS	–	0.85	0.790	0.26, 2.78
PFN versus LISS	–	0.86	0.800	0.27, 2.77
Wound complication				
DHS	1789	0.05	<0.001	0.04, 0.08
PCCP	184	0.01	<0.001	0.01, 0.04
Medoff	268	0.02	<0.001	0.003, 0.09
Gamma	1161	0.05	<0.001	0.03, 0.07
PFN	1095	0.04	<0.001	0.02, 0.06
LISS	28	0.04	0.006	0.003, 0.39
PCCP versus DHS	–	0.40	0.006*	0.20, 0.77
Medoff versus DHS	–	0.36	0.214	0.07, 1.82
Gamma versus DHS	–	0.72	0.202	0.46, 1.02
PFN versus DHS	–	0.68	0.062	0.06, 6.49
LISS versus DHS	–	0.61	0.679	0.06, 0.13
PCCP versus Medoff	–	1.11	0.908	0.19, 6.48
PCCP versus Gamma	–	0.50	0.063	0.24, 1.04
PCCP versus PFN	–	0.58	0.149	0.27, 1.22
PCCP versus LISS	–	0.65	0.733	0.06, 7.60
Medoff versus Gamma	–	0.45	0.347	0.08, 2.38
Medoff versus PFN	–	0.52	0.445	0.10, 2.78
Medoff versus LISS	–	0.59	0.717	0.03, 10.40
Gamma versus PFN	–	1.16	0.428	0.81, 1.66
Gamma versus LISS	–	1.31	0.824	0.12, 14.01
PFN versus LISS	–	1.13	0.919	0.11, 11.91
Late complication				
DHS	1888	0.06	<0.001	0.04, 0.09
PCCP	178	0.05	0.001	0.02, 0.11
Medoff	453	0.10	<0.001	0.06, 0.18
Gamma	1202	0.07	<0.001	0.05, 0.10
PFN	1112	0.08	<0.001	0.06, 0.13
LISS	48	0.18	<0.001	0.07, 0.47
PCCP versus DHS	–	0.76	0.501	0.34, 1.70
Medoff versus DHS	–	1.66	0.062	0.97, 2.82
Gamma versus DHS	–	1.22	0.198	0.90, 1.65

Table 4 continued

Treatment	Operative time			
	N	RR	*p* value	95% CI
PFN versus DHS	–	1.49	0.026*	1.05, 2.10
LISS versus DHS	–	3.06	0.023*	1.16, 8.03
PCCP versus Medoff	–	0.46	0.108	0.18, 1.19
PCCP versus Gamma	–	0.62	0.269	0.27, 1.44
PCCP versus PFN	–	0.51	0.125	0.22, 1.20
PCCP versus LISS	–	0.25	0.027*	0.07, 0.85
Medoff versus Gamma	–	1.36	0.296	0.76, 2.42
Medoff versus PFN	–	1.12	0.722	0.61, 2.05
Medoff versus LISS	–	0.54	0.269	0.18, 1.60
Gamma versus PFN	–	0.82	0.198	0.61, 1.11
Gamma versus LISS	–	0.40	0.059	0.15, 1.04
PFN versus LISS	–	0.49	0.127	0.19, 1.23
Reoperation				
DHS	3197	1.25	0.652	0.48, 3.25
PCCP	446	1.24	0.652	0.48, 3.25
Medoff	906	1.24	0.652	0.48, 3.25
Gamma	2601	1.25	0.653	0.48, 3.25
PFN	1672	1.25	0.654	0.48, 3.24
LISS	96	1.25	0.655	0.47, 3.27
PCCP versus DHS	–	1.00	0.991	0.94, 1.06
Medoff versus DHS	–	1.00	0.996	0.96, 1.05
Gamma versus DHS	–	1.00	0.990	0.97, 1.03
PFN versus DHS	–	1.00	0.968	0.95, 1.05
LISS versus DHS	–	1.00	0.999	0.87, 1.15
PCCP versus Medoff	–	1.00	0.995	0.93, 1.08
PCCP versus Gamma	–	1.00	0.987	0.93, 1.07
PCCP versus PFN	–	1.00	0.971	0.93, 1.07
PCCP versus LISS	–	1.00	0.996	0.86, 1.16
Medoff versus Gamma	–	1.00	0.989	0.95, 1.05
Medoff versus PFN	–	1.00	0.972	0.94, 1.07
Medoff versus LISS	–	1.00	0.998	0.87, 1.15
Gamma versus PFN	–	1.00	0.971	0.96, 1.04
Gamma versus LISS	–	1.00	0.998	0.87, 1.44
PFN versus LISS	–	1.00	0.989	0.88, 1.14

* Statistically significant difference ($p < 0.05$)

compared to the other treatments. Gamma nail was the highest fluoroscopic time and unit transfusion when compared to the other treatments, while LISS was the highest operative time and late complication when compared to the others (see Tables 4, 5). In terms of reoperation, there have no different chances of having reoperation between treatment groups.

The results of this study were consistent to previous meta-analyses [8, 15, 19, 22, 29, 30]; five studies were to compare proximal femoral nail (with or without anti-rotation). Three studies suggest that PFN can reduce blood loss, operative time, blood transfusion and fewer

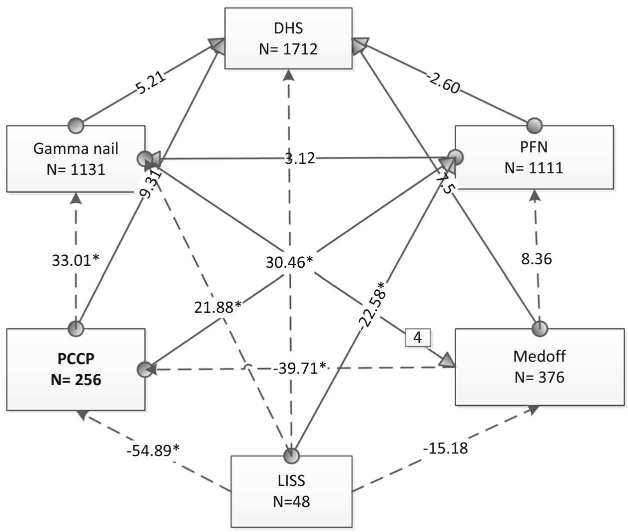

Fig. 2 Network meta-analysis of treatment effects on operative time. A *line in the figure* represents treatment comparisons, with *arrows* and tails referring to intervention and comparators,respectively. *Bold* and *dashed lines* refer to direct and indirect comparisons, respectively. The *number at the line* indicates chanceof treatment responsiveness, in which <0 indicates favors intervention vs the comparator. * $p < 0.05$ with Bonferroni correction

complications in the treatment of intertrochanteric fractures when compared with DHS, whereas two studies show the same effectiveness as DHS. One study was to compare PCCP and DHS; the review found that PCCP was associated with reduced blood loss and less transfusion need, but similar to DHS in operative time, hospital stay, mortality, complications and reoperation rate (Table 6). We, however, have added more evidences which supports that the PCCP, PFN and DHS may be a better choice than the others in the treatment of pertrochanteric fractures.

The direct meta-analysis suggests a potential benefit of PCCP for lowest operative time and unit transfusion while PFN and DHS for hospital stay and fluoroscopic time, but there was no different for complications and reoperation of all implants fixation. Performing a direct meta-analysis is limited by the small number of studies that evaluated each particular pair of treatments, but a network meta-analysis circumvents this problem by creating indirect comparisons between active treatments that can identify the most effective therapy.

This study has a number of strengths. We have applied a network meta-analysis to increase the power of the tests and reduce type I errors [14, 23, 24]. We applied a

Table 5 The highest or lowest effect ranking with multiple comparisons in each outcome

Treatment	Operative time	Fluoroscopic time	Blood loss	Unit transfusion	Hospital stay	General complications	Wound complication	Late complication
DHS	–	Lowest	–	–	–	–	–	–
PCCP	Lowest	–	–	Lowest	–	Lowest	Lowest	Lowest
Medoff	–	–	Highest	–	Highest	–	–	–
Gamma	–	Highest	–	Highest	–	–	–	–
PFN	–	–	Lowest	–	Lowest	–	–	–
LISS	Highest	–	–	–	–	–	–	Highest

Table 6 Previously published systematic review

Study	Year	Intervention	Comparator	Results
Parker MJ	2010	Cephalocondylar intramedullary nails	Extramedullary implants	From 22 trials, the review concluded that current evidence supports the continued use of the sliding hip screw for fixing the more common types of extracapsular hip fractures
Huang X	2013	Proximal femoral nail	Dynamic hip screw	From eight trials, PFN fixation shows the *same* effectiveness as DHS fixation in the parameters measured
Shen L	2013	Anti-rotation proximal femoral nail	Dynamic hip screw	From five trials, PFNA can benefit pertrochanteric fractures patients with *less* blood loss and fewer complications compared with DHS. The significant heterogeneity among the included trials for intra-operative blood loss and operation time
Ma KL	2014	Proximal femoral nails anti-rotation and Gamma nail	Dynamic hip screw	From fourteen trials, PFNA should be a priority choice for the treatment of intertrochanteric fractures with minimal rate of fixation failure, *less* blood loss and shorter length of hospital stay. DHS has distinct advantages over Gamma nail with lower rate of plant-related complications
Zhang L	2014	Percutaneous compression plate	Dynamic hip screw	From five trials, the PCCP was associated with *reduced blood loss and less* transfusion need, but similar to DHS in other respects
Zhang K	2014	Proximal femoral nail	Dynamic hip screw	From six trials, in terms of intra-operative blood loss, time and incision, PFN may be *a better choice* than DHS in the treatment of intertrochanteric fractures

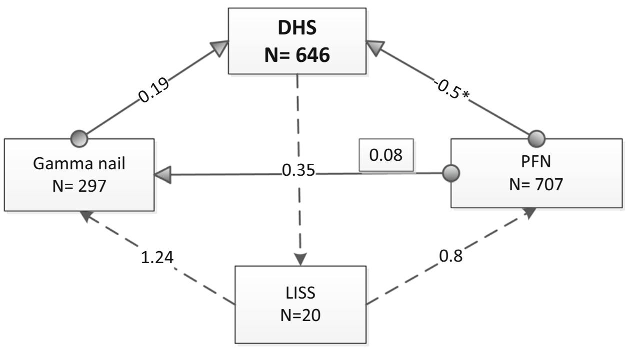

Fig. 3 Network meta-analysis of treatment effects on fluoroscopic time. A *line in the figure* represents treatment comparisons, with *arrows* and tails referring to intervention and comparators,respectively. *Bold* and *dashed lines* refer to direct and indirect comparisons, respectively. The *number at the line* indicates chanceof treatment responsiveness, in which <0 indicates favors intervention vs the comparator. *$p < 0.05$ with Bonferroni correction

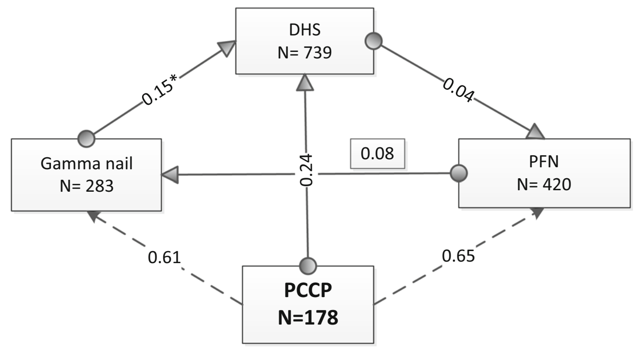

Fig. 5 Network meta-analysis of treatment effects on unit transfusion. A *line in the figure* represents treatment comparisons, with *arrows* and tails referring to intervention and comparators,respectively. *Bold* and *dashed lines* refer to direct and indirect comparisons, respectively. The *number at the line* indicates chanceof treatment responsiveness, in which <0 indicates favors intervention vs the comparator. *$p < 0.05$ with Bonferroni correction

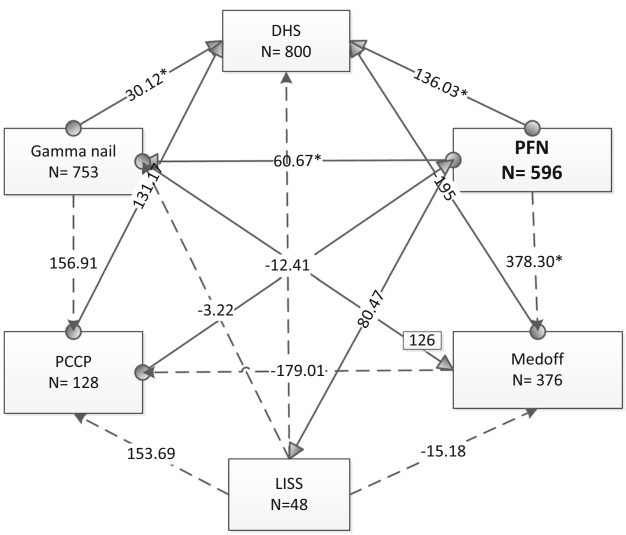

Fig. 4 Network meta-analysis of treatment effects on blood loss. A *line in the figure* represents treatment comparisons, with *arrows* and tails referring to intervention and comparators,respectively. *Bold* and *dashed lines* refer to direct and indirect comparisons, respectively. The *number at the line* indicates chanceof treatment responsiveness, in which <0 indicates favors intervention vs the comparator. *$p <$ 0.05 with Bonferroni correction

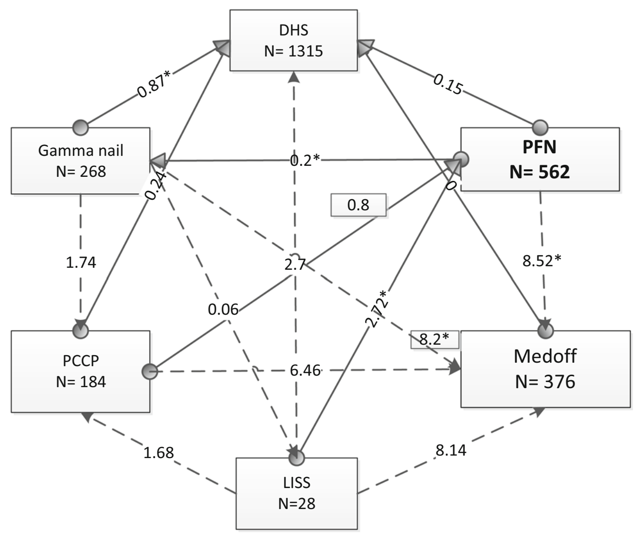

Fig. 6 Network meta-analysis of treatment effects on hospital stay. A *line in the figure* represents treatment comparisons, with *arrows* and tails referring to intervention and comparators,respectively. *Bold* and *dashed lines* refer to direct and indirect comparisons, respectively. The *number at the line* indicates chanceof treatment responsiveness, in which <0 indicates favors intervention vs the comparator. *$p <$ 0.05 with Bonferroni correction

regression model taking into account study effects to assess treatment effects. The network meta-analysis 'borrows' treatment information from other studies and increases the total sample size. As a result, treatment effects that could not be detected in direct meta-analysis could be identified. All possible treatment comparisons are mapped and displayed (see Figs. 2, 3, 4, 5, 6). Although our pooled estimates were heterogeneous, the regression model with cluster effect takes into account variations at the study level. None of RCTs compared proximal femoral nail with anti-rotating, Gamma nails, percutaneous compression plate, Medoff sliding plate, less invasive stabilization system and dynamic hip screws in the treatment of pertrochanteric fractures.

Although all studies were RCTs, 58.3% of the studies were unclear in the randomization sequence generations and allocation concealment; hence, selection bias or confounding factors may be present. Some pooled results were heterogeneous, but we were unable to explore the source of heterogeneity due to limitations of the reported data.

In conclusion, the network meta-analysis suggested that the fixation with PCCP has significantly shorten the operative time and unit transfusion with lower the risk of general complication, wound complication and late complication when compared to others, whereas PFN was the lowest in blood loss and hospital stay. Multiple active treatment comparisons indicated that PCCP fixation in elderly trochanteric fractures was the best treatment choices in terms of intra-operative outcomes and postoperative complication. But many countries have concern about hospital stay due to the high cost of hospitalization than PFN should be used.

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Authors' contributions AA was involved in conception and design, analysis and interpretation of the data, drafting of the article, critical revision of the article for important intellectual content, final approval of the article, collection and assembly of data. TA was involved in conception and design, drafting of the article, critical revision of the article for important intellectual content, final approval of the article, collection and assembly of data. PT was involved in conception and design, drafting of the article, critical revision of the article for important intellectual content, final approval of the article. PP was involved in conception and design, drafting of the article, critical revision of the article for important intellectual content, final approval of the article. PS was involved in conception and design, drafting of the article, critical revision of the article for important intellectual content, final approval of the article. JK was involved in conception and design, analysis and interpretation of the data, drafting of the article, critical revision of the article for important intellectual content, final approval of the article, statistical expertise, collection and assembly of data.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interests.

Ethical standards This article does not contain any studies with human participants performed by any of the authors.

Appendix: Search term and search strategy

#1 Fracture intertrochanteric
#2 Elder
#3 Fracture femur
#4 Proximal femural nail
#5 Dynamic hip screws
#6 Gamma nail
#7 Proximal femural nail anti rotation
#8 Blood loss
#9 Hospital stay
#10 Failure rate
#11 Femeral shaft fracture
#12 Operative times
#13 Complications
#14 #1 or #2 or #3
#15 #4 or #5 or #6 or #7
#16 #8 or #9 or #10 or #11 or #12 or #13
#17 #14 and #15 and #16.

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