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Early mobilisation after hip fracture surgery is associated with improved patient outcomes: a systematic review and meta-analysis

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Abstract

Introduction:- The aims of this systematic review and meta-analysis were to determine if after hip fracture surgery 1) early mobilisation is associated with improved clinical outcomes, and if so 2) are benefits directly proportional to how soon after surgery the patient mobilises

Methods:- A PRISMA systematic review was conducted using four databases to identify all studies that compared postoperative early mobilisation with delayed mobilisation in patients after hip fracture surgery. The Critical Appraisal Skills Programme checklist was employed for critical appraisal and evaluation of all studies that met the inclusion criteria.

Results:- A total of thirteen studies including 297,435 patients were identified, of which 235,275 patients were mobilised early and 62,160 were mobilised late. Six studies assessed 30-day mortality, of which two also investigated 30-day complication rates. Pooled meta-analysis demonstrated that there were significantly lower 30-day mortality rates (OR 0.35, 95% CI 0.31 - 0.41, $p<0.001$) and complication rates (OR 0.43, 95% CI 0.36 - 0.51, $p<0.001$) in patients mobilising early after hip fracture surgery. Five studies investigated length of stay and meta-analysis revealed no difference between groups (mean difference -0.57 days, 95%CI -1.89 - 0.74, p=0.39).

Conclusion:- Early mobilisation in hip fracture patients is associated with a reduction in 30-day mortality and complication rates compared to delayed mobilisation, but no difference in length of stay. These findings illustrate that early mobilisation is associated with superior post operative outcomes. However, a direct casual effect remains to be demonstrated, and further work on the factors underlying delayed mobilisation is required.

Key words:

- Early mobilisation
- Hip fracture
- Meta analysis
- Delayed mobilisation

- Complications
- Mortality rate

Introduction

Hip fracture is the most common acute cause of admission to orthopaedic surgical wards and predominately affects the older people, with frailty a strong risk factor (Tan et al., 2004). Given the rise in the ageing population, the number of individuals presenting with a hip fracture is increasing (Sugand et al., 2023). Projections suggest that global incidence rates of hip fractures will have nearly doubled from 1.66 million in 1990 to 2.6 million by 2025, and will increase markedly further to 6.26 million by 2050 (Cooper et al., 1992; Gullberg et al., 1997; Kannus et al., 1996). A study based on Scottish Hip Fracture Audit data combined with population demographics suggests a 32% increase between 2021 and 2029 (Harris et al., 2023). Hip fracture is associated with increased morbidity, frailty, and mortality risk (Downey et al., 2019; Gdalevich et al., 2004; Schnell et al., 2010), and presents and large socio-economic burden on the healthcare system. Studies agree that hospital and societal costs from hip fractures are significant, with the cost to the UK being £1.1 billion annually (Chrischilles et al., 1994; Johnell et al., 1997; Leal et al., 2016).

Given that healthcare systems across the world are becoming increasingly financially restrained, and the rate of hip fracture is set to rise, interventions to reduce morbidity and mortality in this patient group should be prioritised. The advent of Enhanced Recovery After Surgery (ERAS) has significantly improved surgical pathways in hip fracture care. ERAS encompasses streamlined and standardised preoperative, intraoperative and post operative interventions, which was described by Kehlet in 1997 (Kehlet, 1997). Since then, many professional bodies have incorporated early mobilisation into their standards, as part of ERAS, to help recovery after hip fracture surgery (Sarkies et al., 2023). The National Institute for Health & Care Excellence (NICE) recommends that all patients undergoing surgical management for a hip fracture should receive physiotherapy assessment and attempted mobilisation the day after surgery (NICE, 2023). The National Hip Fracture Database (NHFD) includes the target that patients are out of bed the day after surgery (Database, 2022). Similarly, the Scottish Government has published standards of care for hip fracture management, in conjunction with the Royal College of Emergency Medicine, British Geriatrics Society and Scottish Committee for Orthopaedics and Trauma (Scottish Government et al., 2019). They recommend that patients mobilise on the day after surgery and that they should be seen by a physiotherapist by day 2 post surgery (Scottish Government et al., 2019). Thus, there is consensus that achieving early mobilisation in this patient cohort is desirable. Some studies have suggested that early mobilisation after hip fracture surgery may be associated with outcomes and reduced length of stay (LOS). However, there are no meta-analyses on the relationship between early mobilisation and outcomes after hip fracture surgery.

The aims of this systematic review and meta-analysis were to determine if after hip fracture surgery 1) early mobilisation is associated with improved clinical outcomes, and if so 2) are benefits directly proportional to how soon after surgery the patient mobilises, and to 3) determine the breadth and depth of literature on this topic.

Methods

This systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO), registration number: CRD42023446186.

Database and inclusion criteria

The PRISMA framework was utilised to conduct this systematic review (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)*, 2015). Inclusion and exclusion were defined, through use of the Population, Intervention, Comparison, Outcomes and Study (PICOS) model (O'Connor D, Green S, 2008). Studies in which patients aged ≥18 sustained a hip fracture managed surgically and analysed early or delayed mobilisation were included. Studies which included quantifiable outcomes such as LOS, complications or mortality were included. Consequently, studies which did not include quantifiable outcomes were excluded. Studies in which patients did not sustain hip fractures, or sustained such fractures but were treated non-operatively were excluded. Studies were excluded if the mechanism of injury of hip fractures was pathological or periprosthetic. Articles which did not specifically quantify early mobilisation were excluded. Observational and interventional studies were included. Systematic reviews, methodological studies, index studies, protocols and editorials were excluded. In addition, studies were excluded if full text was not accessible, or if data sets were incomplete. Any ongoing randomised controlled trials (RCTs) were also excluded.

A comprehensive literature search was conducted by two independent researchers ([redacted]). Four databases were included in the search: Medline (1946 to July Week 2 2023), EMBASE (1974 to 14 July 2023), Cochrane library (1946 to July 2023), and Clinical Trials.gov (2000 to 2023).

Using the guidance created by the Cochrane Highly Sensitive Search Strategy, a search strategy was created (Lefebvre et al., 2008). This included but was not limited to the following terms: 'Hip fracture, neck of femur, femoral neck' and 'ambulation' or 'mobilisation'. The specific search strings employed for all four of the databases are displayed in Appendix 1. Studies were restricted to human subjects. Articles which were written in any language other than English were also excluded. Though, excluding articles written in other languages may provide a source of bias, there is no evidence in the literature that this has any bearing on the final information produced from a systematic review (Morrison et al., 2012). Reference screening of the papers revealed an additional paper which was included in the final review. The combined results of the comprehensive search strategy are shown in Figure 1.

Quality assessment

Each paper was independently appraised by xxx and xxx using the Critical Appraisal Skills Programme (CASP) checklist for cohort studies and randomised controlled trials (RCTs)

(Critical Appraisal Skills Programme, 2018). This 12-question checklist was used to assess each of the studies included in the review. Upon completion, the analyses of each study were collated to form a table displaying the conclusive appraisal (Table 1). Any disagreements were solved with discussion with the senior author (N.D.C).

Data extraction

Data available for possible analysis was synthesised whilst critical appraisal was conducted. These included, design study, total number of patients, definition of early and delayed mobilisation, follow up duration and types of outcomes assessed. These can be found in the Table 2, in the results section below.

Meta-analysis with forest plots was carried for outcomes that were common to studies and included 30-day mortality rates, 30-day complication rates and length of stay (LOS) in hospital. The Review Manager Database 5.4.1 was used to extract the data to conduct the meta-analysis. Chi squared, tau squared and I^2 tests were conducted to determine heterogeneity. Dichotomous data was stratified in the form of patients with early mobilisation versus delayed mobilisation, with and without each event. Odds ratios were then calculated with a 95% confidence interval. For continuous data, weighted mean difference (WMD) was calculated with a 95% confidence interval. Random effects models were utilised for all forest plots.

Results

There were 13 eligible studies (Table 2). Eight studies were retrospective cohort studies (Baer et al., 2019; Ferris et al., 2020; Goubar et al., 2021; Heiden et al., 2021; Kenyon-Smith et al., 2019; Sheehan et al., 2021; T., 2019; Warren et al., 2019). Four studies were prospective (A. et al., 2009; L.B. et al., 2006; S. & Vasireddy A. AO - Vasireddy, 2021; Xiang et al., 2021). One was an RCT, whilst the others were cohort studies. One study was cross sectional (Su et al., 2018). Out of the studies included, one was considered to be level one evidence (i.e. RCT) (L.B. et al., 2006), ten were level two evidence (A. et al., 2009; Baer et al., 2019; Ferris et al., 2020; Goubar et al., 2021; Heiden et al., 2021; Kenyon-Smith et al., 2019; S. & Vasireddy A. AO - Vasireddy, 2021; Sheehan et al., 2021; T., 2019; Warren et al., 2019; Xiang et al., 2021) (i.e. cohort studies and non-randomised trials) and one was level three evidence (Goubar et al., 2021; Su et al., 2018) (i.e. case control and cross sectional studies). Three studies were rated to have high risk of bias (L.B. et al., 2006; S. & Vasireddy A. AO - Vasireddy, 2021; T., 2019), with ten rated to have low risk of bias (A. et al., 2009; Baer et al., 2019; Ferris et al., 2020; Goubar et al., 2021; Heiden et al., 2021; Kenyon-Smith et al., 2019; Sheehan et al., 2021; Su et al., 2018; Warren et al., 2019; Xiang et al., 2021). A total of 297,435 patients across thirteen studies were included, of which 235,275 (79.1%) mobilised early and 62,160 (20.9%) mobilised "late". There were 223,559 female patients (75.16%).

Most studies included all types of hip fractures: intracapsular, intertrochanteric and subtrochanteric fractures (A. et al., 2009; Goubar et al., 2021; Heiden et al., 2021; Sheehan et al., 2021; Su et al., 2018; Warren et al., 2019). Some included only intracapsular and intertrochanteric fractures (Baer et al., 2019; S. & Vasireddy A. AO - Vasireddy, 2021; T., 2019). Two studies were limited to intracapsular fractures (Ferris et al., 2020; L.B. et al., 2006). One study only included unstable intertrochanteric fractures (Xiang et al., 2021). One did not classify the type of hip fractures (Kenyon-Smith et al., 2019).

Definitions of early and delayed mobilisation differed amongst studies. All but five studies defined early mobilisation as being within 48 hours, one within 36 hours (Heiden et al., 2021) and four defining it as within 24 hours (Baer et al., 2019; Kenyon-Smith et al., 2019; S. & Vasireddy A. AO - Vasireddy, 2021; T., 2019) of surgery. Thus, there was less consensus on the definition of delayed mobilisation. Most specified this as ambulation after 48 hours, however one specified this to be as late as seven days after surgery (Xiang et al., 2021).

Though most studies classified patient groups as either early or delayed mobilisation, only one study further sub categorised early mobilising patients into true early ambulation and failed early ambulation (L.B. et al., 2006). They found outcomes were better in patients who managed true early ambulation (L.B. et al., 2006). However, results were comparable in patients who failed early ambulation to those who were delayed in mobilisation (L.B. et al., 2006).

The most common outcome assessed was 30 day mortality, with six papers reporting on this outcome (Baer et al., 2019; Goubar et al., 2021; Heiden et al., 2021; Sheehan et al., 2021; T., 2019; Warren et al., 2019). Six papers reported LOS (A. et al., 2009; Baer et al., 2019; L.B. et al., 2006; S. & Vasireddy A. AO - Vasireddy, 2021; T., 2019; Xiang et al., 2021). Two studies utilised the Barthel Index score for assessing activities of daily living (Baer et al., 2019; Xiang et al., 2021). Two further studies reported the 30-day complication rates (Baer et al., 2019; Warren et al., 2019). The remaining outcomes such as 30- day readmission or 1 year mortality was measured by single studies. Table 3 shows the conclusions of outcomes assessed by the studies included in the systematic review. Sheehan et al. (2021) specifically investigated rates of discharge according to mobilisation (Sheehan et al., 2021). They found that there was a two-fold rate increase in discharge rates if mobilisation was commenced within 36 hours of surgery (Sheehan et al., 2021).

Factors influencing early mobilisation

Sheehan et al., (2021) found that there were pre fracture patient characteristics which influenced early mobilisation. These include admission from home, ability to walk outdoors, and patients without delirium (Sheehan et al., 2021). Presence of these factors favoured early mobilisation (Sheehan et al., 2021).

The type of healthcare professional (nursing staff vs physiotherapists) who facilitates early mobilisation did not appear to affect outcomes. Su et al., (2018) revealed that benefits conferred from early mobilisation were comparable to patients who were mobilised by nursing staff to those mobilised by physiotherapists (Su et al., 2018). They did not however investigate the efficacy of mobilisation between healthcare professional groups. Furthermore, They acknowledged that these results could be reflective of the fact that physiotherapists could be working with patients with greater morbidity and frailty (Su et al., 2018).

Pooled analyses

Meta-analysis of six studies that assessed 30-day mortality rates found the pooled odds ratio was 0.35 [95% confidence intervals (CI) 0.31 to 0.41], suggesting a statistically significant reduction in 30-day mortality rates following early mobilisation ($Z = 13.68$, $p < 0.00001$; Figure 2). Of the five studies that assessed LOS, the pooled weight mean difference was -0.57 [95% CI -1.89 to 0.74], suggesting no statistically significant difference in LOS in hospital between patient groups ($Z = 0.86$, $p = 0.39$; Figure 3). For the two studies that reported on the 30-day complication rates., the pooled odds ratio was 0.43 [95% CI 0.35 to 0.51], suggesting a statistically significantly reduction in 30-day complication rates following early mobilisation ($Z = 9.66$, $p < 0.00001$; Figure 4).

Discussion

This large systematic review with pooled meta-analysis has demonstrated that early mobilisation following hip fracture surgery was associated with significantly lower 30-day mortality and complication rates. There was no relationship observed with LOS. The findings of this review support standards and guidance advocating early mobilisation following surgery, though direct trial evidence is lacking. Furthermore, most studies did not explore the reasons underlying the reasons for delayed mobilisation.

Though studies grouped patient groups as either early or delayed mobilisation, only one further analysed whether patients in the early mobilising group managed to mobilised or failed to do so (L.B. et al., 2006). They found that benefits were observed only if true early ambulation was achieved (L.B. et al., 2006). Patient and healthcare resource associated factors associated with a failure to ambulate early should be sought in future studies so that these can be appropriately addressed moving forward.

Pain is one element that could limit early mobilisation following hip fracture surgery. Baer et al. (2019) found that pain after intramedullary nailing was greater than after hip arthroplasty (Baer et al., 2019). These results have been replicated in international studies (Foss et al., 2009; Kristensen, 2013). Baer et al. (2019) however, did not find any limitations to early mobilisation that could be attributed to pain (Baer et al., 2019). Moreover, they found that patients engaging in early mobilisation did not suffer additional pain. They theorised that their orthogeriatric and intensive physiotherapy regimen, coupled with effective pain control, allowed for early mobilisation to be achieved with little deficit to post operative outcomes, regardless of procedure (Baer et al., 2019).

Despite all included studies identifying that early mobilisation is associated with better outcomes, no study tried to quantify this effect. Each study differed in their definition of early mobilisation, varying from the day after surgery to within 48 hours post-surgery. We recommend a standardised definition of “early mobilisation” as ambulation within 36 hours of surgery. Whereas “very early ambulation” could be used for studies which endeavour to mobilise within 24 hours of surgery. Consequently, we would suggest that delayed mobilisation could be defined as mobilisation after 36 hours of surgery. We also recommend not defining early mobilisation based on units of post operative days, but instead use hours after surgery for more accurate assessment. Few studies specifically define what “mobilisation” is. Protocols vary, and there is no standard definition (Tazreean et al., 2022), but ERAS pathways often include specific targets for the total amount of time spent out of bed, the total distance walked, or the frequency of periods of walking. Research in this areas would benefit from standardised definitions of these key factors.

Within the umbrella term of hip fractures, surgery varies considerably for each fracture, ranging from hemiarthroplasty to dynamic hip screws and intramedullary nailing. As such, the type of surgery could hugely impact on the ability to mobilise and could affect post operative outcomes. Warren et al., (2019) stratified data according to the type of surgery conducted (Warren et al., 2019). They found that early mobilisation on the day after surgery across all types of hip fracture surgeries resulted in a greater chance of discharge to home (Warren et al., 2019). They also found that early mobilisation reduced LOS in hospital and major/minor complications following sliding hip screw and intramedullary nailing, but was not observed following hemiarthroplasty (Warren et al., 2019). Early mobilisation also reduced 30-day mortality in the intramedullary nail group (Warren et al., 2019). Therefore, the greatest benefits would seem to be conferred to those patients who underwent nailing for hip fractures. This could be likely explained by the fact that patients who under surgery with nailing, over fixed angled devices such as a dynamic hip screw, regain their mobility earlier (Parker, 2017). As such they would be associated with better outcomes. Xiang et al., (2021), also examined patients who underwent intramedullary nailing. However, this was limited to patients with unstable intertrochanteric fractures (Xiang et al., 2021). They found that despite having more severe fractures, the early mobilisation patient group regained better functional status at both 6 and 12 weeks post operatively (Xiang et al., 2021).

Outside the studies included in this analysis, some literature has discussed barriers to early mobilisation. A national audit conducted by the NHFD and the Chartered Society of Physiotherapy (CSP) called Hip Sprint investigated recovery after hip fractures in acute wards, rehabilitation wards and at home (Physicians & Programme, 2018). As part of this evaluation, they explored barriers to early mobilisation (Physicians & Programme, 2018). They found that alongside pain, hypotension and delirium were the commonest barriers (Physicians & Programme, 2018). Another obstruction noted was patient refusal to mobilise so soon after surgery (Physicians & Programme, 2018). The researchers also noted that the likelihood to mobilise early on weekends was far less compared to that during the week (Physicians & Programme, 2018). They hypothesised this was due to poorer staffing levels on the weekend (Physicians & Programme, 2018). Other post-operative factors such as nausea, drowsiness and light-headedness also affect the ability mobilise further (Gautreau et al., 2020; Warwick et al., 2019). These can be better managed with appropriate medication prescriptions and blood pressure monitoring.

The literature has previously suggested that early ambulation could benefit both pain and delirium rates (Kenyon-Smith et al., 2019)(Dubljanin-Raspopovic et al., 2013). Paradoxically, both pain and delirium hamper early mobilisation attempts. Improvements in pain management and delirium could facilitate early mobilisation, which could in turn reduce post-operative pain and delirium rates.

In addition to post-operative factors such as pain, peri-operative factors also play a role in improving early mobilisation. General anaesthesia, compared to spinal anaesthesia, impairs patient ability to mobilise on the day of surgery and this is an important factor to consider with all ERAS protocols (Gautreau et al., 2020; Warwick et al., 2019). If appropriate, more patients should receive spinal anaesthesia to provide a more conducive environment to early mobilisation.

A review conducted by Sarkies et al., found other peri-operative factors which could further influence early mobilisation (Sarkies et al., 2023). They identified that use of peripheral nerve blocks and TENS analgesia therapies could reduce reliance to opioids and thus reduce side effects such as confusion, nausea, and haemodynamic instability (Sarkies et al., 2023). Furthermore, liaison with orthogeriatric services optimises management of co-morbidities and thus optimises medically stability, reducing complications (Sarkies et al., 2023). They also highlighted that delayus in hip fracture surgery leads to poorer outcomes (Sarkies et al., 2023). Many patients wait more than 48 hours for hip fracture surgery, due to strains on the health care system (Sarkies et al., 2023). They advised that pre-operative mobilisation in this period could reduce rates of pneumonia, and delirium (Sarkies et al., 2023). Future studies should specifically examine pre-fracture and peri-operative factors such as hypotension, peripheral nerve blocks, pre-operative mobilisation, and multidisciplinary rehabilitation to determine their role in facilitating early mobilisation.

There were limitations found across several studies included within this review. One limitation was the short follow up, with most studies assessing outcomes at 30-day follow up, post operation. As a result, the authors were unable to elucidate long term trends in mortality and complications beyond this. Thus, future studies should endeavour to pursue longer follow up time periods. In addition to this, there was little consensus in post operative outcomes investigated. Less than half of the studies included in this meta-analysis explored 30-day mortality, with even less studies looking at the other outcomes meta-analysed. Despite the literature suggesting early mobilisation could benefit post-operative pain and delirium rates, very few studies in this review investigated delirium rates (Sheehan et al., 2021) and post operative pain specifically (Baer et al., 2019; T., 2019). Future studies should endeavour to include these outcomes to allow for more thorough pooled analyses. No study stratified data according to the day when patients first mobilised and the effect of day of surgery mobilisation was not possible to assess. Optimisation of post operative care in hip fracture patients, combined with spinal anaesthesia over general anaesthesia, could provide a more robust environment to facilitate day of surgery mobilisation. Some studies have highlighted that pain was a common barrier to early mobilisation (Aprato et al., 2020; Goubar et al., 2021; Xiang et al., 2021). No study included in this review, however, had specifically tackled post operative pain in a standardised way. Guay & Kopp (2020) conducted a Cochrane systematic review found peripheral nerve blocks improved pain after 30 minutes of administration and reduced the risk of delirium (Guay & Kopp, 2020). However, there are few studies examining standardised methods to manage post operative pain. Finally, only one study with level one evidence in the form of a prospective RCT was found. The remaining studies were all either level 2 or 3 evidence. This demonstrates a gap in the literature regarding direct causal evidence RCTs.

Conclusion

Early mobilisation in hip fracture patients is associated with a reduction in 30-day mortality and complication rates compared to delayed mobilisation. This review has suggested definitions for early and delayed mobilisation to better standardise this in future studies. More RCTs are required in this area before robust guidelines can be implemented. Research should endeavour to further elucidate pre-fracture and peri-operative factors influencing early mobilisation. Studies should also endeavour to elucidate whether day 0 mobilisation provides better outcomes for these patients compared to day 1 and delayed mobilisation.

Statements and declarations

The Authors declare that there are no competing interests.

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Table 1: Critical appraisal of the papers including in this systematic review, using the CASP checklist for cohort studies. Questions 7,8 and 12 were left out of the table due to the fact they are not yes/no questions. (n = 13)

Author (year)	Question 1	Question 2	Question 3	Question 4	Question 5a	Question 5b	Question 6a	Question 6b	Question 9	Question 10	Question 11
Goubar et al (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Sheehan et al (2021)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Xiang et al (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kuru and Olcar (2020)	Yes	Yes	No	No	No	No	Yes	No	Can’t tell	Yes	Yes
Warren et al (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Su et al (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Oldmeadow et al (2006)	Yes	Yes	Yes	Yes	No	No	Yes	No	Can’t tell	Yes	Yes

Barone et al (2009)	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes
Ferris et al (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Heiden et al (2020)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baer et al (2019)	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Kenyon-Smith et al (2019)	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Tan & Vasireddy (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

Table 2:- Characteristics of individual studies included (n = 13)

Author, (year)	Study design	Number of patients (early mobilisation, late intervention)	Number of female patients (number of male patients)	Average age of patients	Type of fracture included	Definition of early mobilisation	Definition of delayed mobilisation	Follow up duration	Outcomes measured
Goubar et al (2021)	Retrospective cohort study	126,897 (99,667, 27,230)	91,962 (34,933)	84 (77 to 89)	Intracapsular, intertrochanteric, subtrochanteric	Day of or day after surgery	More than one day after surgery	30 days	30-day survival 30-day ambulation recovery
Sheehan et al (2021)	Retrospective cohort study	133,319 (106,722, 26,597)	97,001 (36,316)	84 (77 to 89)	Intracapsular, intertrochanteric, subtrochanteric	Day of or day after surgery	More than one day after surgery	30 days	Time to discharge in patients with and without dementia. Timing of mobilisation in patients with and without dementia.

									Time to discharge in patients with and without delirium. Timing of mobilisation in patients with and without delirium. Time to discharge in patients with and without hypotension. Timing of mobilisation in patients with and without hypotension.
Xiang et al (2021)	Prospective cohort study	284 (148, 136)	198 (86)	80.7 (+/- 7.6)	Unstable intertrochanteric (AO/OTA 31-A2 or 31-A3)	Within 48 hours after surgery	Seven days after surgery	4 months	Modified Barthel Index immediately post operatively, at 6 and 12 weeks post operatively

									EuroQol-5D immediately post operatively and at 12 weeks Length of stay
Kuru and Olcar (2020)	Retrospective cohort study	52 (23, 29)	36 (16)	82.9 (+/- 6.5)	Intracapsular Intertrochanteric	Within 24 hours of surgery	After 24 hours	30 days	Harris score Pain score Length of stay
Warren et al (2019)	Retrospective cohort study	7947 (5845, 2102)	5,942 (2,005)	76.1 (+/- 20.1) for early mobilising cephalomedullary nail group. 77.8 (+/- 18.8) for delayed mobilising cephalomedullary nail group.	Intracapsular, intertrochanteric, subtrochanteric	Day after surgery	More than one day after surgery	30 days	30-day mortality 30-day complications 30-day readmission Length of stay Non home discharge disposition

				75.5 (+/- 20.8) for early mobilising sliding hip screw group. 77.0 (+/- 18.7) for delayed mobilising sliding hip screw group. 76.8 (+/- 18.9) for early mobilising hemiarthroplasty group 76.7 (+/- 18.5) for delayed mobilising hemiarthroplasty group.					

Su et al (2018)	Cross sectional study	17, 203 (13,871, 3332)	16,812 (6,228)	N/A	Intracapsular, intertrochanteric, subtrochanteric	Day of or day after surgery	More than one day after surgery	30 days	30-day mobility score
Oldmeadow et al (2006)	Prospective randomised controlled trial	60 (29, 31)	41 (19)	78.8 (+/- 2.14) for early mobilisation group. 80.0 (+/- 2.08) for delayed mobilisation group	Intracapsular	Within 48 hours of surgery	After 48 hours of surgery	In patient duration	7 day functional level with modified Iowa level of assistance scale
Barone et al (2009)	Prospective cohort study	469 (366, 103)	363 (106)	84.6 (+/- 7.0)	Intracapsular, intertrochanteric, subtrochanteric	Within 48 hours of surgery	After 48 hours of surgery	In patient duration	Length of stay Barthel Index Katz Index CIRS – CI CIRS – SI Discharge directly to home

Ferris et al (2021)	Retrospective cohort study	10,412 (8,170, 2,242)	10,807 (4,796)	79 (+/- 10.5) for females, 75 (+/- 13.5) for males	Intracapsular	Day of or day after surgery	Beyond day 1 post operation	In patient duration	Inpatient mortality
Heiden et al (2020)	Retrospective cohort study	218 (150, 68)	N/A	81.6	Intracapsular, intertrochanteric, subtrochanteric	Within 3 days after surgery	After 3 days of surgery	1 year	Modifed 5 factor frailty index 30-day mortality 1 year mortality
Baer et al (2019)	Retrospective cohort study	219 (132, 87)	149 (70)	83 (+/- 7.1)	Intracapsular, intertrochanteric	Within 24 hours of surgery	After 24 hours of surgery	N/A	In patient mortality Overall complications Inpatient pain Hip mobility Ability to walk Length of stay Merle d'Aubigné score
Kenyon-Smith et al (2019)	Retrospective cohort study	240 (97, 143)	165 (75)	82	N/A	Within 24 hours	After 24 hours of surgery	N/A	In patient mortality rates

						of surgery			
Tan & Vasireddy (2021)	Prospective cohort study	115 (55, 60)	83 (32)	80.9 (7.7)	Intracapsular, intertrochanteric	Within 24 hours of surgery	After 24 hours of surgery	N/A	Independent ambulation rates after surgery Length of stay

AO/OTA = Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association, CIRS - CI = Cumulative Illness Rating Scale – Cumulative index, CIRS – SI = Cumulative Illness Rating Scale – Severity index, N/A = Not available

Table 3:- Clinical outcomes (n = 13)

Author, (year)	Outcome conclusions
Goubar et al (2021)	119,939 (94%) of patients survived 30 days after admission. 26,111 with dementia (72%) and 69,150 without dementia (81%) mobilised early 33,308 (92%) patients with dementia and 81,755 (96%) patients without dementia survived to 30 days post admission Out of all the patients who could walk outdoors pre fracture, 20,820 patients (85%) mobilised early and 2,275 patients (9%) recovered their pre fracture ability to walk by 30 days post admission A total of 3,279 patients (39%) with dementia and 4,785 (23%) without dementia recovered their pre fracture ability to walk by 30 days post admission.
Sheehan et al (2021)	Out of the 114,695 patients with complete data, 34,253 (30%) patients presented with dementia, and 80,442 (70%) patients presented without dementia. 24,810 (72.4%) patients with dementia mobilised early, and 65,742 (81.7%) of patients without dementia mobilised early. The average rate of discharge per 1000 patient days was 47.0 (95% CI 46.5-47.4) amongst patients who mobilised early without dementia. The average rate of discharge per 1000 patient days was 34.0 (95% CI 33.4-34.6) amongst patients who mobilised early with dementia. The average rate of discharge per 1000 patient days was 26.2 (95% CI 25.5-26.9) amongst patients who mobilised late without dementia. The average rate of discharge per 1000 patient days was 26.8 (95% CI 26.0-27.6) amongst patients who mobilised late with dementia. By 30 days post operatively, odds ratios of hospital discharge amongst those who mobilised early vs those who mobilised late in patients without dementia was 2.28 (95% CI 2.17-2.39). By 30 days post operatively, odds ratios of hospital discharge amongst those who mobilised early vs those who mobilised late in patients with dementia was 1.83 (95% CI 1.70-1.97). For patients who mobilised early without delirium, the average rate of discharge per 1000 patient days was 44.7 (95% CI 44.2–45.1), whilst the average rate of discharge for patients who mobilised early in patients with delirium was 26.0 (95% CI 25.1–26.9). Rate of discharge was 27.5 (95% CI 27.0–28.1) among those who mobilised late without delirium, and 19.0 (95% CI 17.8–20.3) among those who mobilised late with delirium. For those with and without delirium there were an additional 190 (95% CI

	180–199) and 143 (95% CI 116–169) discharges per 1000 surgeries respectively among patients who mobilised early when compared to those mobilised late. By 30-days postoperatively, the adjusted odds ratios of discharge among those who mobilised early when compared with those who mobilised late were 2.16 (95% CI 2.07–2.26) for those without delirium and 1.84 (95% CI 1.59–2.13) for those with delirium. For patients who mobilised early without hypotension, the average rate of discharge per 1000 patient days was 43.9 (95% CI 43.5–44.3), and was 31.5 (95% CI 30.5–32.6) among those mobilised early with hypotension. It was 27.4 (95% CI 26.8–27.9) among patients who mobilised late without hypotension, and 19.9 (95% CI 18.7–21.2) among those who mobilised late with hypotension. For those with and without hypotension there were an additional 213 (95% CI 187–240) and 183 (95% CI 174–193) discharges per 1000 surgeries respectively, among patients who mobilised early when compared to those mobilised late. By 30-days postoperatively, the adjusted odds ratios of discharge among those who mobilised early when compared with those who mobilised late were 2.12 (95% CI, 2.03–2.22) for those without hypotension and 2.11 (95% CI, 1.85–2.42) for those with hypotension. For patients who mobilised early and were admitted from home, the average rate of discharge per 1000 patient days was 41.6 (95% CI 41.2–42), and was 54.2 (95% CI 53.2–55.2) among those mobilised early and admitted from residential care. It was 22.1 (95% CI 21.6–22.6) among those who mobilised late and admitted from home, and 42.7 (95% CI 41.4–43.9) among those who mobilised late and admitted from residential care. For those who were admitted from home and admitted from residential care, there were an additional 234 (95% CI 224–244) and 103 (95% CI 89–117) discharges per 1000 surgeries respectively among patients who mobilised early when compared to those mobilised late. By 30-days postoperatively, the adjusted odds ratios of discharge among those who mobilised early when compared with those who mobilised late were 2.30 (95% CI 2.19–2.41) among those admitted from home and 1.64 (95% CI 1.51–1.77) among those admitted from residential care. The adjusted odds ratios of discharge among those who mobilised early when compared to those who mobilised late were 2.38 (95% CI 2.26–2.50) for those with outdoor ambulation pre fracture admitted from home, 2.02 (95% CI 1.82–2.23) for those with indoor ambulation only pre fracture admitted from home. For patients with outdoor ambulation pre fracture admitted from residential care was, 1.80 (95% CI 1.65–1.96) and for those with indoor ambulation only, pre fracture admitted from residential care was1.52 (95% CI 1.35–1.72).
Xiang et al (2021)	In patients aged between 65-74, the immediate postoperative modified Barthel index was 52.5 (46.9-58.1) and 32.0 (26.3-37.7) for patients who mobilised early and late respectively. In patients aged between 75-84, the modified Barthel index was the

	immediate postoperative modified Barthel index was 50.6 (47.6-53.5) and 31.6 (28.7-34.5) for patients who mobilised early and late respectively. In patients aged 85 and greater, the modified Barthel index was the immediate postoperative modified Barthel index was 47.8 (44.1-51.4) and 28.0 (23.5-32.4) for patients who mobilised early and late respectively. In patients aged between 65-74, the 6 week post operative modified Barthel index was 87.3 (83.1-91.5) and 75.9 (71.7-80.1) for patients who mobilised early and late respectively. In patients aged between 75-84, the modified Barthel index was the immediate postoperative modified Barthel index was 81.5 (77.9-85.0) and 70.5 (66.9-74.1) for patients who mobilised early and late respectively. In patients aged 85 and greater, the modified Barthel index was the immediate postoperative modified Barthel index was 83.0 (79.0-87.0) and 56.5 (51.7-61.3) for patients who mobilised early and late respectively. In patients aged between 65-74, the 12 week post operative modified Barthel index was 94.3 (91.3-97.3) and 92.7 (89.7-95.7) for patients who mobilised early and late respectively. In patients aged between 75-84, the modified Barthel index was the immediate postoperative modified Barthel index was 81.5 (77.9-85.0) and 70.5 (66.9-74.1) for patients who mobilised early and late respectively. In patients aged 85 and greater, the modified Barthel index was the immediate postoperative modified Barthel index was 90.7 (85.8-95.6) and 71.8 (65.9-77.7) for patients who mobilised early and late respectively. In patients who mobilised early, the EQ-5D VAS was 83.0 (81.0-84.9) preinjury and was 77.2 (75.1-79.3) at 12 weeks post operation. In patients who mobilised late, the EQ-5D VAS was 80.2 (78.2-82.3) preinjury and was 74.9 (72.5-77.3) at 12 weeks post operation. In patients who mobilised early, the EQ-5D Index was 0.97 (0.95-0.99) preinjury and was 0.91 (0.90-0.93) at 12 weeks post operation. In patients who mobilised late, the ED-5D Index was 0.89 (0.87-0.92) preinjury and was 0.87 (0.85-0.89) at 12 weeks post operation.
Kuru and Olcar (2020)	The Harris score for patients who mobilised early was 84.0 (+/- 5.8), and was 71.1 (+/- 2.8) for those who mobilised late ($p < 0.001$). The Pain score for patients who mobilised early was 36.8 (+/- 6.8), and was 24.4 (+/- 6.4) for those who mobilised late ($p < 0.001$).
Warren et al (2019)	In patients who underwent cephalomedullary nailing, overall 30-day complication rates were 1552 patients (54.3%) who mobilised early, and 827 patients (70.0%) who mobilised late ($p <0.001$).

	In patients who underwent sliding hip screw, overall 30-day complication rates were 396 patients (48.1%) who mobilised early, and 199 patients (63.2%) who mobilised late (p <0.001). In patients who underwent hemiarthroplasty or internal fixation, overall 30-day complication rates were 989 patients (45.7%) who mobilised early, and 332 patients (54.9%) who mobilised late (p <0.001). In patients who underwent cephalomedullary nailing, odds ratios for overall 30-day complication rates was 0.631 (0.541-0.736) (p <0.001). In patients who underwent sliding hip screw, odds ratios for overall 30-day complication rates was 0.756 (0.599-1.021) (p = 0.068). In patients who underwent hemiarthroplasty or internal fixation, odds ratios for overall 30-day complication rates was 0.843 (0.690-1.030) (p = 0.095). In patients who underwent cephalomedullary nailing, wound infection rates was found in 94 patients (3.3%) who mobilised early, and 56 patients (4.7%) who mobilised late (p = 0.027). In patients who underwent sliding hip screw, wound infection rates was found in 24 patients (2.9%) who mobilised early, and 20 patients (6.3%) who mobilised late (p = 0.007). In patients who underwent hemiarthroplasty or internal fixation, wound infection rates was found in 72 patients (3.3%) who mobilised early, and 31 patients (5.1%) who mobilised late (p = 0.039). On multivariate analyses, weight bearing on day after surgery was associated with a significantly lower risk of non-home discharge disposition after cephalomedullary nailing, sliding hip screw, hip hemiarthroplasty and internal fixation. The odds ratio for cephalomedullary nailing was 0.661 (95% CI 0.564–0.774; p <0.001). The odds ratio for sliding hip screw was 0.621 (95% CI 0.458–0.842; p=0.002). The odds ratio for hip hemiarthroplasty and internal fixation (0.720; 95% CI 0.584–0.889; p=0.002). Early weight-bearing was found to be associated with reduced in-hospital length of stay. Statistical significance was found in patients who underwent cephalomedullary nail (B = –1.071; 95% CI −1.513 to −0.630; p<0.001) and sliding hip screw (B = −1.486; 95% CI −2.412 to −0.561; p=0.002) when mobilising early. For hemiarthroplasty and internal fixation patients, no statistically significant relationship was found between early mobilisation and length of stay (B = −0.476; 95% CI −1.006 to 0.055; p=0.079).
Su et al (2018)	Odds ratios from univariate analysis comparing early mobilisation with late mobilisation with assistance from physiotherapy was 0.438 (0.415-0.463) (p <0.001).

	Odds ratios from multivariate analysis comparing early mobilisation with late mobilisation with assistance from physiotherapy was 0.541 (0.511-0.573) (p <0.001). Odds ratios from univariate analysis comparing early mobilisation with late mobilisation without assistance from physiotherapy was 0.354 (0.304-0.413) (p <0.001). Odds ratios from multivariate analysis comparing early mobilisation with late mobilisation without assistance from physiotherapy was 0.472 (0.403-0.553) (p <0.001).
Oldmeadow et al (2006)	At 7 days, the mean walking distance was 82.55 (0.5-400) in patients who managed true early ambulation (p = 0.008). In patients who admitted early mobilisation but failed, distance was 34.70 (5-103) (p = 0.03). In patients who underwent delayed mobilisation, distance at 7 days was 29.71 (0-150) (p = 0.15). Length of stay was 9.27 (4-33) in the true early ambulation group, 17.9 (5-33) in the failed early ambulation group, and 11.39 (5-24) in the delayed ambulation group (p = 0.003).
Barone et al (2009)	In hospital stay was 15.0 (+/- 8.1) days in the early mobilising group, and 17.2 (+/- 14.6) days in the delayed mobilising group (p = 0.23). Barthel index was 76 (+/- 30) in the early mobilising group, and was 64 (+/- 34) days in the delayed mobilising group (p < 0.001). Katz index was 4.7 (+/- 2.6) in the early mobilising group, and was 3.8 (+/- 2.7) days in the delayed mobilising group (p < 0.001). CIRS-CI was 3.5 (+/- 1.9) in the early mobilising group, and was 3.9 (+/- 2.1) days in the delayed mobilising group (p = 0.17). CIRS-SI was 1.7 (+/- 0.4) in the early mobilising group, and was 1.8 (+/- 0.4) days in the delayed mobilising group (p = 0.04). Discharge directly to home was 27.3% in the early weight bearing group, and was 17.5% in the delayed mobilisation group (p = 0.04).
Ferris et al (2021)	Patients who did not mobilise on the day of/after surgery were 46% more likely to die in-hospital than those patients who were mobilised early – odds ratio 1.46 (95% CI 1.25-1.70, p<0.001).
Heiden et al (2020)	Patients who did not mobilise within the first 3 days had significantly increased mortality at 30 days (odds ratio [OR] 4.42, P = 0.010, 95% confidence intervals [CIs] 1.42 to 13.75) and 1 year (OR 2.26, P = 0.022, 95% CI 1.12 to 4.53). After multivariable logistic regression they found that ambulation status remained strongly associated with 30-day (OR 3.87, P = 0.024) but not 1-year mortality (OR 1.66, P = 0.176).

(Baer et al., 2019)	Patients treated with total hip replacement had a better ability to walk than patients with an intramedullary nail or partial hip replacement ($p < 0.001$ and $p = 0.002$). The overall Merle d'Aubigné score at discharge was 10 ± 1.9. In bivariate analysis, patients with a) femoral neck fracture or b) with a total hip replacement were associated with a better) Merle d'Aubigné score ($p < 0.001$ and $p = 0.013$). In multivariate analysis, femoral neck fracture was a signif The overall length of stay was 9.8 ± 5.1 days. There were four factors which increased length of stay - female gender ($p = 0.015$), partial weight bearing rather than full weight bearing ($p = 0.021$), femoral neck fractures ($p = 0.027$), and treatment with total or partial hip replacements ($p = 0.038$). In multivariate analysis, gender was the only significant predictor for length of stay . In bivariate analysis, time until first mobilization was associated with increased mortality ($p < 0.001$). Complications The overall complications rate, including death, was 39.7%. Gender, ASA, and time between operation and first mobilization were associated with in-hospital complications ($p = 0.033$, $p < 0.001$, and $p = 0.023$). The level of pain in patients with intramedullary nail was much higher compared to patients who underwent total and partial hip replacements ($p < 0.001$ and $p = 0.004$). Pain was also higher in patients with trochanteric fractures than those with femoral neck fractures ($p < 0.001$). Patients treated with a total hip replacement were significantly better mobilized than patients after intramedullary nailing or partial hip replacement ($p < 0.001$ and $p = 0.008$). In multivariate analysis, fracture type and fracture treatment were significant: femoral neck as well as total hip replacement
Kenyon-Smith et al., 2019	Patients who mobilised early had a 36% chance of developing complications, whilst patients who did not mobilise had a 52% chance. OR = 1.9, 95% CI $p = 0.044$. Complication rate increased the longer it took to mobilise patients. There was a significant difference in time to mobilisation for complication free patients. For those who were complication free, average time to mobilise was 28.7 hours, whilst those with complications was 37.3 hours. $P = 0.001$. Delirium was the only complication which was statistically significantly reduced with early mobilisation. Those who developed post operative delirium had a greater chance of developing another post operative complication (39% vs 22%), OR ¼ 2.3, 95% CI ¼ 1.2-4.4; P ¼ .008

Tan& Vasireddy, 2021	The early mobilising group had a significantly higher proportion of patients who had their POD 1 day occurring on weekday (unadjusted odds ratio: 3.00; 95% Confidence Interval (CI) 1.27-7.08, p=0.010). At discharge, 9.6% (n = 11) of the overall cohort could ambulate independently with a walking frame or better. The early mobilising group had significantly more patients who could achieve this compared to delayed mobilising group (16.4% vs 3.3%; p = 0.018). After adjusting for possible co-variates (age, pre-morbid status, health status, type of surgery, day of the week of POD 1), POD 1 ambulation remained as a significant factor for this measure (adjusted odds ratio 9.20; 95% CI 1.50-56.45; p = 0.016). The overall cohort had a mean total length of stay of 11.5 days (median 10.0, interquartile range (IRQ) 4.0). The early mobilising group had a mean total length of stay of 11.0 days (median 10.0, IRQ 4.0) and delayed mobilisation group had a mean total length of stay of 12.1 days (median 10.5, IRQ 5.0) (p = 0.768).

CI = Confidence Interval, CIRS - CI = Cumulative Illness Rating Scale – Cumulative index, CIRS – SI = Cumulative Illness Rating Scale – Severity index, EQ-5D VAS = EuroQol 5D Visual Analogue Scale

Figure 1: Combined results of the comprehensive search

Figure 2: Forest plot showing 30-day mortality rate in patients who mobilised early, compared to those who mobilised late (CI = confidence interval, df = degrees of freedom, M-H = Mantel-Haenszel).

Figure 3: Forest plot showing length of stay in hospital in patients who mobilised early, compared to those who mobilised late (CI = confidence interval, df = degrees of freedom, IV = instrumental variable, SD = standard deviation).

Figure 4: Forest plot showing 30-day complication rates in patients who mobilised early, compared to those who mobilised late (CI = confidence interval, df = degrees of freedom, M-H = Mantel-Haenszel).