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Efficacy of telerehabilitation for patients after hip fracture surgery: A systematic review and meta-analysis

Takahiro Tsuge[1,2], Norio Yamamoto[2,3], Shunsuke Taito[3,4], Takanori Miura[5], Daijo Shiratsuchi[6,7] and Takashi Yorifuji[2]

Abstract

Introduction: This study aimed to determine the efficacy of telerehabilitation for patients after hip fracture surgery through a systematic review and meta-analysis.

Methods: Eight electronic databases were searched in August 2022. The primary outcomes were mobility outcomes, activities of daily living (ADL) outcomes, and all adverse events, whereas the secondary outcomes were pain, health-related quality of life, and fall efficacy scale score.

Results: Seven randomized controlled trials were eligible for this study. The evidence regarding the effect of telerehabilitation on mobility outcomes (standardized mean difference (SMD): 0.05, 95% confidence interval (CI): −0.39 to 0.48) and all adverse events (risk ratio: 1.14, 95% CI: 0.62 to 2.21) was very uncertain. A clinically irrelevant but significant mean difference (MD) in ADL outcomes was found (MD: 4.82, 95% CI: 2.63 to 7.01). Telerehabilitation may result in a slight increase in fall efficacy scale score (SMD: 0.26, 95% CI: −0.02 to 0.54) and little to no difference in pain (MD: −1.0, 95% CI: −18.31 to 16.31).

Conclusions: The efficacy of telerehabilitation for patients after hip fracture surgery was uncertain with respect to the mobility outcomes, all adverse events, and pain, with no clinically meaningful differences in ADL outcomes. Telerehabilitation may be necessary to be considered for patients after hip fracture surgery to improve their confidence in their ability to perform daily activities without falling. Therefore, medical staff may consider telerehabilitation for hip fractures.

Keywords

Telerehabilitation, telephone, mobile application, hip fractures, fall efficacy, telehealth, systematic review, meta-analysis

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Introduction

Hip fractures are a serious global problem, and both the incidence of hip fractures and the mean age of those with hip fractures are rising.[1–3] Hip fractures are generally treated surgically, and postoperative rehabilitation is important to restore the preinjury walking ability.[4,5]

Telemedicine has been introduced in the orthopedic field since the 1990s.[6,7] Recently, telemedicine received considerable attention during the coronavirus disease pandemic outbreak because of the need for social distancing and reduced costs.[8] Telerehabilitation, a form of telemedicine, was introduced as a method of postoperative rehabilitation.[9,10] Telerehabilitation has been reported to be efficacious in improving the quality of life in patients after thoracic, upper abdominal, and orthopedic surgeries (e.g. hip fracture surgery, total knee arthroplasty, shoulder hemiarthroplasty,

[1]Department of Rehabilitation, Kurashiki Medical Center, Kurashiki, Okayama, Japan
[2]Department of Epidemiology, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama University, Okayama, Japan
[3]Scientific Research WorkS Peer Support Group (SRWS-PSG), Osaka, Japan
[4]Division of Rehabilitation, Department of Clinical Practice and Support, Hiroshima University Hospital, Hiroshima, Japan
[5]Department of Orthopedic Surgery, Tazawako Hospital, Tazawako, Senboku, Akita, Japan
[6]Department of Rehabilitation, Japan Community Health Care Organization Kumamoto General Hospital, Yatsushiro, Kumamoto, Japan
[7]Graduate School of Health Sciences, Kagoshima University, Kagoshima, Japan

Corresponding author:
Takahiro Tsuge, Department of Rehabilitation, Kurashiki Medical Center, 250 Bakuro, Kurashiki, Okayama 710-8522, Japan.
Email: takahiro_tsuge@yahoo.co.jp

and arthroscopic surgery), as compared with comparison groups receiving usual care, face-to-face contact rehabilitation, or no care; nonetheless, telerehabilitation limited to hip fractures has not been investigated.[11] Therefore, the efficacy of telerehabilitation for patients after hip fracture surgery remains uncertain owing to the absence of systematic reviews and meta-analyses of randomized controlled trials (RCTs).

In the present study, we aimed to determine the efficacy of telerehabilitation, as compared with usual care, in patients after hip fracture surgery by conducting a systematic review and meta-analysis of RCTs.

Patients and methods

We conducted the systematic review based on a previously published protocol[12] and in accordance with the Cochrane Handbook[13] and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 guidelines (Supplemental Table S1).[14]

Eligibility criteria

Study types. We included RCTs that assessed the efficacy of telerehabilitation for patients after hip fracture surgery. Restrictions on language, publication year, or country were not applied. All types of papers, including published articles, conference abstracts, and letters, were eligible for this review. However, we excluded cluster trials, crossover trials, quasi-experimental studies, and quasi-randomized trials but did not exclude studies based on their observation period.

Study participants. All patients after hip fracture surgery (inpatients, outpatients, and community-care patients) were included without any restriction.

Interventions and control. For this review, the intervention was telerehabilitation, which was defined as follows based on a previous study: "the delivery of therapeutic rehabilitation at a distance or offsite using telecommunication technologies."[15] The control was usual care, placebo, or standard therapy. We included telerehabilitation conducted by one or more medical professionals using a telephone, mobile application, or remote sensing technology or via video conferencing, remote consultation, videotape recording, or virtual rehabilitation. We excluded telerehabilitation which was used for educating and supporting healthcare professionals instead of patient care. When rehabilitation was performed both face-to-face and remotely, it was included when the proportion of remoteness was higher than 0.50.[16]

Outcome measures. Based on the consensus on the core outcomes set for patients after hip fracture surgery,[17] we selected the primary and secondary outcomes and prioritized them in terms of clinical importance. When several outcomes from the same study were measured, the outcome listed first was prioritized.

The primary outcomes were as follows:

1. Mobility outcomes (Timed Up and Go test and gait speed).[18]
2. Activities of daily living (ADL) outcomes (Barthel index,[19] functional independence measure,[20] and Katz ADL scale[21]).
3. All adverse events defined by the original authors.

The secondary outcomes were as follows:

1. Pain (visual analog scale[22] and numeric rating scale[23]).
2. Health-related quality of life (HRQoL) (EuroQol- 5 Dimension (EQ-5D)[24,25] and 36-item Short Form Survey (SF-36)[26]).
3. Fall efficacy scale score (modified falls efficacy scale[27] and falls efficacy scale-international[28]).

Search strategy and study selection. The following eight electronic databases were searched on 25 August 2022: MEDLINE via PubMed, Cochrane Central Register of Controlled Trials via Cochrane Library, Embase via Dialog, World Health Organization's International Clinical Trials Registry Platform Search Portal (ICTRP), ClinicalTrials.gov, Cumulative Index to Nursing and Allied Health Literature, Physiotherapy Evidence Database, and OTseeker (see the Data Supplement for details of search strategies; Supplemental Table S2). Additional literature was manually searched from the reference lists of included articles for the meta-analysis, as well as clinical guidelines.[29,30]

We requested unpublished or additional data from the authors of original research articles. Three reviewers (TT, TM, and DS) reviewed the titles and abstracts independently and in pairs; subsequently, eligibility was assessed based on the full texts. The articles extracted by the reviewers were included in the full-text review. Any difference in opinion was resolved by consulting a third reviewer (NY).

Data extraction. Two out of three reviewers (TT, TM, and DS) independently performed data extraction of the included studies using a standardized data collection form and confirmed it. Authors of research articles with insufficient data were contacted when necessary. All disagreements were resolved via discussion, and a third reviewer (NY) arbitrated when necessary.

Quality assessment. Two out of three reviewers (TT, TM, and DS) independently evaluated the risk of bias using the Cochrane risk-of-bias tool for randomized trials version 2 (RoB 2)[31] and confirmed it. Any disagreement regarding the risk of bias was resolved by consulting a third reviewer (NY).

Data analysis. All analyses were conducted using RevMan software version 5.4.1 (Nordic Cochrane Center, Cochrane Collaboration, Copenhagen, Denmark). We used a random-effects model and pooled the risk ratios and 95% confidence intervals (CIs) for all adverse events (i.e. binary variables). Additionally, the mean differences (MDs) and 95% CIs were pooled for the following continuous variables: mobility outcomes (Timed Up and Go test and gait speed), ADL outcomes (Barthel index, functional independence measure, and Katz ADL scale), pain (visual analog scale and numeric rating scale), HRQoL (EQ-5D and SF-36), and fall efficacy scale score (modified falls efficacy scale and falls efficacy scale-international). The MD was applied when the same scale had been used for an outcome in the included studies, whereas the standardized MD (SMD) was utilized when several different scales had been used for an outcome in the included studies. We did not conduct a meta-analysis when the respective detailed outcome data were not available and could not be quantitatively synthesized.

We performed an intention-to-treat analysis for all dichotomous variables with reference to the management of missing data. For continuous data, we did not impute missing data, as recommended by the Cochrane Handbook.[13] We conducted a meta-analysis using the available data from the original study.

With respect to heterogeneity assessment, we evaluated the statistical heterogeneity by visually inspecting the forest plots and calculating the I^2 statistic (I^2 values of 0% to 40%: might not be important; 30% to 60%: might represent moderate heterogeneity; 50% to 90%: might represent substantial heterogeneity; and 75% to 100%: considerable heterogeneity). When substantial heterogeneity was present ($I^2 > 50\%$), we assessed the reason for such heterogeneity. The Cochrane chi-squared test (Q-test) was performed for the I^2 statistic, and statistical significance was set at a p-value of <0.10.[13]

With regard to reporting bias assessment, we searched the clinical trial registry systems (i.e. ClinicalTrials.gov and ICTRP) and performed an extensive literature search for unpublished trials. As for the evaluation of outcome reporting bias, funnel plots were visually examined to determine any potential publication bias. We did not perform a funnel plot analysis because the pooled analysis only included fewer than 10 papers.

Subgroup analysis. In order to determine the possible causes of heterogeneity, a prespecified subgroup analysis of the primary outcomes was planned as follows:

1. Patient age: <65 years versus ≥65 years.[32]
2. Duration of intervention: <12 weeks versus ≥12 weeks.[33]
3. Type of intervention delivery: telephone versus other methods.

Sensitivity analysis. A prespecified sensitivity analysis of the primary outcomes was planned as follows:

1. Exclusion of studies using imputed statistics.
2. Exclusion of studies with a high risk of bias in the overall risk-of-bias assessment.
3. Focusing on studies that presented results at 3 months after hip fracture surgery.

Summary of findings table. We presented the primary and secondary outcomes of our review in an summary of findings table, which we prepared according to the Cochrane Handbook.[13] Two reviewers (TT and NY) evaluated the certainty of evidence using the grading of recommendations, assessment, development and evaluations (GRADE) approach.[34] For this review, clinically important MD was defined as 10 points for ADL[35] and 20 points for pain[36] based on the previously defined minimum clinically important difference (MCID).

Results

Search results

A total of 751 records were identified after searching in September 2022 and removing the duplicates. We identified 52 relevant articles after screening the titles and abstracts of the identified articles. Eligibility was evaluated based on the full texts, resulting in the exclusion of 45 records (Supplemental Table S3). There were seven ongoing studies (Supplemental Table S3). We contacted Latham et al.[37] and Chang et al.[38] because of suspected duplication; however, we did not receive any response. Thus, we included the study by Latham et al.[37] but excluded the study by Chang et al.[38] Finally, a total of seven studies[37,39–44] were included in the qualitative synthesis (Figure 1).

Study characteristics and risk of bias in studies

The characteristics of the seven included RCTs are summarized in Table 1. Two types of telerehabilitation were included—namely, telerehabilitation via the telephone (five studies)[37,39–42] and telerehabilitation using a mobile application (two studies).[43,44] The duration of the telerehabilitation intervention was <12 weeks in four studies[37,39–41] and ≥12 weeks in three studies.[42–44] Five studies were conducted on patients at 3 months after hip fracture surgery.[37,39–42] The risk of bias using RoB 2 is shown in Supplemental Tables S4 to S8. The overall risk of bias was high for mobility outcomes in one study,[41]

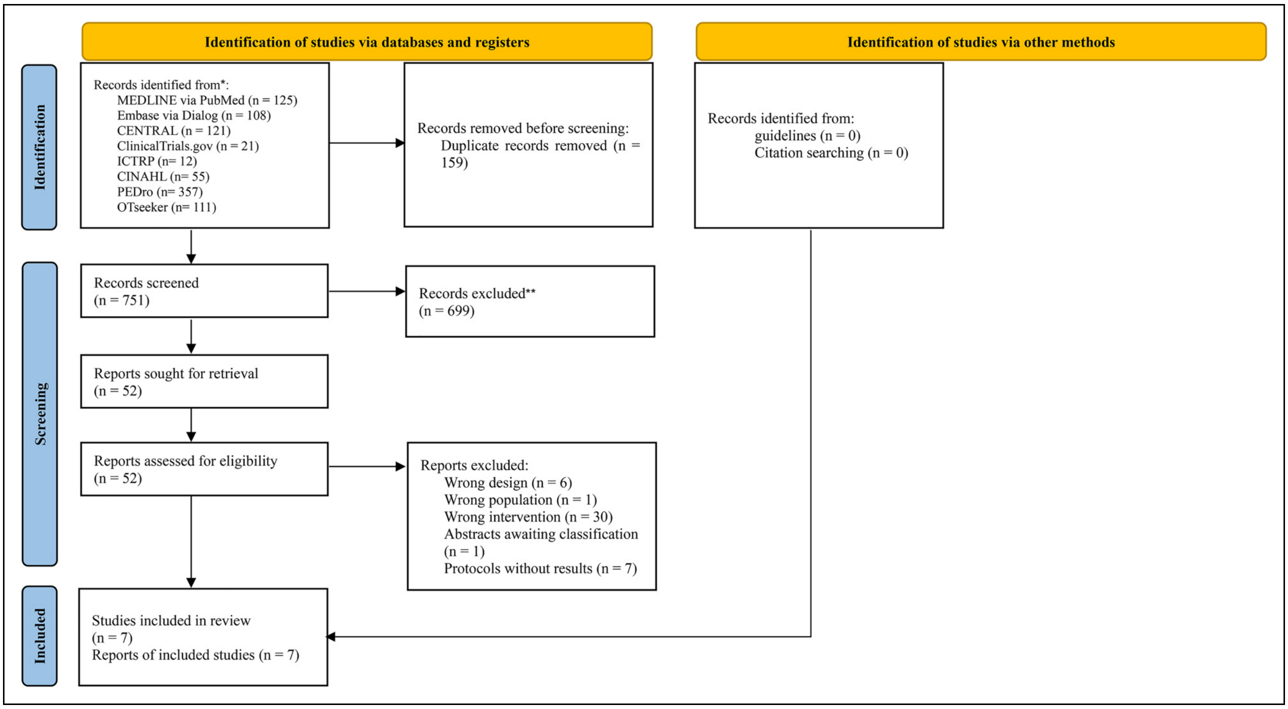

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) study flow diagram.
*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools. From Page et al.[14] For more information, visit: http://www.prisma-statement.org/.

and ADL outcomes, all adverse events, fall efficacy scale scores were low or some concern, and pain was low.

Primary outcomes

Mobility outcomes. Data from three studies (81 participants)[39,41,42] that evaluated the mobility outcomes were pooled for this meta-analysis (Figure 2). For outcome evaluation, one trial used the Timed Up and Go test, whereas two trials used gait speed. Telerehabilitation may increase little to no effect on mobility outcomes but the evidence is very uncertain (SMD: 0.05, 95% CI: −0.39 to 0.48, $p = 0.99$; very low-quality evidence), and no statistical heterogeneity was indicated ($tau^2 = 0.00$, $I^2 = 0\%$).

ADL outcomes. Data from two studies (183 participants)[40,42] that evaluated the ADL outcomes were pooled for this meta-analysis. All studies used the Barthel index for outcome evaluation. Telerehabilitation results in little to no difference in the ADL outcomes (MD: 4.82, 95% CI: 2.63 to 7.01, $p = 0.0001$; moderate-quality evidence), and no statistical heterogeneity was indicated ($tau^2 = 0.00$, $I^2 = 0\%$).

All adverse events. Data from six studies (364 participants)[39–44] that evaluated all adverse events were pooled for this meta-analysis. Telerehabilitation may reduce little to no effect on all adverse events but the evidence is very uncertain (risk ratio: 1.14, 95% CI: 0.62 to 2.21, $p = 0.54$; very low-quality evidence), and no statistical heterogeneity was indicated ($tau^2 = 0.00$, $I^2 = 0\%$).

Secondary outcomes

Pain. Data from one study (30 participants)[43] that evaluated pain were pooled for this meta-analysis (Figure 3). Telerehabilitation may result in little to no difference in pain (MD: −1.0, 95% CI: −18.31 to 16.31, $p = 0.91$; low-quality evidence).

Health-related quality of life. Data on HRQoL were not available in any of the included studies.

Fall efficacy scale score. Data from three studies (236 participants)[37,42,43] that evaluated the fall efficacy scale score were pooled for this meta-analysis. Telerehabilitation may result in a slight increase in the fall efficacy scale score (SMD: 0.26, 95% CI: −0.02 to 0.54, $p = 0.07$; low-quality evidence). No statistical heterogeneity was indicated ($tau^2 = 0.00$, $I^2 = 0\%$).

Additional analyses. The subgroup analysis of mobility outcomes, ADL outcomes, and all adverse events revealed no

Table 1. Summary of the patient characteristics in the included studies.

Author	Year	Country	Setting	Enrollment, *n*	Mean age (SD)		Female (%)	Intervention type of telerehabilitation	Control	Outcomes	Follow-up period
					Intervention	Control					
Tsauo et al.[39]	2005	Taiwan	Single center	54	74.1 (12.0)	71.9 (12.5)	80.0	Telephone	Standard care	Gait speed, all adverse events	6 months
Latham et al.[37]	2014	USA	Unclear	232	77.2 (10.2)	78.9 (9.4)	69.0	Telephone	Placebo	Modified fall efficacy scale	9 months
Di Monaco et al.[40]	2015	Italy	Single center	169	78.7 (7.2)	79.3 (8)	100.0	Telephone	No intervention	Barthel index, all adverse events	6 months
Langford et al.[41]	2015	Canada	Single center	30	83 (8.0)	82 (10)	63.3	Telephone	Standard care	Gait speed, all adverse events	4 months
O'Halloran et al.[42]	2016	Australia	Single center	30	83 (4.8)	82.3 (5.7)	84.0	Telephone	Standard care	All adverse events, modified fall efficacy scale	63 days
Li et al.[43]	2022	China	Single center	31	76.5 (8.6)	82.1 (9.7)	80.6	Mobile application	Standard care	Timed Up and Go test, Barthel index, all adverse events, pain (visual analog scale), modified fall efficacy scale	42 days
Cheng et al.[44]	2022	China	Single center	50	75.8 (7.2)	79 (8.8)	48.7	Mobile application	Standard care	All adverse events	2 months

SD: standard deviation.

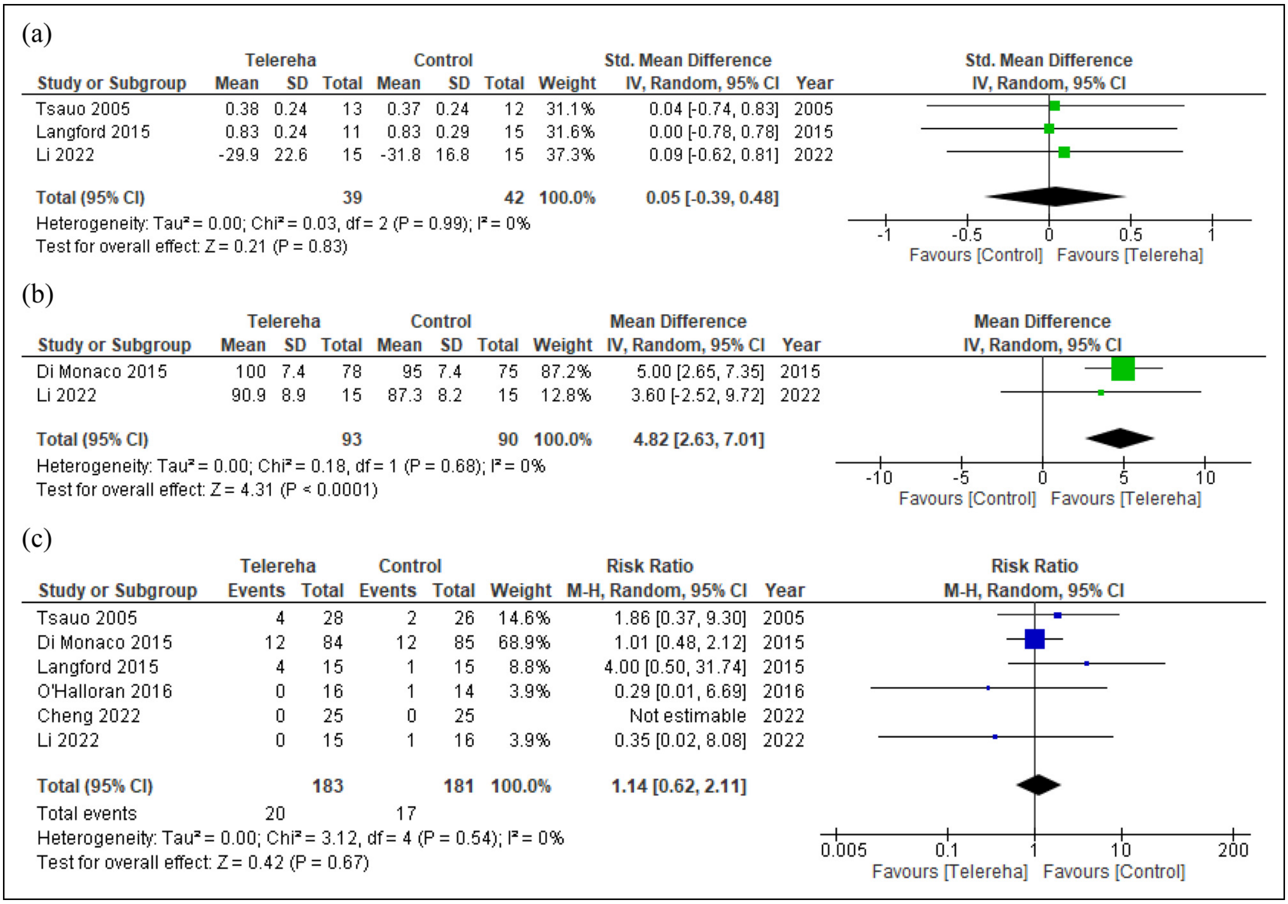

Figure 2. Forest plot of comparison between the following (primary outcomes): (a) mobility outcomes, (b) activities of daily living (ADL) outcomes, and (c) all adverse events.

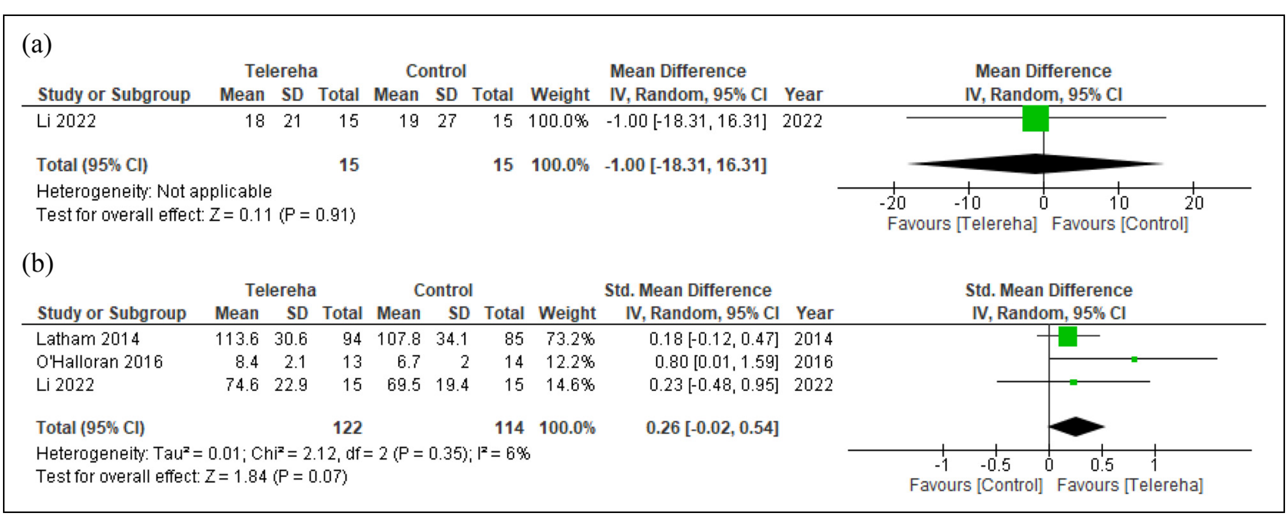

Figure 3. Forest plot of comparison between the following (secondary outcomes): (a) pain and (b) fall efficacy scale score.

significant heterogeneity based on the *p*-value for interaction (Supplemental Table S9). We also performed a sensitivity analysis for the primary outcomes by (i) excluding the studies with a high risk of bias in the overall risk-of-bias assessment and (ii) focusing on studies that presented the results at 3 months after hip fracture surgery. The analysis

Table 2. Summary of findings

Telerehabilitation compared to control for hip fractures

Patient or population: patients with hip fractures
Setting: Patients after hip fracture surgery without specifying age, gender, race, operative technique, or history of fracture.
Intervention: Telerehabilitation
Comparison: Control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Certainty of the evidence (GRADE)
	Risk with control	Risk with telerehabilitation			
Mobility outcomes	—	SMD 0.05 SD higher (0.39 lower to 0.48 higher)	—	81 (3 RCTs)	⊕◯◯◯ Very low[a,b]
ADL outcomes	—	MD 4.82 higher (2.63 higher to 7.01 higher)	—	183 (2 RCTs)	⊕⊕⊕◯ Moderate[c]
All adverse events	94 per 1000	107 per 1000 (58 to 198)	RR 1.14 (0.62 to 2.11)	364 (6 RCTs)	⊕◯◯◯ Very low[b,d]
Fall efficacy scale score	—	SMD 0.26 higher (0.02 lower to 0.54 higher)	—	236 (3 RCTs)	⊕⊕◯◯ Low[b]
Pain	—	MD 1 lower (18.31 lower to 16.31 higher)	—	30 (1 RCT)	⊕⊕◯◯ Low[b]

ADL: activities of daily living; CI: confidence interval; MD: mean difference; RCTL randomized controlled trial; RR: risk ratio; SMD: standardized MD.
*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).
GRADE Working Group grades of evidence.
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: We have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.
[a]Downgraded one level for serious risk of bias.
[b]Downgraded two levels for very serious imprecision.
[c]Downgraded one level for serious imprecision.
[d]Downgraded one level for serious inconsistency.

results were consistent with the main results (Supplemental Table 10). Due to the limitations of available data, we could not compare the outcomes with those in other prespecified subgroups and sensitivity analyses.

Discussion

This review showed that telerehabilitation for patients after hip fracture surgery did not demonstrate clinically meaningful differences in ADL outcomes and pain. Telerehabilitation might slightly increase the fall efficacy scale score and might have little to no effect on mobility outcomes and all adverse events; nevertheless, the evidence was very uncertain.

Telerehabilitation at home could improve the ADL outcomes of patients after hip fracture surgery but would not be effective in achieving clinically significant improvements. Not only statistically significant differences, but also clinically important differences are essential when evaluating the outcomes.[35] The point estimate of MD in the Barthel index did not exceed the predefined MCID. Improvement in ADLs in those with hip fractures is likely to be achievable during the first postoperative month[45] and is more likely to be attainable with acute hospital care.[46] In this review, telerehabilitation was performed at least 1 month postoperatively and was conducted at home; hence, the patients might have good ADL function. Even if the number of cases would increase in the future, the MCID of 10 points is unlikely to be exceeded.

Telerehabilitation for patients after hip fracture surgery may prevent falls. In this review, telerehabilitation included not only exercise therapy, but also education against the fear of falling[37,42] and ADL-related interventions in the patients' home environment[43] (Table 1). In a previous review, only exercise therapy was performed for hip fractures, which showed no effect on fall efficacy.[46] Exercise therapy supplemented with education may be more effective than exercise therapy alone in preventing falls among older adults.[47] We consider that education and ADL-related interventions in the patients' home environment after hip fracture surgery may be effective in improving the fall efficacy when combined with exercise therapy.

Considering the very low certainty of evidence, telerehabilitation did not provide a clear benefit with respect to mobility outcomes and all adverse events. Another review investigating mobility in hip fractures reported that strategies aimed at improving mobility resulted in clinically meaningful improvements in mobility.[4] The differences in intervention content might have led to these differences in results because the telerehabilitation in this review included interventions that were not implemented for mobility.[41] The result regarding hospital readmission as an adverse event was consistent with the finding of a previous review.[5]

The current review has strength in that this is the first systematic review and meta-analysis of the efficacy of telerehabilitation for patients after hip fracture surgery. Furthermore, in this review, the clinical outcomes were determined based on a consensus on the core outcomes set. Additionally, the screening, selection, and evaluation processes were comprehensive and conducted by two independent reviewers to reduce bias. This review was also performed in accordance with the Cochrane Handbook[13] and was prepared as per the PRISMA 2020 guidelines[14] for reporting quality and assessing the methodological quality of systematic reviews-2[48] for methodological quality.

Nevertheless, the present study also has some limitations. First, we only included seven RCTs that met the inclusion criteria. Second, the total sample size for analysis was relatively small; however, we conducted a comprehensive search in several databases, including a manual search for ongoing studies. Third, we did not perform a statistical assessment of publication bias due to the lack of studies. However, we checked the trial registry and found that many of them were recently registered; hence, the risk of publication bias was considered low.

Conclusions

This review suggested that the efficacy of telerehabilitation for patients after hip fracture surgery did not demonstrate clinically meaningful differences in ADL outcomes and was uncertain with respect to the mobility outcomes, all adverse events, and pain. Telerehabilitation may be necessary to be considered for patients after hip fracture surgery to improve their confidence in their ability to perform daily activities without falling. Therefore, medical staff may consider telerehabilitation for hip fractures. Larger and well-designed RCTs are required to confirm the effectiveness of telerehabilitation for patients after hip fracture surgery.

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Author contributions

All authors contributed to the study's conception and design. Data collection was performed by TT, TM, DS, and NY. Data analysis was performed by TT, TM, DS, NY, and ST. The first draft of the manuscript was written by TT and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Author's note

Daijo Shiratsuchi, Department of Physical Therapy, School of Health Sciences, Faculty of Medicine, Kagoshima University.

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Ethical approval

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

ORCID iDs

Takahiro Tsuge https://orcid.org/0000-0003-0497-944X
Daijo Shiratsuchi https://orcid.org/0000-0002-0220-7940

Data availability statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

Supplemental material

Supplemental material for this article is available online.

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