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Impact of concomitant upper-extremity injuries in patients with hip fractures: a systematic review and meta-analysis

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Abstract

Introduction Combined hip and upper-extremity fractures raise clinical concerns because upper-extremity fractures may hinder early mobilization, thereby affecting rehabilitation and mortality. This systematic review and meta-analysis aimed to evaluate the effects of combined upper-extremity and hip fractures on rehabilitation and mortality.

Materials and methods We systematically searched MEDLINE, Embase, and the Cochrane Library for studies published before March 20, 2022, that evaluated the impact of concomitant upper-extremity injuries in geriatric patients with hip fractures. The pooled analysis identified differences in the (1) length of hospital stay, (2) discharge destination, and (3) mortality rates between the isolated and combined hip fracture groups.

Results A total of 217,233 patients with isolated hip fractures ($n = 203{,}816$) and combined hip and upper-extremity fractures ($n = 13{,}417$) from 12 studies were analyzed. The average length of hospital stay was significantly longer in the combined upper-extremity fracture group than in the isolated hip fracture group (mean difference = 1.67 days; 95% confidence interval [CI] 0.63–2.70; $P = 0.002$). Patients in the combined upper limb fracture group were less likely to be discharged directly home (odds ratio [OR] = 0.64; 95% CI 0.52–0.80; $P < 0.001$) and showed significantly higher 30-day mortality (OR = 1.44; 95% CI 1.32–1.58; $P < 0.001$). The mortality rate after 30 days was not significantly different between the two groups.

Conclusions Concomitant upper-extremity fractures have debilitating effects on rehabilitation and early mortality in geriatric patients with hip fractures. Therefore, more focus should be placed on the early ambulation of patients with hip fractures and simultaneous upper limb fractures to promote rehabilitation and alleviate the public health burden.

Level of evidence III meta-analysis.

Keywords Concomitant fracture · Hip · Upper extremity · Mortality · Rehabilitation

Introduction

The growth in the global senile population has resulted in an increased incidence of geriatric hip fractures. It is estimated that there will be a 2.28-fold and 1.59-fold increase in the Asian hip fracture incidence and medical costs, respectively, by the year 2050 [1]. Patients with hip fractures are among the oldest and most fragile orthopedic patients. The overall 1-month mortality rate following hip fracture is 13.3%; the 3 to 6-month mortality, 15.8%; and the 1-year mortality, 24.5% [2]. Given the scale of this condition, optimal and cost-effective hip fracture care is critical. Standardized hip fracture care, including early mobilization and rehabilitation, is known to minimize mortality and healthcare expenditure [3, 4].

Combined hip and upper-extremity fractures are rare; however, due to the recent increase in hip fracture incidence among the global aging population, the incidence of concomitant injuries warrants attention [5–7]. Furthermore, combined fractures raise clinical concern because upper-extremity fractures may hinder early mobilization and rehabilitation, thereby affecting the hospitalization period and mortality.

To the best of our knowledge, only one cohort study comprising of a small meta-analysis was conducted on the impact of concomitant wrist injuries in geriatric patients

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with hip fractures in 2015 [8], however, this study was limited to the investigation of wrist fractures and performed a single-arm meta-analysis of only three studies. Several newly updated comparative studies have been published; however, to the best of our knowledge, no meta-analysis has directly compared the outcomes of combined hip and total upper-extremity fractures with those of isolated hip fractures in a large number of studies [9–16].

Therefore, in the current study, we aimed to evaluate the effects of combined upper-extremity and geriatric hip fractures on the length of hospital stay, discharge destination, and mortality rate in direct comparison with the effects of isolated hip fractures using double-arm meta-analyses.

Materials and methods

This study was performed in accordance with the revised assessment of multiple systematic reviews and preferred reporting items for systematic reviews and meta-analysis guidelines [17, 18].

Literature search

In accordance with the referenced guidelines, we searched MEDLINE, Embase, and Cochrane Library for studies that evaluated the impact of concomitant upper-extremity injuries in geriatric patients with hip fractures. Using an a priori search strategy, we identified articles published up to March 20, 2022. The search terms included synonyms and terms related to combined hip and upper-extremity fractures as follows: ("hip" OR "proximal fem*") AND ("fracture*") AND ("concurrent" OR "simultaneous" OR "concomitant" OR "coincident" OR "combined") AND ("upper" OR "humer*" OR "elbow" OR "wrist" OR "radi*"). We placed no restrictions on the language or publication year. After the initial electronic search, the relevant articles and their bibliographies were manually searched.

Study selection

Using titles and abstracts, two board-certified orthopedic surgeons trained in adult hip reconstruction and trauma surgery (CHK and HSK) independently selected studies for full-text review. If the data from the abstract were insufficient to make a decision regarding article inclusion, the full article was reviewed.

The inclusion criteria were as follows: (1) design type: a clinical randomized controlled trial, prospective cohort study, retrospective cohort study (RCS), or case–control study; (2) study subjects treated for hip fractures; and (3) comparison of postoperative outcomes between the isolated hip fracture and combined hip and upper-extremity fracture groups. The exclusion criteria were as follows: (1) non-original articles and (2) duplicate articles from the same investigation group.

We calculated the kappa values at each stage of the literature search to determine the inter-reviewer agreement for study selection. We correlated the agreement between reviewers based on the following kappa values: $\kappa = 1.0$, perfect agreement; $1.0 > \kappa \geq 0.8$, almost perfect agreement; $0.8 > \kappa \geq 0.6$, substantial agreement; $0.6 > \kappa \geq 0.4$, moderate agreement; $0.4 > \kappa \geq 0.2$, fair agreement; and $\kappa < 0.2$, slight agreement.

Data extraction

All extracted data were recorded independently by two investigators, and all disagreements were resolved by discussion. The following information and variables were extracted using a standardized form from the selected studies for qualitative data synthesis: (1) year and country of publication, (2) sample size, (3) age, (4) sex, (5) anatomic sites of upper limb fractures analyzed in the study, and (6) study design.

For the meta-analyses, the following outcome variables were collected: (1) length of hospital stay, (2) number of patients who were discharged home, (3) mortality within 30 days postoperatively, and (4) mortality beyond 30 days postoperatively.

Risk-of-bias assessment

We assessed the methodological quality of the included studies using the Methodological Index for Non-randomized Studies (MINORS) [19], a valid tool for assessing the quality of non-randomized studies. The maximum MINORS checklist score for the comparative studies was 24. Two independent reviewers performed the quality assessments, and any disagreements were resolved through discussion.

Data synthesis and statistical analyses

Heterogeneity in the study results was assessed using chi-squared and I^2 tests. In cases of high heterogeneity ($P \leq 0.05$, $I^2 > 50\%$), a random-effects model was used, whereas in cases of acceptable heterogeneity ($P > 0.05$, $I^2 \leq 50\%$), a fixed-effects model was used. Comparisons of dichotomous data were reported by odds ratios (ORs) and 95% confidence intervals (CIs), and continuous variables were analyzed as mean ± standard deviation and compared on the basis of mean differences (MDs). Forest plots were used to present the meta-analysis results. Statistical significance was set at $P < 0.05$. We did not perform a test for publication bias because it is recommended only when at least 10 studies are included in the meta-analysis [20]. Data analyses were performed using RevMan (Review Manager) version 5.4 (The

Cochrane Collaboration) and R (R Foundation for Statistical Computing).

Results

Study identification

The primary search yielded 1712 studies, of which 844 duplicates were excluded. Eight additional articles were identified through manual search. After careful review of the titles and abstracts, 854 articles were excluded. Full-text articles were retrieved and reviewed, resulting in the exclusion of 10 studies. Ultimately, 12 cohort studies were included (Fig. 1) [6, 8–16, 21, 22]. The inter-reviewer agreement was substantial ($\kappa = 0.704$) at the title review stage, almost perfect at the abstract review stage ($\kappa = 0.814$), and perfect at the full-text review stage ($\kappa = 1.0$).

Study characteristics

Of the 12 studies, nine were retrospective in nature [8, 10–12, 14–16, 21, 22], and the other three were prospective studies [6, 9, 13]. A total of 217,233 patients with isolated hip fractures ($n = 203{,}816$) and combined hip and upper-extremity fractures ($n = 13{,}417$) were analyzed. The mean age of both the isolated and combined hip fracture cohorts in all the studies was > 70 years. Likewise, all 12 studies in both cohorts included more female than male participants. Five studies investigated wrist or distal radius fractures [8, 9, 12, 14, 22], three included both wrist and proximal humerus fractures [13, 15, 21], and one investigated only proximal humerus fractures [10]. Three other studies included wrist

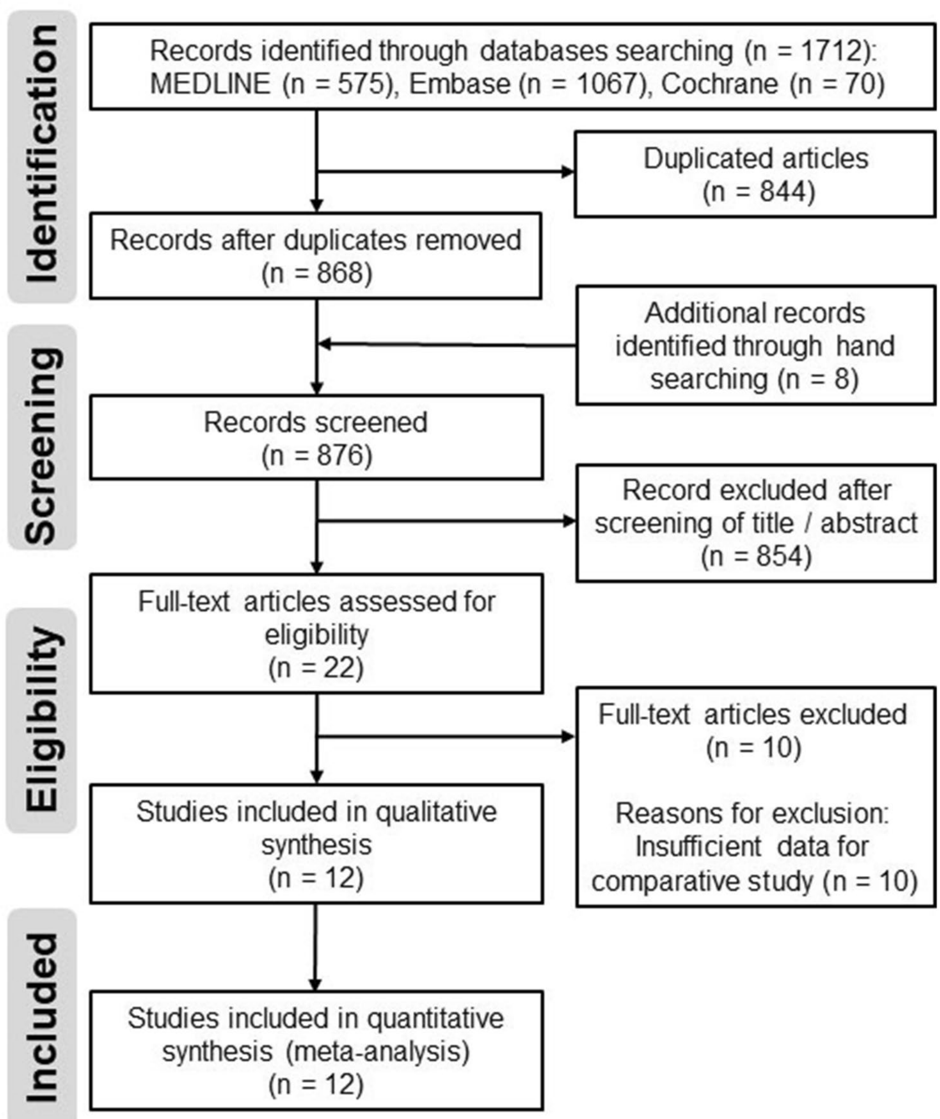


Fig. 1 The PRISMA flow diagram of study selection

and proximal humerus, as well as all other upper-extremity fractures in the shoulder, upper arm, elbow, forearm, and hand regions [6, 11, 16]. The overall incidence of concomitant upper limb fractures was 6.2%. The additional details are presented in Table 1.

Risk-of-bias assessment

The mean MINORS score for methodological quality assessment was 18.4 (range 17–20; Table 1). All 11 studies received point deductions for (1) a lack of double-blind evaluation of subject endpoints and (2) a lack of prospective sample size calculation from the eight main evaluation parameters. Nine studies [8, 10–12, 14–16, 21, 22] received point deductions owing to their retrospective design. In the "baseline equivalence of the group" domain, one point was deducted in one study [8] while another study [10] scored zero for the absence of baseline characteristic analysis.

Quantitative data synthesis (meta-analysis)

Length of hospital stay

Eleven studies were included to compare the average length of hospital stay between the isolated and combined fracture groups [6, 9–16, 21, 22]. The results of the heterogeneity analysis showed high heterogeneity among the studies ($P<0.001$, $I^2=78\%$). The details are shown in Fig. 2A (MD = 1.67; 95% CI 0.63–2.70; $P=0.002$). The mean length of hospital stay was significantly longer in the combined upper limb fracture group than in the isolated hip fracture group.

Discharge destination

Four studies [10, 13, 14, 16] reported the discharge destination. The meta-analysis revealed that patients in the combined upper limb fracture group were less likely to be discharged directly home (OR = 0.64; 95% CI 0.52–0.80; $P<0.001$; $I^2=53\%$) than those in the isolated hip fracture group. The results are shown in Fig. 3.

Mortality

Nine studies [6, 8–10, 13–16, 22] assessed the 30-day mortality associated with isolated hip fractures in comparison with that associated with the combined upper limb fracture groups. The pooled estimate revealed significantly higher 30-day mortality in the combined upper limb fracture group (OR = 1.44; 95% CI 1.32–1.58; $P<0.001$), with moderate heterogeneity (P = 0.05; $I^2=49\%$; Fig. 4A).

Six studies [6, 8–10, 13, 15] reported a mortality rate of > 30 days; no significant differences were found between the isolated hip fracture and combined upper limb fracture groups (OR, 0.93; 95% CI 0.78–1.11; $P=0.43$; $I^2=24\%$), as shown in Fig. 4B.

Discussion

The principal findings of this pooled analysis were that compared with the patients in the isolated hip fracture group, those in the combined hip and upper-extremity fracture group (1) required a longer average length of hospital stay, (2) were less likely to be discharged directly home, and (3) had higher 30-day mortality.

In this meta-analysis, the mean length of hospital stay was significantly longer in the combined upper-extremity and hip fracture group. Although two studies [9, 14] concluded that there were no significant differences between the two groups, the other included studies favored longer hospital stays for the combined fracture groups. Although conflicts may exist owing to differences in healthcare systems among countries, the facts that the results varied between the two groups from the same country [14, 15] and that the other studies were from various other countries support our findings. The average length of hospital stay is an important indicator of healthcare expenditure, clinical efficiency, and outcomes [23] and increased hospital stay among patients with simultaneous hip and upper limb fractures indicates that this subset of geriatric patients with hip fractures requires more rigorous acute management in an inpatient facility, which inevitably incurs a higher financial cost.

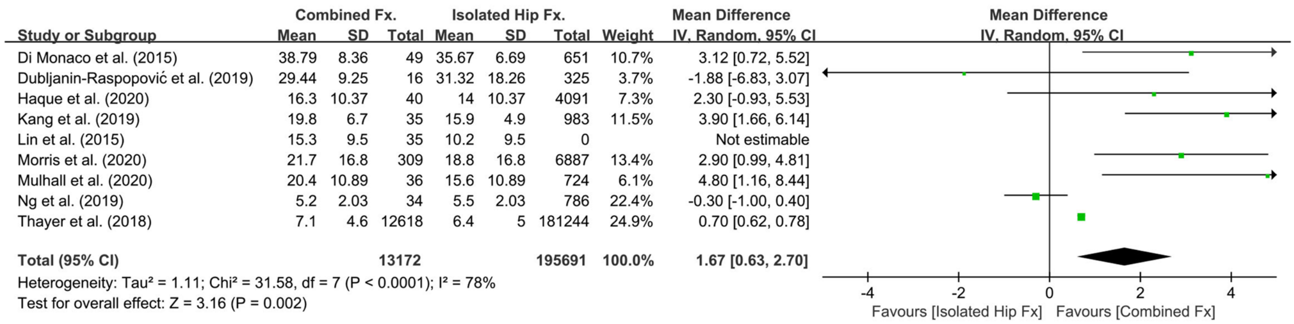
According to our meta-analysis, patients with geriatric hip fractures and concomitant upper limb fractures are at a higher risk of discharge to postoperative rehabilitation facilities. To the best of our knowledge, this is the first meta-analysis evaluating this parameter. Early ambulation within 48 h of a hip fracture surgery is critical for functional rehabilitation and is correlated with less discharge to rehabilitation facilities [24–26]. As hip fracture patients require walking aids to facilitate early postoperative ambulation, concomitant injuries to the upper limb result in a debilitating effect on mobilization and rehabilitation. In a matched pair study, Tow et al. demonstrated that a smaller number of patients with combined wrist fractures were able to ambulate at discharge (12 vs. 21, $P=0.049$) [27]. Ng et al. also indicated that concurrent upper limb fractures require longer rehabilitation after discharge to rehabilitation facilities (mean: 34.6 versus 19.9 days, $P=0.009$) [14]. Extended hospitalization is also indicative of an increased burden on healthcare resources. Therefore, more focus should be placed on the early ambulation of patients with hip fractures with simultaneous upper limb fractures to facilitate better outcomes and decrease both the length of hospital stay and the need for assistance with rehabilitation in care facilities.

Table 1 Characteristics of the included studies

Study (Year)	Year	Country	Study design	Age		Sex (F:M)		Sample size		Injured site	MINORS
				Isolated	Combined	Isolated	Combined	Isolated	Combined		
Di Monaco et al. [21]	2015	Italy	RCS	80.3	(DR) 79.1 (PH) 82.0	9:1	(DR) 32.3:1 (PH) 13.3:1	651	(DR) 34 (PH) 15	PH, DR	19
Dubljanin-Raspopović et al. [9]	2019	Serbia	PCS	78.17	78.05	3.9:1	7:1	325	16	DR	20
Haque et al. [10]	2020	UK	RCS	80.9	80.3	2.4:1	3.4:1	4091	40	PH	17
Kang et al. [11]	2019	ROK	RCS	79.3	75.9	1.7:1	2.1:1	983	35	PH, DR, Others[a]	19
Lin et al. [12]	2015	Taiwan	RCS	81.3	77.6	2.5:1	6:1	2765	35	DR	19
Morris et al. [13]	2020	UK	PCS	82.7	DR) 81.4 PH) 82.0	2.7:1	DR) 8.5:1 PH) 5.6:1	6887	DR) 172 PH) 95	PH, DR	20
Mulhall et al. [22]	2002	Ireland	RCS	77.3	83.9	2.4:1	8:1	724	36	DR	19
Ng et al. [14]	2019	Australia	RCS	81.8	82.9	2.7:1	2.8:1	786	34	DR	19
Robinson et al. [6]	2012	UK	PCS	82.3	W) 82.7 PH) 79.8	3.5:1	W) 5.8:1 PH) 4.3:1	1898	W) 34 PH) 21	PH, DR, Others[a]	20
Siaw et al. [15]	2017	Australia	RCS	84	W) 83 PH) 84	3:1	W) 6:1 PH) 5:1	2690	144	PH, DR	19
Thayer et al. [16]	2018	US	RCS	80	80	2.3:1	3.5:1	181,244	12,618	PH, DR, Others[a]	19
Uzoigwe et al. [8]	2015	UK	RCS	80	79	9:1	4:1	772	88	DR	18

F female, *M* male, *DR* distal radius, *PH* proximal humerus, *UK* United Kingdom, *ROK* Republic of Korea, *US* United States, *RCS* retrospective cohort study, *PCS* prospective cohort study

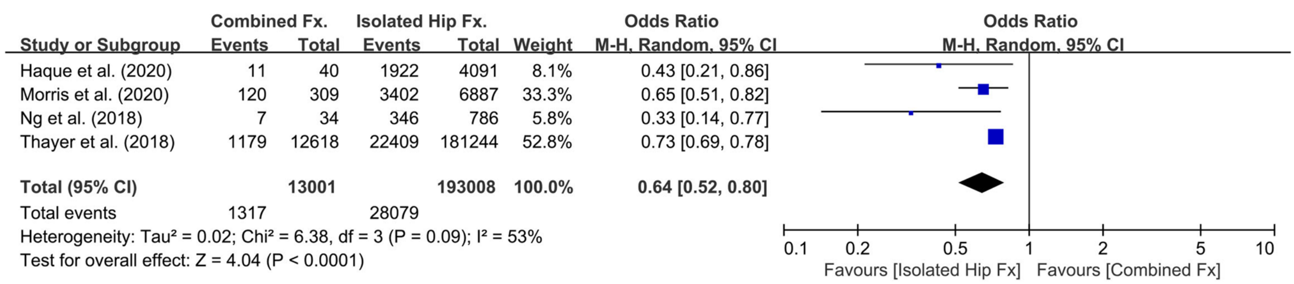
[a]Other upper limb fracture sites in the shoulder, upper arm, elbow, forearm, and hand regions, including clavicle, humeral shaft, distal humerus, olecranon, forearm shaft, carpal, and phalanx fractures



Study or Subgroup	Combined Fx. Mean	SD	Total	Isolated Hip Fx. Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Di Monaco et al. (2015)	38.79	8.36	49	35.67	6.69	651	10.7%	3.12 [0.72, 5.52]
Dubljanin-Raspopović et al. (2019)	29.44	9.25	16	31.32	18.26	325	3.7%	-1.88 [-6.83, 3.07]
Haque et al. (2020)	16.3	10.37	40	14	10.37	4091	7.3%	2.30 [-0.93, 5.53]
Kang et al. (2019)	19.8	6.7	35	15.9	4.9	983	11.5%	3.90 [1.66, 6.14]
Lin et al. (2015)	15.3	9.5	35	10.2	9.5	0		Not estimable
Morris et al. (2020)	21.7	16.8	309	18.8	16.8	6887	13.4%	2.90 [0.99, 4.81]
Mulhall et al. (2020)	20.4	10.89	36	15.6	10.89	724	6.1%	4.80 [1.16, 8.44]
Ng et al. (2019)	5.2	2.03	34	5.5	2.03	786	22.4%	-0.30 [-1.00, 0.40]
Thayer et al. (2018)	7.1	4.6	12618	6.4	5	181244	24.9%	0.70 [0.62, 0.78]
Total (95% CI)			**13172**			**195691**	**100.0%**	**1.67 [0.63, 2.70]**

Heterogeneity: Tau² = 1.11; Chi² = 31.58, df = 7 (P < 0.0001); I² = 78%
Test for overall effect: Z = 3.16 (P = 0.002)

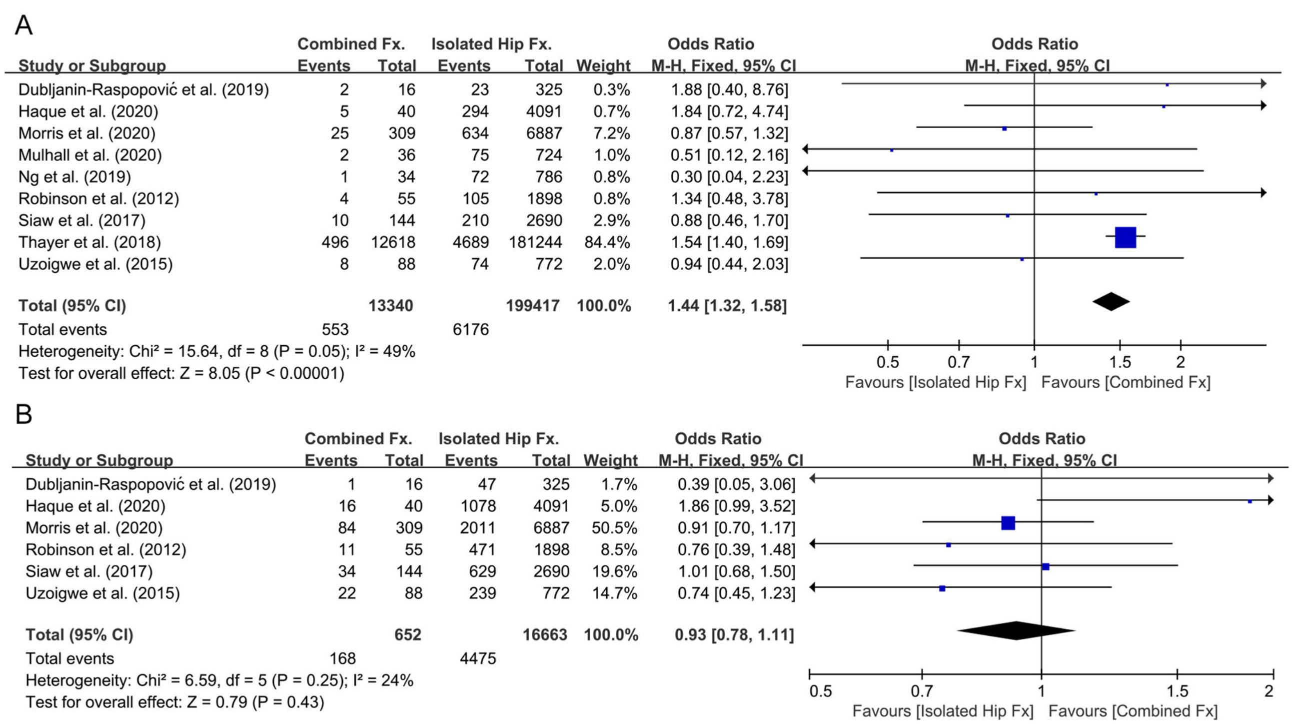
Fig. 2 A forest plot of the length of hospital stay in the isolated hip fracture group compared with that in the combined upper-extremity fracture group



Study or Subgroup	Combined Fx. Events	Total	Isolated Hip Fx. Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Haque et al. (2020)	11	40	1922	4091	8.1%	0.43 [0.21, 0.86]
Morris et al. (2020)	120	309	3402	6887	33.3%	0.65 [0.51, 0.82]
Ng et al. (2018)	7	34	346	786	5.8%	0.33 [0.14, 0.77]
Thayer et al. (2018)	1179	12618	22409	181244	52.8%	0.73 [0.69, 0.78]
Total (95% CI)		**13001**		**193008**	**100.0%**	**0.64 [0.52, 0.80]**
Total events	1317		28079			

Heterogeneity: Tau² = 0.02; Chi² = 6.38, df = 3 (P = 0.09); I² = 53%
Test for overall effect: Z = 4.04 (P < 0.0001)

Fig. 3 A forest plot of the percentage of patients discharged home in the isolated hip fracture group compared with that in the combined upper-extremity fracture group



A

Study or Subgroup	Combined Fx. Events	Total	Isolated Hip Fx. Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Dubljanin-Raspopović et al. (2019)	2	16	23	325	0.3%	1.88 [0.40, 8.76]
Haque et al. (2020)	5	40	294	4091	0.7%	1.84 [0.72, 4.74]
Morris et al. (2020)	25	309	634	6887	7.2%	0.87 [0.57, 1.32]
Mulhall et al. (2020)	2	36	75	724	1.0%	0.51 [0.12, 2.16]
Ng et al. (2019)	1	34	72	786	0.8%	0.30 [0.04, 2.23]
Robinson et al. (2012)	4	55	105	1898	0.8%	1.34 [0.48, 3.78]
Siaw et al. (2017)	10	144	210	2690	2.9%	0.88 [0.46, 1.70]
Thayer et al. (2018)	496	12618	4689	181244	84.4%	1.54 [1.40, 1.69]
Uzoigwe et al. (2015)	8	88	74	772	2.0%	0.94 [0.44, 2.03]
Total (95% CI)		**13340**		**199417**	**100.0%**	**1.44 [1.32, 1.58]**
Total events	553		6176			

Heterogeneity: Chi² = 15.64, df = 8 (P = 0.05); I² = 49%
Test for overall effect: Z = 8.05 (P < 0.00001)

B

Study or Subgroup	Combined Fx. Events	Total	Isolated Hip Fx. Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Dubljanin-Raspopović et al. (2019)	1	16	47	325	1.7%	0.39 [0.05, 3.06]
Haque et al. (2020)	16	40	1078	4091	5.0%	1.86 [0.99, 3.52]
Morris et al. (2020)	84	309	2011	6887	50.5%	0.91 [0.70, 1.17]
Robinson et al. (2012)	11	55	471	1898	8.5%	0.76 [0.39, 1.48]
Siaw et al. (2017)	34	144	629	2690	19.6%	1.01 [0.68, 1.50]
Uzoigwe et al. (2015)	22	88	239	772	14.7%	0.74 [0.45, 1.23]
Total (95% CI)		**652**		**16663**	**100.0%**	**0.93 [0.78, 1.11]**
Total events	168		4475			

Heterogeneity: Chi² = 6.59, df = 5 (P = 0.25); I² = 24%
Test for overall effect: Z = 0.79 (P = 0.43)

Fig. 4 A forest plot of **A** ≤ 30-day mortality and **B** > 30-day mortality in the isolated hip fracture group compared with that in the combined upper limb fracture group

A previous meta-analysis on the differences in mortality between isolated hip fracture and concurrent wrist fracture groups showed that both 30-day and beyond 30-day mortality had no significant differences [8]. However, this study pooled only three studies, including their own RCS, for a single-arm meta-analysis. Our study is the first well-structured meta-analysis to analyze mortality associated with all concurrent upper limb fractures in geriatric patients with hip fractures, not only within but also beyond the 30-day mark. In our study, the 30-day mortality was higher in the combined fracture group than in the isolated hip fracture group, although mortality beyond 30 days showed no significant differences. This analysis supports our initial hypothesis that simultaneous upper-extremity and hip fractures result in higher early mortality due to failure in mobilization of patients with these fractures early in the acute postoperative stage. Moreover, several other studies have indicated that early mobilization of patients with hip fractures reduces the in-hospital 30-day mortality [4, 25, 28].

The current study had several limitations. First, we could not include outcome variables that assess the degree of rehabilitation, such as the Barthel Index (BI), Instrumental Activities of Daily Living (IADL), and Motor Functional Independence Measure (FIM), owing to the lack of comparable data in the included studies. Di Monaco et al. showed that concomitant shoulder fractures resulted in a lower median BI after rehabilitation (70 vs. 90, $P = 0.003$) [21]. Dubljanin-Raspopović et al. compared motor FIM gain and IADL scores at the 4-month follow-up between patients with hip fractures with and without concomitant wrist fractures and found no significant differences [9]. Lin et al. assessed the BI of patients with concomitant wrist fractures at the 6-month follow-up and found no significant differences (75.7 vs. 75.1, $P = 0.831$) [12]. As these measures are more direct means of evaluating functional rehabilitation than the length of hospital stay and discharge destination, further studies should be undertaken to investigate these measures. Second, our study was limited by the fact that most of the included studies were retrospective cohort studies. As the absolute incidence rate of combined hip and upper limb fractures is relatively small, it is difficult to perform randomized controlled trials. Third, the results of the meta-analysis of the length of hospital stay showed high heterogeneity, which poses a potential risk of bias in interpreting the synthetic results. Regardless, this study has the following strengths: (1) it is the first to pool all concomitant upper-extremity fractures for analysis, not confined to just a systematic review. A meta-analysis is a widely accepted 'gold standard' modality for evidence synthesis and provides a powerful means of looking across datasets [29]; (2) it included a larger number of studies than previous meta-analyses; (3) it is the first meta-analysis to evaluate discharge destination; and (4) it successfully correlated rehabilitation difficulty and higher early mortality in the combined upper limb fracture groups.

Conclusion

Collectively, this meta-analysis revealed that concomitant upper-extremity fractures have debilitating effects on rehabilitation and early mortality in geriatric patients with hip fractures. Therefore, more focus should be placed on the early ambulation of patients with hip fractures and simultaneous upper limb fractures to promote rehabilitation and alleviate the public health burden.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethics approval No ethical approval was retrieved because data from previous published studies, in which informed consent was obtained by primary investigators, are to be retrieved and analysed.

Informed consent No additional informed consent was necessary since informed consent was obtained by primary investigators of previous published studies analysed in this study, and all investigations were conducted in conformity with ethical principles of research.

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