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REVIEW ARTICLE

Rehabilitation protocols in unstable trochanteric fractures treated with cephalomedullary nails in elderly: current practices and outcome

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Abstract

Background Optimal rehabilitation treatment after surgery for fixation of unstable trochanteric fractures is challenging in elderly patients.

Purpose The objective of this study is to analyse the existing literature on available rehabilitation protocols with regards to permitting or restricting early weight bearing following fixation of unstable trochanteric fractures treated by the use of cephalomedullary nails in patients at least 65 years of age.

Methods A systematic review was performed based on the checklist of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Studies published between 1948 and 2018 on elderly patients with unstable trochanteric fractures treated with cephalomedullary nails that offered information on the postoperative rehabilitation protocol have been selected. Subsequently, the results and complications have been analysed according to the protocols.

Results Fifteen of the 7056 initial articles have been selected for analysis. Authors who did not restrict weight bearing to their patients reported a shorter hospitalization time and a lower orthopaedic complication rate but a greater systemic complication rate, worse functional scores, and a higher reoperation and mortality rates. Those results should be taken with caution because of the heterogeneity of provided clinical information and the fact that none of the included studies considered the different rehabilitation protocols as study variables to analyse its influence on the results.

Conclusion With evidence available to date, there is no clear agreement on the postoperative rehabilitation protocol following fixation of an unstable trochanteric fracture by cephalomedullary nail in the elderly.

Keywords Trochanteric · Unstable · Nail · Aftercare · Rehabilitation · Weight bearing

Introduction

Hip fractures are one of main causes of hospitalization and surgery for most trauma services in developed countries [1–3]. Most of them (> 90%) occur in patients older than 65 years of age, and represent an important cause of morbidity and mortality. The incidence of such fractures is expected to increase markedly with the aging population, up to an estimate of more than 6 million in the next 30 years [3, 4]. Closed or open reduction and internal fixation (CRIF/ORIF) or replacement (hemiarthroplasty/total hip replacement) are the main methods of treatment. For fixation, cephalomedullary nails are recommended in unstable trochanteric fractures [5–8]. The final result is mainly influenced by the prior functional status of the patient [9–11]. Some authors reported a longer duration for functional recovery in unstable fractures [12], and some studies concluded that

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elderly patients are unable to comply with restrictions on weight bearing [13–15], even advising the abandonment of this practice [16]. The objective of this study is to analyse the existing literature on available rehabilitation protocols following fixation of isolated, unstable trochanteric fractures treated by the use of cephalomedullary nails in patients at least 65 years of age. The detailed study questions were as follows:

- Are there different rehabilitation protocols reported, depending on postoperative weight-bearing (WB) restrictions?
- Do surgeons restrict aftercare (weight bearing) postoperatively to protect the osteosynthetic construct from failure in cases with poor reductions?
- Does unrestricted aftercare (weight bearing) result in shorter hospitalization time, shorter time to heal, better functionality, lower rates of systemic complications and a decreased 1-year mortality?
- Does restricted aftercare (weight bearing) result in lower rates of orthopaedic complications and reoperations?

Materials and methods

The present study has been carried out in accordance to PRISMA guidelines [17].

Eligibility criteria, information sources and search strategy

Inclusion criteria included articles published on any date that fulfilled: (1) human clinical studies, (2) unstable femoral trochanteric fractures (AO/OTA 31 A2-3) or trochanteric with subtrochanteric extension (Fig. 1) [18], (3) patients 65 years of age or older, (4) cephalomedullary nails. Exclusion criteria included: (1) animal studies, biomechanical studies, cadaver or model studies, (2) other treatment than osteosynthesis with cephalomedullary nails, (3) pathologic fractures, previous surgery, previous trochanteric fractures, (4) reviews, letters, case reports or technical notes. Given the objective of analysing the rehabilitation protocols in the immediate postoperative period, it was decided not to impose a minimum follow-up.

An internet search was performed in PubMed, MEDLINE (Ovid) and Cochrane library databases from inception up to Oct 26, 2018. The search strategy included the following terms in “all fields”: “trochanteric”, “fracture”, “nail” and “unstable”. Duplicates and articles written in languages others than English, German or Spanish were removed. A thorough analysis of the bibliographies was carried out in search of eligible reports.

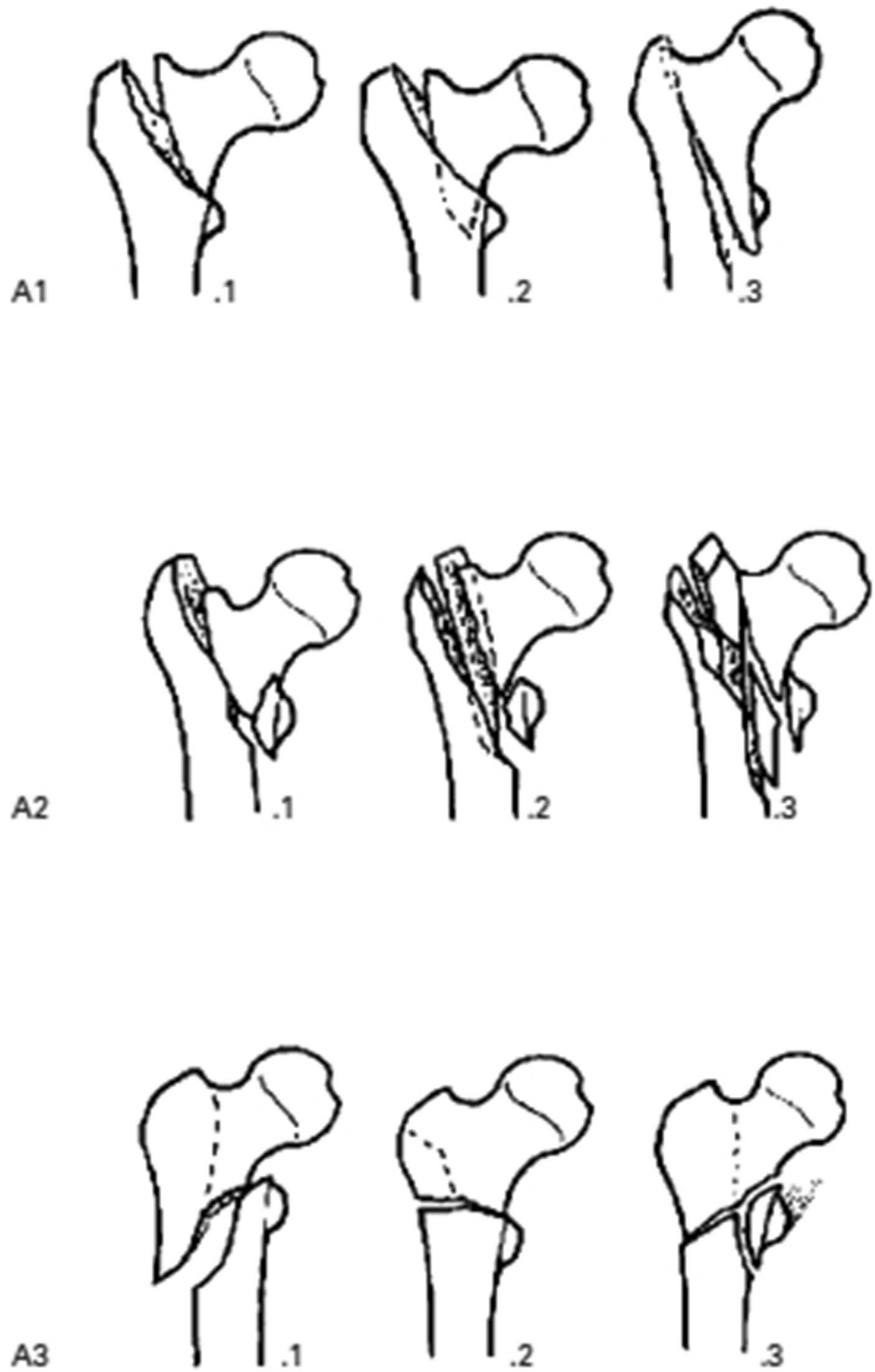
Study selection, extraction of data and data analysis

Eligibility assessment was performed by one of the authors. Titles and/or abstracts were analysed for the eligibility criteria and then were excluded or the corresponding full-text articles were obtained for further analysis. An accurate extraction of the information considered relevant was carried out. Authors’ information, type of study, year of publication, number of patients, average age, implants used, supplementary treatments, classification of fractures, quality of reduction, time of follow-up, rehabilitation protocols, functional results, occurrence of complications and mortality rates were analysed.

Outcomes of interest were expressed as mean (age, time of hospitalization, time to heal) or proportions (%) (complications, reoperations or death rate). The time to heal refers to the time reported by the authors in which a radiological union and unpainful ambulation has been achieved. The quality of reduction was assessed by the Tip to Apex Distance (TAD) in millimeters [19], the Garden or the Baumgaertner criteria modified by Fogagnolo (% of patients with good, acceptable or poor reduction) [20, 21]. Based on this, several authors carried out qualitative classifications on reduction (e.g. good/acceptable/poor). Functional results were expressed in points (BADL: basic activities of daily living [22]; PMS: Parker mobility score [23]; HHS: Harris hip score [24]; OHS: Oxford hip score [25]; EQ-5D: Euro QoL-5D [26] and SF-36: short form 36 [27]), seconds (TUG: time up and go [28]) or proportions (%) of recovery/walking ability.

Complications considered in the review were unexpected fractures (both intraoperatively and in follow-up), infection, screw cut-out, non/mal-union (mal-union was considered as angular or rotational deformity of more than 10° or more than 1 cm of shortening compared with the contralateral side; non-union was considered as absence of signs of consolidation and pain after 9 months), and other complications related to the fracture and surgery (e.g., pain or implant breakage). Non-local complications that occur in organs or parts of the body other than the hip were considered to be systemic complications (also called medical or general complications according to the authors included). The systemic complications considered by the authors included pressure soars, cardiopulmonary complications, infectious complications (mostly urinary or respiratory), circulatory complications (venous thrombosis) or acute confusional syndrome. These data were then assessed in relation to the postoperative weight-bearing recommendations, which were categorized to either “with weight bearing restrictions” or “no weight bearing restrictions”.

Fig. 1 AO/OTA classification of intertrochanteric fractures [18]



Risk of bias

One of the authors assessed the methodological quality of the studies [29, 30]. The risk of biases was analysed using the following criteria: (1) sequence generation and allocation concealment: for selection bias assessment, depending on the randomization methods, if performed and reported, (2) outcome assessor blinding: report of the knowledge about the treatment in the professionals assessing the results (detection bias); (3) incomplete reporting: loss of outcome data, due for example to a drop-out greater than 20% in study groups (attrition bias), (4) selective reporting: any of the expected results according to protocol (if specified) has not been reported (reporting bias) and (5) any other source of risk of bias in the study.

Results

Study selection

Initial search on the databases identified 7056 articles between the years 1948 to 2018 and 16 more articles were identified through bibliographic citations of the initial search. Duplicates ($n=4647$) and articles in languages others than English, German or Spanish ($n=283$) were removed. The abstract and/or titles of 2142 articles were then screened for eligibility. After application of the exclusion criteria, 2004 articles were removed and 138 were selected for further analysis. Five of the studies initially met the inclusion criteria, but did not clarify the age of the youngest patient included. After trying to contact the corresponding authors, no response was obtained, so they were discarded [31–35]. Finally, after the full-text analysis, 15 articles satisfied all our inclusion/exclusion criteria and were selected for the review [36–50] (Fig. 2).

Risk of bias and level of evidence

Due to the presence of diverse retrospective studies, only 33% of the selected papers presented a low risk of selection bias. In two studies (13.4%), the collection of results was analysed by a member of the team who was not involved in the treatment. In 66% of the studies, it was not specified if the member who has collected the results has been part of the treatment, and a detection bias cannot be ruled out. In 40% of the studies, an attrition bias could present because of more than 20% of losses at the final follow-up. In 93.3%

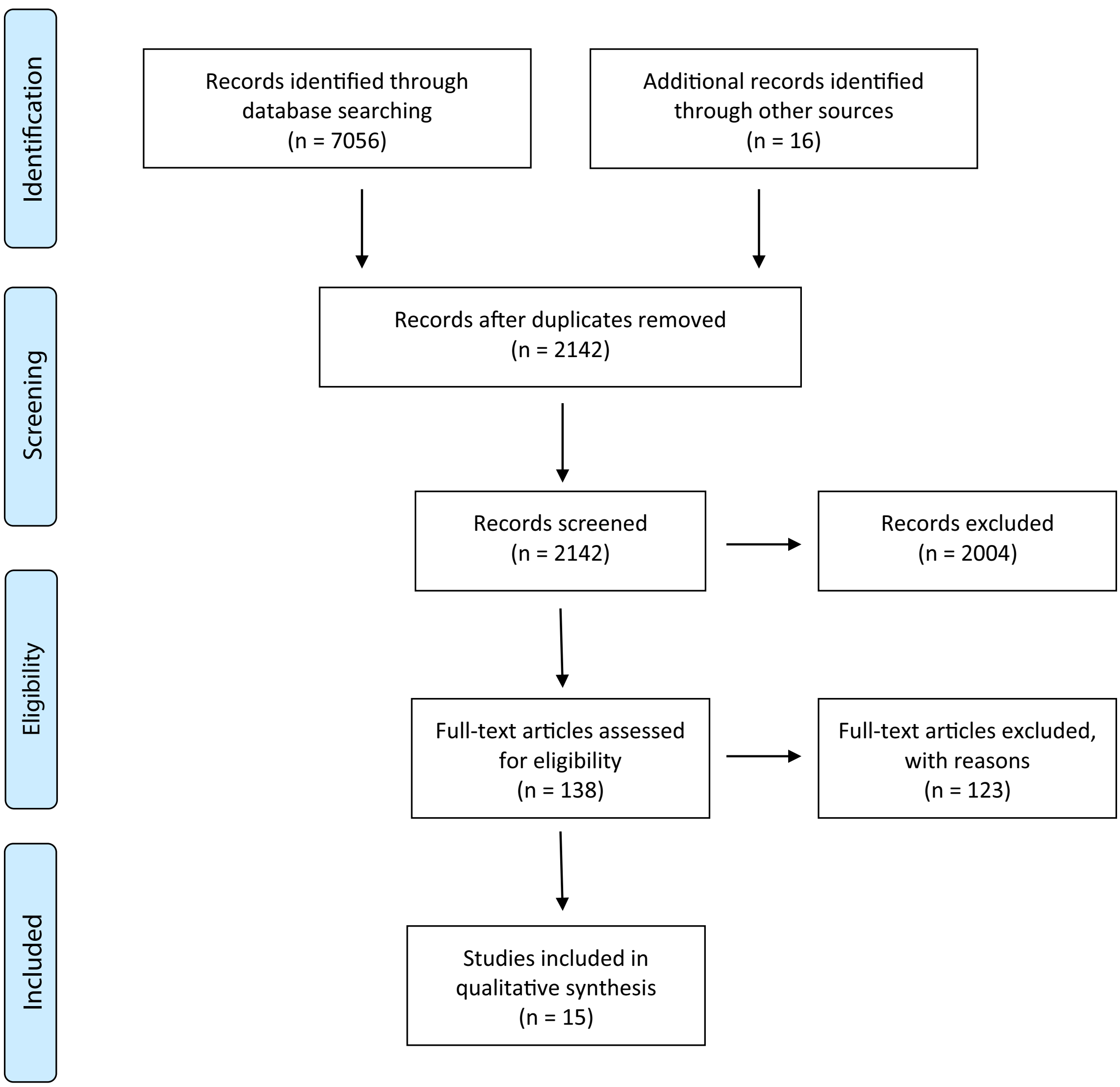


Fig. 2 Flow-diagram

of the cases, the results presented were those specified in the protocol or in the materials and methods of the study. In 8 of the 15 studies (53.3%), no data were found to suggest the occurrence of other biases. Results are shown in Table 1. The set of selected studies and their levels of evidence was composed of three randomized controlled trials (I), three randomized non-controlled trials (II), three retrospective cohort studies (III) and six retrospective or prospective case series (IV) (compare Table 2).

Characteristics of the studies and demographics

The 15 studies included equated to a total of 1565 cases from 2010 to 2018 [36–50]. The mean age of the patients was higher than 70 years, with a minimum age of 65 years and a maximum of 99 years of age including all the studies.

The minimum follow-up was 1 year in 11 studies [38–42, 44–49]; 6 months in 3 studies [36, 37, 43] and 1 study only achieved a minimum follow-up of 1 month, despite the fact that their median follow-up was greater than 1 year [50]. All the authors used the AO classification to classify their fractures: A1 is defined as a stable trochanteric fracture, as opposed to A2 and A3, which are considered unstable fractures [18]. Thirteen studies included the unstable fracture types A2 and A3 [36–43, 45–49], while 1 only includes type A2 [36] fractures and another study only included reverse oblique type A3 fractures [45]. More than ten different types of cephalomedullary nails were used for the various studies, both long and short versions. Six studies compared the results between types of implants [36, 39, 45, 48–50] and in two studies, cement augmentation was used [37, 41]. Results are shown in Table 2.

Weight-bearing recommendations

Of the 15 included studies, 8 authorised weight bearing from the first or second day depending on the patient's own tolerance, in most cases with crutches or walker [37, 38, 41, 42, 45–47, 50]. Among the other seven articles in which limited weight bearing was advised, there was a disparity of protocols. Chang et al. prevented weight bearing until the tenth postoperative day, initiating partial weight bearing according to a tolerance limit which was not declared [36]. Galanopoulos et al. limited the weight bearing to a maximum of 30% of the weight during the first month [39]. Gao et al. left the decision on weight-bearing restrictions to the operating surgeon to recommend partial weight bearing or non-weight bearing of the operated limb [40]. In the two studies by Kim et al., the authors recommended partial weight bearing according to tolerance during the first 2 months and subsequently allowing full weight bearing once there was radiological evidence of fracture callus [43, 44]. Both Vaquero et al. and Xu et al. advised partial weight bearing according to patients' pain tolerance without specifying the duration of partial weight bearing [48, 49]. None of the authors made a comparison between different postoperative weight-bearing protocols. Results are shown in Table 3.

Table 1 Risk-of-bias assessment

First author	Sequence generation	Allocation concealment	Outcome assessor blinding	Incomplete reporting	Selective reporting	Other source of risk of bias
Chang [36]	✗	✗	?	✓	✗	✓
Dall'Oca [37]	✓	✓	?	✓	✓	✗
Ertürer [38]	✗	✗	?	✓	✓	✓
Galanopoulos [39]	✗	?	?	✓	✓	✗
Gao [40]	✗	✗	?	✓	✓	✓
Kammerlander [41]	✓	✓	✗	✗	✓	✗
Karakus [42]	✗	?	?	✓	✓	✓
Kim [43]	✗	✗	✗	✓	✓	✗
Kim [44]	✗	✗	✗	✓	✓	✗
Okcu [45]	✓	✓	✓	✓	✓	✗
Sawaguchi [46]	✗	✗	✓	✗	✓	✓
Temiz [47]	✗	✗	?	✗	✓	✓
Vaquero [48]	✓	✓	?	✗	✓	✓
Xu [49]	✓	✓	?	✗	✓	✓
Zehir [50]	✗	✗	?	✗	✓	✗

✓: low risk of bias; ✗: high risk of bias; ?: unclear risk of bias

Table 2 Characteristics of included studies

First author	Date	Study design (level of evidence)	Number of patients	Mean age (years)	Classification of fractures	Treatment	Augmentation/ supplementary treatment	Mean/ minimum follow-up (months)
No WB restrictions								
Dall'Oca [37]	2010	RCT (I)	80	84	AO 31-A2, A3	GN-3	+ Cement (n: 40)	NR/6
Ertürer [38]	2012	RCS (IV)	32	70.7	AO 31-A2, A3	Profin	–	17.3/12
Kammerlander [41]	2018	RCT (I)	223	85.8	AO 31-A2, A3	PFNA	+ Cement (n: 87)	NR/12
Karakus [42]	2018	PCS (IV)	54	79.3	AO 31-A2.2, A2.3, A3.1, A3.2	APFN	–	14.1/12
Okcu [45]	2013	RCT (I)	40	79	AO 31-A3	PFNA, PFNA long	–	14/12
Sawaguchi [46]	2014	PCS (IV)	176	84	AO 31-A2, A3	PFNA-II	–	NR/12
Temiz [47]	2015	RCS (IV)	41	72	AO 31-A2, A3	DLT	–	18.3/12
Zehir [50]	2015	RCOS (III)	276	77.5	AO 31-A2, A3	PFNA, InterTan, Talon	–	NR/1 Median follow-up per group: 12.2, 16.1, 16
WB restrictions								
Chang [36]	2015	RCS (IV)	127	78.7	AO 31-A2.2, A2.3	PFNA-II, GN-3	–	NR/6
Galanopoulos [39]	2018	RT (II)	50	80	AO 31-A2, A3	Affixus, VeroNail long	–	24/12
Gao [40]	2014	PCS (IV)	84	76.5	AO 31-A2, A3	EPFNs	–	NR/12
Kim [43]	2018	RCOS (III)	89	81.9	AO 31-A2, A3	PFN	+ Calcium phosphate (n:40)	14.4/6
Kim [44]	2018	RCOS (III)	96	82	AO 31-A2, A3	PFN	– Subcutaneous teriparatide (n:46)	22.8/12
Vaquero [48]	2012	RT (II)	61	83.6	AO 31-A2, A3	PFNA, GN-3	–	NR/12
Xu [49]	2010	RT (II)	136	75.7	AO 31-A2, A3	PFNA, GN-3	–	17.7/12

RCS retrospective case series, *RCT* randomized controlled trial, *PCS* prospective case series, *RCOS* retrospective cohort study, *RT* randomized trial, *NR* not reported, *PFNA/-II* proximal femoral nail antirotation/-II (Synthes, Oberdorf, Switzerland), *GN-3* Gamma nail 3 (Stryker, Mahwah, New Jersey, USA), *Profin* (TST Tibbi Aletler San. Ve Tic. Ltd. Sti, Istanbul, Turkey), *Affixus* Affixus hip fracture nail system (Zimmer-Biomet, Warsaw, IN, USA), *VeroNail* OrthofixVeroNail trochanteric nail (Orthofix, Verona, Italy), *EPFNs* expandable proximal femoral nails (Disc-O-Tech Medical Technologies, Herzliya, Israel), *APFN* anti-rotational proximal femoral intramedullary nail (TST, Istanbul, Turkey), *DLT* Dyna locking trochanteric nail (U&I corporation, Uijungbu Kyunggi-Do, Korea), *InterTan* (Smith & Nephew, Memphis, Tennessee), *Talon* Talon distal fix nail/lag screw (ODI, Florida, USA)

Quality of reduction

Most authors reported more than 90% good or acceptable reductions with tip-to-apex-distances of less than 25 mm in their groups. The only author with a higher TAD is Kammerlander et al. in their group with augmented nails, probably to avoid intra-articular injuries or cement leakage [41]. None of the authors modified their weight-bearing restrictions depending on the reduction. There were no substantial differences between the reductions achieved in the two groups according to the rehabilitation protocol. Results are shown in Table 4.

Duration of hospitalization, time to heal, functional outcomes

Mean hospitalization time reported was 9.7 days (5.2–18.0). Six of the studies did not provide this information. Seven authors reported a mean time to heal of 14.1 weeks (10.0–23.0) [38, 39, 44, 46, 47, 49, 50]. The authors made no comparisons between different types of rehabilitation protocols and time to heal. Results are shown in Table 5.

Most authors reported poor results or a moderate functional limitation at the end of the follow-up. Only between 45 and 75% of the included patients regained the functional

Table 3 Weight-bearing recommendations

First author	Rehabilitation protocol
Chang [36]	PWBAT from 10th day
Dall'Oca [37]	Immediate WBAT
Ertürer [38]	Immediate WBAT with crutches or a walker
Galanopoulos [39]	PWBAT up to 30% with a walker during 1st month, WBAT with a walker or canes thereafter
Gao [40]	PWBAT from 2nd day or NWB (depending on the surgeon)
Kammerlander [41]	Immediate WBAT
Karakus [42]	Immediate WBAT with a walker
Kim [43]	PWBAT with a walker within 2nd to 8th week FWB from 8th week if callus observed
Kim [44]	PWBAT with a walker within 2nd to 8th week FWB from 8th week if callus observed
Okcu [45]	WBAT from 2nd day
Sawaguchi [46]	WBAT from 1st to 2nd day with walking aids until 6th week
Temiz [47]	Immediate WBAT with a walker or crutches until 6th week Single cane subsequent 6 weeks
Vaquero [48]	Immediate PWBAT
Xu [49]	Immediate PWBAT
Zehir [50]	Immediate WBAT

PWBAT partial weight bearing as tolerated, *WBAT* weight bearing as tolerated, *NWB* non-weight bearing, *FWB* full weight bearing

Table 4 Quality of reduction and weight-bearing limitations

First author	Quality of reduction (TAD in mm/% good, acceptable, poor reductions)
No WB restrictions	
Dall'Oca [37]	TAD: 15/17 mm
Ertürer [38]	93.7% good or acceptable
Kammerlander [41]	TAD: 24.2/26.9 mm
Karakus [42]	TAD: 16.8/17.5 mm
Okcu [45]	TAD: 22/24 mm
Temiz [47]	TAD: 15.5 mm 65.6% good, 28.1% acceptable, 6.3% poor
Zehir [50]	TAD: 21.3/22.7/24.2 mm
WB restrictions	
Gao [40]	82.2% good, 10.7% acceptable, 7.1% poor
Vaquero [48]	TAD: 24.5 mm
Xu [49]	54.4% good, 39% acceptable, 6.6% poor

More than one value expresses the results of the different groups within the studies

TAD tip-to-apex distance

status they had had prior to the fracture. The different studies compared functional results or complications between different fracture patterns, nail models or treatments (augmentation or teriparatide), but none of them compared the functional results between restricted or non-restricted weight bearing after the surgery. The most frequent parameter used to describe the functional results in the selected studies was the Harris Hip Score (HHS), with values ranging between 58 and 85 points at the end of the follow-up. The Parker–Palmer Mobility Score (PMS) was used by several authors to express the functional results of their patients. Karakus et al. showed higher Parker–Palmer Mobility Score (PMS) values in patients with A2 fractures compared to patients with oblique reverse type A3 fractures at 1 year [42]. Dall'Oca et al. [37] and Kim et al. [43] obtained better functional results with augmentation in the short-term follow-up (3 and 6 months, respectively). Results are shown in Table 5.

Complications, reoperation and mortality rates

None of the authors included in the review analysed the relation between the different rehabilitation protocols and the risk of complications. In their study, Okcu et al. used the Dindo's classification to define complications, and reported one grade II and two grade IIIb complications [45]. They were the only authors who reported their complications using an established classification system. Sawaguchi et al. reported a 2.9 times higher probability of a fracture fixation complication in type A3 fractures than in type A2 [46]. Among the mechanical complications, most frequently reported were secondary displacement/mal-union, intra- or postoperative fracture and excessive screw sliding and/or pain on the lateral side. The total number of unexpected fractures reported in our review ranges from 1.5 to 12%, which includes intraoperative (diaphyseal and trochanteric) and postoperative fractures. The nine authors who reported infections did so between

Table 5 Time to heal, duration of hospitalization, previous functional status and outcomes (results with unified study groups, except for cases with significant differences)

First author	Time to heal (weeks)	Duration of hospitalization (days)	Previous functional status (points)	Functional result (points) (follow-up)
No WB restrictions				
Dall'Oca [37]	NR	9.8	HHS: 56.6	HHS: 58.9 (1 year)
Ertürer [38]	17.6	NR	NR	OHS: 23.7 (1 year)
Kammerlander [41]	NR	NR	PMS: 6.8 Barthel: 90.6	TUG: 21.9 s PMS: 5.8 Barthel: 81.9 (1 year)
Karakus [42]	NR	8.9	NR	PMS*: 5.6 (A2), 3.3 (A3) (1 year)
Okcu [45]	NR	5.2	PMS: 7.3	HHS: 76.5 PMS: 5.4 (1 year)
Sawaguchi [46]	12 (85% of patients)	NR	NR	EQ-5D: 45% 'no problems' with mobility and usual activities. (1 year)
Temiz [47]	13.1	6	53.2% walk unassisted 46.8% walk with assistance	HHS: 63.4 28.1% walk unassisted 59.3% walk with assistance 62.5% recovered previous walking ability (1 year)
Zehir [50]	22.6	7.2	NR	HHS: 74.3 (6 months)
WB restrictions				
Chang [36]	NR	NR	BADL: 15.2 PMS: 7.8	BADL: 13.2 PMS: 7.4 (6 months)
Galanopoulos [39]	11	NR	NR	Time to FWB: 7.6 weeks
Gao [40]	NR	NR	NR	HHS: 85.7 75% recovered preoperative function (1 year)
Kim [43]	NR	14.5	NR	HHS*: 59.2 (PFN), 63.4 (PFN augmented) (6 months)
Kim [44]	12.5	18.0	NR	HHS: 63.8 (6 months)
Vaquero [48]	NR	10.5	SF-36 Physical: 40.9 SF-36 Mental: 49.3	HHS: 68.9 SF-36 Physical: 35.8 SF-36 Mental: 47.1 BADL: 3.8 (1 year)
Xu [49]	9.9	7.3	PMS: 6.9	PMS: 6.2 44.9% recovered previous walking ability (1 year)

BADL basic activities of daily living, *PMS* Parker mobility score, *HHS* Harris hip score, *OHS* Oxford hip score, *TUG* time up and go, *EQ-5D* Euro QoL-5D, *SF-36* short form 36, *PMCS* positive medial cortical support, *NMCS* negative medial cortical support, *NR* not reported

*Statistically significant differences between study groups were found

1.2 and 12.2% of cases [40, 41, 43–45, 47–49]. In most cases, they were superficial infections that were controlled by antibiotics, without the need for revision. Screw Cut-out/screw penetration was observed in less than 5% of cases in most of the series. Zehir et al. reported a higher risk of cut-out with the use of the PFNA than with InterTAN nails [50]. With regards to non/mal-union, a less than 10% rate was reported by most authors except Okcu and Vaquero et al., who reported a rate of 22.5% and 46%, respectively [45, 48]. Painful hardware, usually occurring due to excessive sliding of the screw was reported between 1 and 10%. Breakage of the intramedullary nail was an uncommon complication with a frequency between 0 and 2%. In studies with patients in whom augmentation was performed, cement leakage was reported in 1% and 2.5% of cases, respectively [37, 41]. The frequency of systemic complications was absent or underreported in many of the studies included in this review, and ranged from 7 to 52.5% of cases in the five studies in which they were reported [40, 41, 48–50]. The rate of reinterventions reported was between 0 and 9% in all studies. Mortality per year, in those studies in which it was reported, ranged between 5.7% and 18.8%. Results are shown in Table 6.

Table 6 Complications, reoperation and mortality rate

First author	Complications rate (%)	Fracture	Infection	Cut-out/through	Non/mal-union	Systemic complications	Others	Reoperation rate (%)	Mortality rate (%) (period)
No WB restrictions									
Dall'Oca [37]	NR	0	0	0	0	NR	Cement leakage: 1 (2.5%)[a]	0	11.2% (NR)
Ertürer [38]	NR	3 (9.4%)	NR	0	NR	NR	Lateral pain: 4 (12.5%)	9.4	18.8% (1 year)
Kammerlander [41]	49%	11 (5%)	4 (1.8%)	2 (0.9%)	3 (1.3%)	94 (42%)	Cement leakage: 1 (1.1%)[a] Lateral pain: 3 (1.3%) Hematoma: 4 (1.8%)	2.7	9% (1 year)
Karakus [42]	NR	NR	NR	3 (5.6%)	NR	NR	NR	5.6	24% (NR)
Okcu [45]	NR	NR	2 (5%)	1 (2%)	9 (22.5%)	NR	NR	5	18% (1 year)
Sawaguchi [46]	10.2%	0	0	3 (1.7%)	9 (5.1%)	NR	Implant breakage: 3 (1.7%)	1.7	5.7% (1 year)
Temiz [47]	41.4%	5 (12.2%)	5 (12.2%)	0	3 (7.3%)	NR	Heterotopic ossification: 4 (9.8%) Deep vein thrombosis: 1 (2.4%)	0	17.1% (1 year)
Zehir [50]	NR	NR	16 (5.8%)	8 (2.9%) Only in PFNA[b]	NR	88 (32%)	Hematoma: 7 (2.5%) Excessive screw sliding: 5 (1.8%) Only in PFNA[b] Tight pain: 13 (4.7%) Hip pain: 9 (3.3%)	6.2	3.3% (1 month) 16.2% (NR)
WB restrictions									
Chang [36]	NR	13 (10.2%)	NR	NR	NR	NR	Tight pain: 13 (10.2%)	0	NR
Galanopoulos [39]	NR	1 (2%)	NR	1 (2%)	NR	NR	NR	4	NR
Gao [40]	NR	1 (1.2%)	1 (1.2%)	2 (2.4%)	0	6 (7.1%)	0	2.4	8.3% (1 year)
Kim [43]	21.4% (PFNA) 5% (PFNA augmented)[b]	NR	5 (5.6%)	NR	5 (5.6%)	NR	Excessive screw sliding: 1 (1.1%)	3.4	3.4% (NR)
Kim [44]	18.8%	NR	5 (5.2%)	NR	11 (11.4%)	NR	Excessive screw sliding: 2 (2.1%)	4.2	2% (NR)

Table 6 (continued)

First author	Complications rate (%)	Fracture	Infection	Cut-out/through	Non/mal-union	Systemic complications	Others	Reoperation rate (%)	Mortality rate (%) (period)
Vaquero [48]	70.5%	1 (1.6%)	3 (5%)	3 (5%)	28 (46%)	32 (52.5%)	Implant breakage: 1 (1.6%) Hematoma: 1 (1.6%) Lateral pain: 1 (1.6%)	8.2	6.6% (1 year)
Xu [49]	NR	4 (2.9%)	3 (2.2%)	0	0	17 (12.5%)	Hematoma: 11 (8%) Excessive screw sliding: 9 (6.6%)	0.7	2.2% (1 month) 11% (NR)

NR not reported

[a]Percentage of the sample operated with cement

[b]Results with significative differences between groups

Comparison between weight-bearing recommendations

The studies without weight-bearing restrictions showed a shorter time of hospitalization (7.4 days) and a lower orthopaedic complication rate (15.4%). They obtained a lower Harris Hip Score at 1 year (66.3 points), but given the heterogeneity of the scores used and the follow-ups, these have been calculated from only five studies. This group reported a higher rate of systemic complications (36.5%) as well as a higher rate of reoperations (3.7%) and mortality (9.8%) at 1 year [37, 38, 41, 42, 45–47, 50]. Results are shown in Table 7.

Discussion

Mobilization of elderly patients after fixation of trochanteric fractures is challenging. There is no general consensus on the best specific rehabilitation protocol for this patient cohort. This systematic review attempts to give more clarity to this issue, and assessed whether or not (1) different weight-bearing recommendations have been reported, (2) weight-bearing restrictions have been reported more frequently in cases with poor fracture reduction, (3) unrestricted weight bearing resulted in shorter hospitalization time, shorter time to heal, better functionality, lower rates of systemic complications and/or 1 year mortality, (4) restricted weight bearing resulted in lower rates of orthopaedic complications and/or

Table 7 Relation between weight-bearing recommendations, functional results and complications

	Weight-bearing restrictions [36, 39, 40, 43, 44, 48, 49] $n = 643$ patients	No weight-bearing restrictions [37, 38, 41, 42, 45-47, 50] $n = 922$ patients
Duration of hospitalization (mean) [37, 42–45, 47–50]	12.6 days $n = 382$	7.4 days $n = 491$
Functional result at 1 year (HHS) [37, 40, 45, 47, 48]	77.3 points $n = 145$	66.3 points $n = 161$
Rate of orthopedic complications [36–50]	19.6% $n = 643$	15.4% $n = 922$
Rate of systemic complications [40, 41, 48–50]	19.6% $n = 281$	36.5% $n = 499$
Reoperation rate [36–50]	2.6% $n = 643$	3.7% $n = 922$
1-year mortality rate [38, 40, 41, 45–48]	7.6% $n = 145$	9.8% $n = 512$

reoperations in patients at least 65 years of age treated with cephalomedullary nails for fixation of unstable trochanteric fractures.

The results found in the articles included in our review showed the diversity of the postoperative rehabilitation protocols for unstable trochanteric fractures. In our review, we did not observe a trend toward protective weight bearing during the postoperative period in authors with worse rates of reduction. In fact, none of the authors stated that they changed the rehabilitation protocols depending on the degree of postoperative reduction achieved.

Unrestricted weight bearing resulted in shorter hospitalization time of about 7 days compared to about 13 days if weight bearing was restricted postoperatively. The data published to date show very variable hospitalization times for unstable trochanteric fractures between 7 and 20 days depending on social factors and protocols [32, 35]. Oldmeadow et al. reported also a shorter hospitalisation time in patients in whom a true early ambulation was performed [51]. Longer hospitalization periods might occur due to problems in organizing patient care after discharge. This might depend on the family support, housing and health system of each country. In contrast, patients that are either more mobile and/or receive sufficient family support may not require further downstream care without any delay in length of stay.

The time to fracture union varied between 10 and 23 weeks independent of whether or not weight bearing was restricted. This time to fracture consolidation is in agreement with that published by other authors [52, 53].

Unrestricted weight bearing did not result in a higher functional result at 1 year. In contrast, the functional result (HHS) after 1 year in the group of patients with weight-bearing restrictions was higher than that of patients who were not restricted. Lindskog et al. commented that only about 50% of patients with unstable trochanteric fractures could recover to previous functional status [54]. These data are in agreement with other results published in the literature, which were in the same range as those referred previously [55, 56]. In our review, only between 45 and 75% of the patients recovered their pre-fracture functional status. However, given the limitations in the available data, it is not possible to confirm whether or not the rehabilitation protocols in the postoperative period are relevant in affecting the functional outcome.

In the studies included in this systematic review, it was not specified what the authors considered to be a systemic (or medical or general) complication. From what can be extracted from their results, they consider such complications to be non-local complications that appear in other organ systems or locations within the organism other than the operated hip. Unrestricted weight bearing did not result in a lower rate of systemic complications; in fact, the systemic complications were higher in the unrestricted weight-bearing cohort. Some of the authors reported in our review reflected on the high rate of their noted systemic complications. These were in accordance with previously published literature and probably related to the diversity and quantity of assessed systemic complications that elderly patients may have following these fractures (e. g. such as cardiovascular, urogenital, pulmonary or neurological complications) [35, 57]. Another option that may explain these results, apart from potential underreporting, are a hypothetical greater intervention of geriatricians in studies with higher systemic complication rates, since these could detect and report these complications more accurately than orthopaedic surgeons; or the selection of patients with a higher comorbidity rate in studies with a higher rate of systemic complications. Unfortunately, as with other variables, many of the authors do not cite the comorbidities of patients in the preoperative period, or do so in differing ways, making comparisons between the studies difficult. In the studies where geriatricians' duties were carried out by other medical personnel, the role and duties of this personnel was not reported. However, the decreased rate of systemic complications in the restricted weight-bearing group should be taken with caution as there is significant underreporting of systemic complications in the studies included in our review.

Unrestricted weight bearing did not result in a lower 1-year mortality rate. The 1-year mortality rate in the selected studies ranged between 5.7 and 18.8%. The comparison between groups according to weight-bearing restrictions was limited as only two studies in the group "with weight bearing restrictions" and five in the group "without weight bearing restrictions" clearly expressed their 1-year mortality rate.

Restricted weight bearing did not result in lower orthopaedic complications or reoperation rates. Several studies in the literature reported different kinds of complications which can occur after trochanteric fractures, but most of them have not reported outcomes separately for stable and unstable fractures. Some classifications have been published to standardize the methods of grading and reporting complications in orthopaedic surgery [58, 59]. In their study, Okcu et al. used the Dindo's classification, reporting one grade II complication and two of grade IIIb [45, 58]. None of the other studies included in this review have reported their complications according to a classification system. The frequency of intraoperative and postoperative fractures obtained in our review was in agreement with those previously published, with reported frequencies of around 35–5% intraoperatively and 1–4.5% during the postoperative period [54, 55, 60, 61]. None of the studies study had analysed the risk of (postoperative) fractures according to the restrictions of the weight bearing. Also, the frequency of infections in our review (1.2–12.2%) was similar to that reported by other authors, ranging between 1 and 9%. In most cases, these were superficial infections that did not require reoperation [55, 61, 62]. Based on the results reported in our review, it was not possible to demonstrate whether the risk of screw cut-out/penetration is influenced by the postoperative weight-bearing protocol. Some of the risk factors described to date include non-anatomical reduction, non-optimal lag screw position (tip-apex distance), more complex or basicervical fractures. In most series, these complications do not exceed 5% of cases [60, 63-65]. The rate of reoperations reported in the studies included in our review was between 0 and 9%, which is in agreement with most of the papers published to date [57, 60, 66]. The study with the highest reported re-operation rate was by Simmermacher et al., who reported almost a 9% rate of reoperations in unstable fractures operated with PFNA nails. The most frequent cause was a peri-implantary fracture, followed by acetabular penetration of the helical blade [55]. In our review, we found that both (the restricted and unrestricted weight bearing) groups had similar reoperation rates of 3.7% and 2.6%, respectively.

As a limitation of this study, the heterogeneity of the included articles, and lack of high-quality randomised controlled trials, does not reliably allow comparisons between their results. In addition, the type of aftercare and rehabilitation was probably not the focus within the identified articles and, therefore, some information might be lacking. Comparison between studies was also limited due to the lack of standards for complication reporting (complication classifications) and assessment. Accordingly, for future studies, orthopaedic surgeons, therefore, are asked to provide as many details as possible on rehabilitation protocols, follow-up period, complications and functional results. To express the functional results, it is necessary to use relevant parameters for the population being evaluated and to report these using reliable and validated scores to allow comparison.

Based on previous studies, it appears that elderly patients in general are believed to be unable to perform partial weight bearing [13, 16]. The evidence upon which this belief is based has probably some limitations as the results in these studies are obtained to a selected patient population in specific circumstances and set-up with only a very short follow-up. In contrast, other studies such as that of Hershko et al. have shown an increase in compliance with partial weight bearing even in elderly patients combining standard physiotherapy instructions with a new device with alarms ('biofeedback') compared to verbal feedback or bathroom scales [67].

Accordingly, in that controversy, there might be also a need for further studies to identify predictors for difficulties to follow the postoperative rehabilitation protocols, such as specific comorbidities (cognitive impairment, motivation in depression, polyneuropathy in diabetes, pre-existing gait disturbances, etc.) and/or to adjust patient instructions including modern concepts such as 'biofeedback' insoles and continued patient follow-up to avoid failure to comply with postoperative restrictions.

With the evidence available to date, there is no clear agreement on the postoperative rehabilitation protocol following fixation of an unstable trochanteric fracture by cephalomedullary nail in the elderly. Furthermore, it is questionable if elderly patients can maintain postoperative weight-bearing restrictions. There is a lack of evidence on the influence of the various rehabilitative protocols (in terms of restricting or not-restricting the weight bearing) on functional outcomes and complications in the short term. We should refine our aftercare protocols with proper aids and instructions to enable elderly to comply. Accordingly, further studies are needed to assess the impact of different rehabilitation protocols in the outcome of unstable trochanteric fractures in elderly and the best way to help our patients to comply with our recommendations. In the future, individualized protocols based on distinct physiotherapeutic perioperative assessments would be useful to facilitate decision-making for the ideal rehabilitation protocol. To achieve this, close collaboration between surgeons and physiotherapists is needed.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest for the present investigation.

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