The efficacy and safety of fast track surgery (FTS) in patients after hip fracture surgery: a meta-analysis

Mingyang Jiang¹, Siyi Liu², Huachu Deng², Xuzhi Liang² and Zhandong Bo¹*

Abstract

Background: Fast track surgery (FTS) has been gradually applied in perioperative management of orthopedic surgery, but there still some research suspected that the prognosis of patients is not as expected and the cost is high, the effect of the FTS still urgently needed for support by evidence-based medicine.

Methods: We retrieved RCTs from medical research literature databases. Risk ratios (RR), standard mean difference (SMD), and 95% confidence intervals (CI) were calculated to compare the primary and safety endpoints.

Results: Overall, a total of 8886 patients were retrieved from 57 articles, of which 4448 patients (50.06%) were randomized to experimental group whereas 4438 patients (49.94%) were randomized to control group. The result showed that FTS could significantly shorten the length of stay (LOS), decrease the visual analog scale (VAS), reduce the leaving bed time and the hospitalization costs, and improve Harris hip joint function score. The incidence of complications such as respiratory system infection, urinary system infection, venous thrombus embolism (VTE), pressure sore, incision infection, constipation, and prosthesis dislocation also has been decreased significantly. Meanwhile, FTS improved patients’ satisfaction apparently.

Conclusions: This meta-analysis reveals that FTS could significantly shorten the length of stay, alleviate the pain, reduce the leaving bed time and the hospitalization costs, and improve hip function. The incidence of complications also has been decreased significantly. Meanwhile, FTS has been spoken highly in patients in terms of nursing satisfaction. Its efficacy and safety were proved to be reliable.

Keywords: Fast track surgery (FTS), Enhanced recovery after surgery (ERAS), Hip replacement, Meta-analysis

Introduction

Hip fracture is a public health problem that could come with number of complications even threaten your life [1]. It could happen in any age and most common caused by falling [2]. Surgery is the most common treatment, and the rehabilitation therapy is being encouraged in order to avoid complications and resume routine activities of life. With the increase of age, the realization of rehabilitation plan is more limited. Especially with other basic diseases, the difficulty of rehabilitation increases, and the recovery of hip fracture may be limited [3].

Fast track surgery (FTS), also known as enhanced recovery after surgery (ERAS), is a new surgical concept aiming at early ambulation, discharge, and return to activities of daily living [4, 5]. It uses a series of perioperative optimization measures confirmed by evidence-based medicine to eliminate the factors that delay postoperative recovery [6]. There are 3 parts of FTS: preoperative, intraoperative, and postoperative [7]. Psychological comfort and physical muscle training might reduce patients’
response to psychological and surgical stress preoperative; intraoperative, optimizing anesthesia, and procedure (minimally invasive surgery, MIS), which can reduce pain and shorten recovery time; postoperative nutrition support and pain management are beneficial to improve organ dysfunction, and early rehabilitation exercise could prevent surgery-related complications [8–13].

Currently, the concept of FTS has been widely used in surgical malignant tumors and laparoscopic surgery (especially colorectal surgery), which is expected to be extended to other surgical specialties safely and effectively [14]. Though it is also gradually applied to the perioperative management of orthopedic surgery, the effect of perioperative in elderly patients with hip fracture is

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**PRISMA 2009 Flow Diagram**

- Records identified through database PubMed, Embase, Cochrane Library, Web of Science and Google Scholar searching (n = 15018)
- Additional records identified through other sources (n = 1000)
- Records after duplicates removed (n = 16018)
- Records screened (n = 11875)
- Records excluded (n = 4143)
- Full-text articles assessed for eligibility (n = 8200)
- Full-text articles excluded, with reasons (n = 3675)
- Studies included in qualitative synthesis (n = 140)
- Studies included in quantitative synthesis (meta-analysis) (n = 57)

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Fig. 1 Flow diagram of the study selection process. CNKI China national knowledge infrastructure, VIP China Science and Technology Journal Database
Table 1: Characteristics of studies included in the meta-analysis. FTS fast track surgery, NA not applicable

| Author | Publication year | Characteristics of study population | Hip fracture surgery | FTS measures | Follow-up | Endpoints |
|--------|------------------|-------------------------------------|----------------------|--------------|-----------|-----------|
| Li [21] | 2016             | 60 60                               | 72.05±6.37          | Total hip arthroplasty; hemiarthroplasty | 1, 2, 3, 4, 5, 7, 8 | 8 weeks | LOS, Harris hip joint function score, satisfaction, VTE, dislocation of prosthesis |
| Tian [22] | 2016            | 40 40                               | NA                  | Total hip arthroplasty | 1, 2, 8 | 6 months | LOS, respiratory, incision infection |
| Xu [23] | 2016             | 55 55                               | 73.58±5.27          | Hip arthroplasty; internal fixation | 1, 2, 3, 4, 5, 6, 7, 8 | 6 months | LOS, Harris hip joint function score, respiratory, urinary tract infection, VTE, pressure sores, dislocation of prosthesis |
| Li [21] | 2016             | 60 60                               | 72.05±6.37          | Total hip arthroplasty; hemiarthroplasty | 1, 2, 3, 4, 5, 7, 8 | 8 weeks | LOS, Harris hip joint function score, satisfaction, VTE, dislocation of prosthesis |
| Zou [24] | 2016             | 126 132                             | 64.2±9.4            | Unilateral hip arthroplasty | 1, 2, 6, 7, 8 | 3 months | LOS, VTE, dislocation of prosthesis |
| Zhang [25] | 2016            | 56 52                               | 73.91±7.18          | Hip arthroplasty; internal fixation | 1, 4, 6, 7, 8 | NA | LOS, Harris hip joint function score, VAS, respiratory, urinary tract infection, VTE, pressure sores |
| Chen [26] | 2017            | 106 92                              | 68.5±4.1            | NA                  | 1, 2, 4, 5, 6, 7, 8 | NA | LOS, satisfaction, cost, VTE, pressure sores, constipation |
| Chen [27] | 2017            | 40 40                               | 74.28±6.85          | Unilateral hip arthroplasty | 1, 7, 8 | 3d, 7d, 1 month, 3 months | Harris hip joint function score, VAS, respiratory, VTE, dislocation of prosthesis |
| Fu [28] | 2017             | 40 40                               | NA                  | Hip arthroplasty | 1, 2, 4, 6, 7, 8 | 2 weeks, 1 month, 3 months, 6 months | Harris hip joint function score, VAS, respiratory, urinary tract infection, VTE, pressure sores |
| Li [29] | 2017             | 45 45                               | 53.08±2.07          | Hip arthroplasty | 2, 4, 8 | 8 weeks | Harris hip joint function score, LOS, respiratory, urinary tract infection, VTE, incision infection |
| Liu [30] | 2017            | 41 41                               | 50.02±1.85          | Hip arthroplasty | 3, 4, 6, 8 | 6 months | Harris hip joint function score, LOS, respiratory, urinary tract infection, VTE, incision infection |
| Wan [31] | 2017             | 43 43                               | NA                  | Hip arthroplasty | 1, 4, 7, 8 | NA | LOS |
| Wei [32] | 2017             | 50 50                               | 74.1±6.3            | NA                  | 1, 2, 3, 4, 5, 6, 7, 8 | NA | LOS, satisfaction, VTE |
| Yu [33] | 2017             | 40 40                               | 73.2±5.2            | NA                  | 1, 2, 6, 7, 8 | NA | LOS, Harris hip joint function score, VTE, pressure sores |
| Zhang [34] | 2017            | 43 43                               | 70.13±3.75          | Hip arthroplasty | 1, 3, 4, 7, 8 | NA | LOS, Harris hip joint function score, cost, respiratory, urinary tract infection, VTE, incision infection |
| Zou [35] | 2017             | 40 40                               | NA                  | Hip arthroplasty | 1, 2, 6, 7, 8 | NA | LOS, Harris hip joint function score, VTE, pressure sores |
| Ding [36] | 2018             | 45 45                               | 65.8±3.4            | Total hip arthroplasty, unilateral hip arthroplasty | 1, 2, 5, 7, 8 | NA | LOS, cost, respiratory, urinary tract infection, VTE, constipation |
| Jin [37] | 2018             | 40 40                               | 69.3±4.2            | Hip arthroplasty, resection of hip fracture | 4, 7, 8 | NA | LOS, VAS |
| Li 1 [38] | 2018             | 41 41                               | 64.5±4.5            | Hip arthroplasty | 1, 4, 6, 7, 8 | NA | Harris hip joint function score, VTE |
| Li 2 [39] | 2018             | 60 60                               | 73.3±8.75          | Hip arthroplasty | 3, 4, 6, 8 | NA | LOS, respiratory, urinary tract infection, VTE, pressure sores |
| Liu [40] | 2018             | 53 53                               | 73.29±2.25          | NA                  | 1, 4, 7, 8 | NA | VAS |
| Qian [41] | 2018            | 41 41                               | 81.21±4.46          | Hip arthroplasty | 1, 4, 7, 8 | 5 months | Harris hip joint function score, VAS |
| Wang [42] | 2018            | 47 46                               | 79.58±8.42          | Hip arthroplasty | 1, 4, 5, 7, 8 | NA | LOS, satisfaction, the leaving bed time, urinary tract infection |

Characteristics of studies included in the meta-analysis. FTS fast track surgery, NA not applicable.
| Author | Publication year | Sample size (n) | Age (years) | Women, No. (%) | Hip fracture surgery | FTS measures | Follow-up | Endpoints |
|--------|-----------------|----------------|-------------|----------------|---------------------|--------------|-----------|-----------|
| Yang [43] | 2018 | 50 50 | 58.5± 8.53 | 57.96± 8.41 | 25 (50.00) | Hip arthroplasty | 1, 2, 3, 5, 7, 8 | NA | LOS, Harris hip joint function score, VTE, pressure sores |
| Yang [44] | 2018 | 40 40 | 57.4 ± 11.3 | 58.3 ± 12.9 | 22 (55.00) | Hip arthroplasty | 1, 2, 4, 7, 8 | 1d, 3d, 7d | VAS, the leaving bed time, VTE, incision infection |
| You [45] | 2018 | 100 100 | 86±5.1 | 82±5.3 | 40 (40.00) | PFNA internal fixation | 1, 2, 3, 4, 5, 6, 7, 8 | NA | LOS, satisfaction, cost |
| Zhang [46] | 2018 | 40 40 | 71.5± 1.5 | 70.5± 3.0 | 19 (47.50) | Femoral head replacement | 1, 2, 4, 7, 8 | 18 months | Satisfaction |
| Zhai [47] | 2018 | 40 40 | 73.45± 2.54 | 72.99± 3.14 | 19 (47.50) | Femoral head replacement | NA | NA | Satisfaction, VTE, pressure sores |
| Zheng [48] | 2018 | 45 45 | 71.16± 5.05 | 71.08± 5.07 | 19 (42.22) | Hip arthroplasty | 4, 6, 7, 8 | 6 months | LOS, Harris hip joint function score, cost, VTE |
| Zuo [49] | 2018 | 40 40 | 72.36± 10.48 | 71.72± 10.24 | 19 (47.50) | Hip arthroplasty | 1, 4, 5, 6, 8 | 3 months | Harris hip joint function score, respiratory, VTE |
| Bai [50] | 2019 | 64 64 | NA | NA | NA | Total hip arthroplasty, unilateral hip arthroplasty | 1, 2, 4, 5, 7, 8 | 3 months | Harris hip joint function score, VTE, pressure sores, dislocation of prosthesis |
| Bao [51] | 2019 | 49 48 | NA | NA | NA | Hip arthroplasty | 2, 4, 5, 6, 7, 8 | 6 months | Harris hip joint function score, VAS, respiratory, urinary tract infection, VTE, pressure sores |
| Chen [52] | 2019 | 44 43 | 68.21± 6.44 | 65.58± 6.34 | 29 (65.91) | Hip arthroplasty | 1, 3, 4, 7, 8 | NA | LOS, satisfaction, the leaving bed time, cost |
| Fusco [53] | 2019 | 40 40 | NA | NA | 0 | Hip arthroplasty | 8 | 12 months | Cost |
| Guo 1 [54] | 2019 | 51 51 | 72.6± 3.5 | 72.3± 3.4 | 18 (35.29) | Hip arthroplasty | 1, 2, 3, 4, 5, 7, 8 | 7d | LOS, respiratory, VTE, incision infection |
| Guo 2 [55] | 2019 | 42 42 | 82.24± 4.58 | 82.29± 4.73 | 17 (39.48) | Reduction of hip fracture, hip arthroplasty | 1, 4, 8 | NA | LOS, Harris hip joint function score, VAS, cost, urinary tract infection, VTE, pressure sores |
| He [56] | 2019 | 43 43 | 83.85± 3.79 | 82.47± 3.18 | 19 (44.19) | Hip arthroplasty | 1, 4, 5, 6, 7, 8 | 1d, 2d, 1 week | The leaving bed time, respiratory, urinary tract infection, VTE, incision infection |
| Huang [57] | 2019 | 40 40 | NA | NA | NA | Hip arthroplasty | 1, 2, 4, 5, 6, 8 | NA | LOS, VAS, satisfaction, the leaving bed time, VTE, pressure sores |
| Jia [58] | 2019 | 60 60 | NA | NA | NA | Hip arthroplasty | 1, 2, 4, 5, 6, 8 | NA | Satisfaction |
| Jiang [59] | 2019 | 43 43 | 46.5± 2.4 | 41.5± 5.7 | 20 (46.51) | Hip arthroplasty | 1, 2, 4, 6, 7, 8 | 1 month, 3 months | LOS, cost |
| Jin 1 [60] | 2019 | 43 43 | 68.5± 5.6 | 66.4± 5.6 | 23 (53.49) | Hip arthroplasty | 1, 4, 5, 6, 7, 8 | 3 months | Harris hip joint function score, respiratory, urinary tract infection, VTE, pressure sores |
| Jin 2 [61] | 2019 | 132 146 | 73.5± 7.6 | 71.7± 5.2 | 103 (78.03) | Hip arthroplasty | 4, 5, 6, 7, 8 | 1d, 2d, 1 week | The leaving bed time, respiratory, urinary tract infection, VTE, incision infection |
| Li [62] | 2019 | 40 40 | 62.30± 10.40 | 62.25± 10.34 | 18 (45.00) | Hip arthroplasty | 1, 2, 3, 4, 6, 7, 8 | 1 month, 3 months | LOS, cost |
| Liang [63] | 2019 | 53 53 | 76.7± 2.4 | 77.9± 2.7 | 24 (45.28) | Hip arthroplasty | 1, 4, 5, 6, 7, 8 | 3 months | Harris hip joint function score, respiratory, urinary tract infection, VTE, pressure sores |
| Liu [64] | 2019 | 60 60 | 81.9± 4.9 | 81.6± 5.2 | 17 (28.33) | Hip arthroplasty | 3, 5, 6, 8 | NA | LOS |
| Sun [65] | 2019 | 45 45 | 69.24± 2.89 | 69.78± 2.82 | 13 (28.89) | Hip arthroplasty | 1, 3, 4, 5, 6, 7, 8 | NA | Harris hip joint function score, satisfaction, respiratory, urinary tract infection, VTE, pressure sores |
still controversial [15, 16]. Eriksson et al. pointed out that there was no difference in mortality or length of stay (LOS) between the FTS group and the standard group [17]. The result that the incidence of adverse events (AEs) in FTS group was less than standard group [18]. Hau
gan et al. also showed that there was no statistically significant difference in mortality and readmission rates between the FTS and the standard care models for first-time admission [19]. All in all, the data of FTS in the rehabilitation and prognosis of elderly patients did not meet the expectations.

The purpose of this article is to analyze the effect of nursing intervention based on FTS concept on perioperative pain management, postoperative length of stay and incidence of complications of hip fracture in the elderly by meta-analysis. It could provide effective evidence for perioperative nursing of hip fracture in the elderly.

Methods

Search strategy

Published articles were searched by two researchers for comparing the efficacy and safety of fast-track surgery (FTS) in elderly patients with hip fracture following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [20]. We have searched the RCTs systematically in the

Table 1 Characteristics of studies included in the meta-analysis. FTS fast track surgery, NA not applicable (Continued)

| Author | Publication year | Characteristics of study population | Hip fracture surgery | FTS measures | Follow-up | Endpoints |
|--------|-----------------|-------------------------------------|---------------------|-------------|----------|-----------|
| Xiao   | 2019            | 40 E 40 C 72.11±4.35 71.39±4.15 | Unilateral hip arthroplasty | 1, 4, 8 | NA | VTE, constipation |
| Yang   | 2019            | 56 E 56 C 70.24±17.76 71.57±17.43 | Hip arthroplasty, Internal fixation | 1, 7, 8 | NA | LOS |
| Yu     | 2019            | 66 E 60 C 73.94±3.87 73.77±4.25 | Hip arthroplasty, Internal fixation | 1, 2, 4, 5, 7, 8 | 3 months | LOS, satisfaction, respiratory, urinary tract infection, VTE, dislocation of prosthesis |
| Zhang  | 2019            | 49 E 49 C 73.14±2.28 73.75±2.54 | Hip arthroplasty | 4, 6, 8 | NA | LOS, satisfaction |
| Zhu    | 2019            | 90 E 90 C 72.1±8.3 72.4±8.6 | NA | 1, 4, 6, 7, 8 | 6 months | Harris hip joint function score, VAS, respiratory, urinary tract infection, VTE, pressure sores, incision infection |

FTS fast track surgery, NA not applicable. FTS measures: (1) preoperative propaganda and education/psychological counseling, (2) the method of optimizing anesthesia, (3) simplification of routine intestinal preparation before operation, (4) perioperative nutrition management, (5) perioperative heat preservation, (6) rational use of drainage tube and catheter, (7) postoperative analgesia, and (8) early postoperative normative functional exercise
| Author | Random allocation | Hidden distribution | Blind method | Incomplete Outcome Data | Selective reporting of results | Other bias | Quality grade |
|--------|-------------------|---------------------|--------------|-------------------------|-------------------------------|------------|---------------|
| Li [21] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Tian [22] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Xu [23]  | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Yang [24] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Zhang [25] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Chen 1 [26] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Chen 2 [27] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Fu [28] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Li [29] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Liu [30] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Wan [31] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Wei [32] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Yu [33] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Zhang [34] | Randomized         | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Zou [35] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Ding [36] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Jin [37] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Li 1 [38] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Li 2 [39] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Liu [40] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Qian [41] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Wang [42] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Yang 1 [43] | Randomized         | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Yang [44] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| You [45] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Zang [46] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Zhai [47] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Zheng [48] | Randomized         | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Zuo [49] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Bai [50] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Bao [51] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Chen [52] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Fusco [53] | Randomized         | No clear            | Double-Blind | Low                     | Low                           | Low        | B             |
| Guo 1 [54] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Guo 2 [55] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| He [56] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Huang [57] | Randomized         | No clear            | Double-Blind | Low                     | Low                           | Low        | B             |
| Jia [58] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | C             |
| Jiang [59] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Jin 1 [60] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Jin 2 [61] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Li [62] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Liang [63] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Liu [64] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Sun [65] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Xiao [66] | Randomized        | No clear            | Double-Blind | Low                     | Low                           | Low        | A             |
| Yang [67] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
| Yu [68] | Randomized        | No clear            | No clear     | Low                     | Low                           | Low        | B             |
Table 2: Assessment of methodological quality of included studies (Continued)

| Author | Random allocation | Hidden distribution | Blind method | Incomplete Outcome Data | Selective reporting of results | Other bias | Quality grade |
|--------|------------------|---------------------|--------------|-------------------------|-------------------------------|-----------|---------------|
| Zhang [69] | Randomized       | No clear            | No clear     | Low                     | Low                           | Low       | B             |
| Zhu [70] | Randomized       | No clear            | No clear     | Low                     | Low                           | Low       | B             |
| Borges [71] | Randomized | No clear            | No clear     | Low                     | Low                           | Low       | B             |
| Du [72] | Randomized       | No clear            | Single-Blind | Low                     | Low                           | Low       | A             |
| Ge [73] | Randomized       | No clear            | No clear     | Low                     | Low                           | Low       | C             |
| Jiang [74] | Randomized | No clear            | No clear     | Low                     | Low                           | Low       | C             |
| Liang [75] | Randomized      | No clear            | No clear     | Low                     | Low                           | Low       | B             |
| Yu [76] | Randomized       | No clear            | No clear     | Low                     | Low                           | Low       | B             |
| Zheng [77] | Randomized      | No clear            | No clear     | Low                     | Low                           | Low       | B             |

Fig. 2: Comparison of LOS between the experimental group and the control group. SMD standardized mean difference, LOS length of stay.
databases such as the Cochrane Library, Embase, PubMed, Google Scholar, Baidu Scholar, CNKI, and VIP with no restrictions on language or publication date from January 1, 2015, to August 1, 2020. The following keywords and MeSH terms were used: ‘enhanced recovery’ or ‘ERAS’ or ‘fast track surgery’ or ‘accelerated rehabilitation’ or ‘accelerated care’) and ‘hip fracture’ and ‘standard care’. Additional relevant studies were retrieved from reviews, meta-analyses, and other literature. Two authors screened and double-reviewed the retrieved studies. In the event of a dispute, it shall be settled by the third author. In this meta-analysis, all data were extracted from previously published studies, thus patient consent and ethical approval were not required.

Inclusion and exclusion criteria
The following inclusion criteria were used: (1) studies that assessed the efficacy and safety of FTS in elderly patients with hip fracture, (2) the study was a randomized controlled trial (RCT), (3) the study subjects were elderly patients undergoing hip fracture, (4) general information (e.g., gender, age, disease type) of the experimental group and the control group was not statistically different at baseline, (5) at least one of the evaluated groups was based on FTS, (6) included articles provide sufficient

Fig. 3 Comparison of Harris hip joint function score between the experimental group and the control group. SMD standardized mean difference.
data for analysis, (7) language was limited to English or Chinese, and (8) the study was extracted from January 1, 2015, to August 1, 2020.

The following exclusion criteria were used: (1) non-clinical trials, case reports or series; (2) animal experiments; (3) semi-randomized controlled trials or non-randomized trials; and (4) articles with incorrect or incomplete data, or articles whose data could not be extracted.

Endpoints
The primary endpoints for this study were length of stay (LOS), Harris hip joint function score, VAS, satisfaction.

The secondary endpoints for this study were the leaving bed time.

The postoperative complication endpoints included respiratory system infection, urinary system infection, venous thrombus embolism (VTE), pressure sore, incision infection, constipation, and prosthesis dislocation.

Fig. 4 Comparison of Harris hip joint function score between the experimental group and the control group (subgroup analysis). SMD standardized mean difference

NOTE: Weights are from random effects analysis.
Data extraction
The two authors independently reviewed the contents of the retrieval research. The primary endpoints were extracted by two authors and verified by a third author. The extracted data included the following main information: first author’s name, year of publication, sample size, sex ratio, average age, clinical diagnosis or operative type, FTS measures, follow-up time, and endpoints measured in each study. If the contents of the studies needed to be clarified, please contact the first author of the study. Disagreements were resolved through consensus or consultation with a third author.

Risk-of-bias assessments
The quality of the methodology in included studies was independently evaluated by the two authors according to the Cochrane Risk of Bias criteria. Each quality item was divided into low risk, high risk, and no obvious risk. The seven items used to estimate bias in each trial included randomization sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other biases.

Statistical analysis
Stata (version 12.0, Stata Corp, College Station, Texas) was used to analyse and pool the individual research results. Pooled results were recorded as risk ratios (RR), Standard mean difference (SMD) and 95% confidence intervals (CI) with two-sided P values. P values <0.05 were considered to be statistically significant. Heterogeneity was evaluated using the $I^2$ test. The heterogeneity was considered to be small when $I^2<50\%$ and substantial when $I^2>50\%$. The fixed effect model was used when $I^2<50\%$, while the random effect model was used when $I^2>50\%$. A funnel plot was generated to examine the publication bias and to explore the sources of heterogeneity if more than ten studies were included to assess this endpoint.
Results
Studies retrieved and characteristics
A total of 16018 relevant studies were enrolled according to PRISMA guidelines. The titles and abstracts of the studies were screened to exclude irrelevant studies. Then, we further eliminated the unfit studies by reading the full text of the articles. Finally, 57 studies [21-77] were included according to the inclusion and exclusion criteria and they had a total of 8886 patients as shown in Fig. 1. In general, 4448 patients (50.06%) were randomized to experimental group whereas 4438 patients (49.94%) were randomized to control group. All studies included in this meta-analysis were RCTs. The basic characteristics of the individuals from the trials are described in Table 1.

Literature quality evaluation
The Cochrane Risk of Bias criteria was used to evaluate the quality of the retrieved studies by two authors. The included studies were all randomized controlled trials. Fifty-seven studies [21-77] described random sequence generation and allocation concealment. Four studies [53, 57, 66, 72] described blinding of participants and personnel. Four studies [53, 57, 66, 72] described blinding of outcome assessment. None of the studies described other biases. The literature quality score is shown in Table 2.

Primary endpoints
Length of stay (LOS)
Thirty-three studies [21-26, 30-37, 39, 42, 43, 45, 48, 52, 54, 56-58, 60, 62, 64, 67-69, 73, 75, 76] reported

![Fig. 6 Comparison of VAS between the experimental group and the control group. (subgroup analysis). SMD standardized mean difference, VAS visual analog scale](image-url)
length of stay (LOS). In total, 3526 patients were involved to evaluate LOS, wherein 1773 were assigned to experimental group and 1753 were assigned to control group. The result showed that patients’ LOS in experimental group was significantly less than that in control group (SMD: −1.94, 95% CI −2.29 to −1.59, I²=94.7%) as shown in Fig. 2.

**Harris Hip Joint Function Score**

Harris hip joint function score scale is a widely used method to evaluate hip function. The higher the total score, the stronger the function. Harris hip joint function score was reported in 25 studies [21, 23, 25, 27–29, 33–35, 38, 41, 43, 48–51, 55, 56, 63, 65, 70, 72–74, 77]. 2441 patients were involved in all, wherein 1232 were assigned to the experimental group and 1209 were assigned to control group. The result showed that patients’ score in experimental group was significantly greater than that in control group (SMD: 2.22, 95% CI 1.73 to 2.71, I²=95.9%) as shown in Fig. 3. The random effect model was applied. Subgroup analysis was performed according to the follow-up period and divided into 1 month after surgery, 6 months after surgery, and not applicable three group. The result of follow-up time subgroup showed that patients’ Harris hip joint function score 6 months after surgery in experimental group was significantly higher than that in control group, though the not applicable group is the highest. (SMD: 1.50, 95% CI 0.88 to 2.13; SMD: 2.20, 95% CI 1.27 to 3.12; SD, 95% CI 2.21 to 4.34) as shown in Fig. 4.

**VAS**

Visual analog scale (VAS) was used to score the pain degree of patients, which the score was in direct proportion to the pain degree. It was reported by 13 studies [25, 27, 28, 37, 40, 41, 44, 51, 56, 58, 70, 72, 76] included 1293 patients, wherein 649 were assigned to the experimental group and 644 were assigned to control group. The result showed that FTS could reduce VAS significantly in experimental group than control group (SMD: −2.38, 95% CI −3.26 to −1.49, I²=97.4%) as shown in Fig. 5. The random effect
model was applied. Subgroup analysis was performed according to the follow-up time and divided into 1 month after surgery and others’ group. The result of follow-up subgroup was showed that the VAS in experimental group was significantly less than that in control group in 1 month after surgery subgroup (SMD: -2.76, 95% CI -3.79 to -1.73; SMD: -1.93, 95% CI -3.38 to -0.47) as shown in Fig. 6.

Satisfaction
Sixteen studies [21, 26, 32, 42, 45–47, 52, 58–60, 65, 68, 69, 75, 76] reported patients’ satisfaction about the FTS. In total, 903 out of 930 patients in experimental group satisfied with the FTS while 740 out of 908 patients in the control group satisfied with the standard care. The result showed that FTS care significantly raised the satisfaction compared to the control group (97.1% vs 81.0%) (RR: 1.19, 95% CI 1.15 to 1.23, $I^2=68.9\%$) as shown in Fig. 7.

Secondary endpoints
The result showed that compared to the control group, FTS could significantly reduce the leaving bed time (SMD: -3.09, 95% CI -4.27 to -1.92, $I^2=97.6\%$) as shown in Fig. 8; it also could decrease the hospitalization costs (SMD: -4.83, 95% CI -6.32 to -3.34, $I^2=98.5\%$) as shown in Fig. 9.

Postoperative complications endpoints
The result showed that compared to the control group, FTS could significantly reduce the incidence of respiratory system infection (3.52% vs 5.28%) (RR: 0.68, 95% CI 0.52 to 0.87, $I^2=20.7\%$); urinary system infection (2.22% vs 6.98%) (RR:0.33, 95% CI 0.21 to 0.52, $I^2=0.0\%$); VTE (1.13% vs 3.24%) (RR:0.40, 95% CI 0.29 to 0.56, $I^2=0.0\%$); pressure sore (2.50% vs 4.02%) (RR:0.63, 95% CI 0.47 to 0.86, $I^2=13.5\%$); incision infection (2.08% vs 4.66%) (RR:0.47, 95% CI 0.23 to 0.95, $I^2=0.0\%$); constipation (3.33% vs 7.75%) (RR:0.43, 95% CI 0.20 to 0.93, $I^2=0.0\%$) and prosthesis dislocation (0.65% vs 3.04%) (RR:0.31, 95% CI 0.12 to 0.84, $I^2=0.0\%$) as shown in Figs. 10, 11, 12, 13, 14, 15 and 16.

Publication bias and sensitivity analysis
The funnel plot showed that there was bias among retrieved articles as shown in Supply Fig. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13.
Discussion

Fast track surgery (FTS), also named as enhanced recovery after surgery (ERAS), improved or reselected partially perioperative steps of traditional hip arthroplasty in order to reduce the direct surgical injury, surgical stress response, and operation-related complication and achieve the purpose of promoting the rapid rehabilitation of patients, which could shorten the length of stay and reduce the cost of hospitalization [78–80]. The ultimate objective of FTS is to achieve “painless and risk-free surgery,” which has attracted worldwide attention [81].

Kehlet published an article to describe “fast-track surgery” (also known as enhanced recovery after surgery, ERAS) in 2001 first. The ERAS society, a non-profit and multidisciplinary medical association, was founded later that same year, aimed to help worldwide to carry through ERAS Social Guidelines systematically, and it has remained a challenge to monitor patient compliance and follow-up the rehabilitation outcomes [82]. The UK’s National Hip Fracture Database (NHFD), which collected information about fractured neck of femur, was established in 2007 and the most recent report supported early rehabilitation exercise [83]. NHFD has been focus on orthogeriatric assessment recently, an assessment before operation similar to the ERAS principles [84].

Nowadays, preoperative management of diabetes and anemia, personalized risk assessment, path sharing between enhanced recovery and hospitals, individualized pain management, multimodal anesthesia strategies, and the great differences in nursing in different area and so on still have room for improvement, which limited the promotion of FTS in worldwide [85]. Meanwhile, the research on ERAS has gradually shifted from standard indicators such as mortality, morbidity, and readmission rate to patient-reported outcome measures (PROMs).

The results we got consist with Husted et al.’s [86] (a prospective study), Larsson et al.’s [13] (a retrospective pilot study), and Bao et al.’s (a meta-analysis), which suggested that patients could leave bed, recover the function of hip joint faster, suffer less pain, and reduce
the incidence of postoperative complications, which could achieve the purpose of leaving hospital as soon as possible in addition after FTS. The novel nursing care delivery system also has a better satisfaction. However, the focus of their RCTs was to shorten the preparation time and nursing time, which means the results they come to may be influenced by shorter waiting times for surgery and cannot be attributed solely to the improvement of the chains of nursing. Bao et al. included a portion of studies with a lower quality, which might be measurement bias and selective bias, besides, the meta-analysis only analyzed the perioperative pain management of FTS [87]. Pollmann et al. [88] suggested that although the introduction of fast-track care for hip fractures significantly reduced length of stay, duration of surgery and risk of reoperation within 30 days, there was no significant difference in 30-day, 90-day, or 1-year mortality rates. The data of the study were obtained retrospectively from electronic hospital records so that we could not identified that whether the patients follow the nursing protocol strictly. About half of the data on the admission are unclear, the others were admitted through fast-track admission pathway, which may have an influence on the outcome of mortality. The study by Amlie et al. reported that compared with the standard THA patients, patients with FTS regimen had an increased risk of postoperative revision surgery due to deep infection [89]. Therefore, there is still a controversial about whether FTS is effective and safe enough in the perioperative period for elderly patients with hip fracture.

At the time of assessment of the primary end point, a subgroup analysis was performed based on follow-up time. Subgroup analysis is performed only if each subgroup has more than two experimental comparisons. The result of follow-up time subgroup showed that

![Incidence of respiratory infection between the experimental group and the control group. RR risk ratio](image_url)
patients’ Harris hip joint function score 6 months after surgery in the experimental group was significantly higher than that in control group, though the not applicable group is the highest. It could be concluded that FTS improves the long-term functional recovery of patients after hip replacement. The VAS in experimental group was significantly less than that in the control group 1 month after surgery.

As the primary endpoint, we evaluated was highly heterogeneous, and we did sensitivity analyses to decompose it. The results showed that after excluding Jia et al.’s article [59], and the overall effect of LOS has been affected significantly. We speculated that that the control group in research also offer a guidance of fracture functional exercise postoperative. There is also a great deal of influence of the overall effect of respiratory, VTE, and pressure sores after excluding Borges et al.’s article [72]. However, the RCT focused on accelerated surgical treatment (within 6 h), so that the waiting time for surgery is shorter than that of other patients, which may lead to heterogeneity.

The potential clinical implications of this meta-analysis are as follows: (1) 57 RCTs were retrieved which included a large sample size of 8886 participants compared to previous studies. (2) Subgroup analyses were performed according to the follow-up period to explain the influence of different factors on the overall effect. (3) We evaluated 12 indicators, including length of stay (LOS), Harris hip joint function score, VAS, satisfaction, the leaving bed time, respiratory system infection, urinary system infection, VTE, pressure sore, incision infection, constipation, and prosthesis dislocation, which were more comprehensive than previous articles.

The limitations of this study are as follows: (1) Most of the elderly patients with hip fractures were associated with risk factors (such as elder age, smoking), other complications (such as diabetes,
hypertension), or some drug use history, which were adverse to incision healing. The influence of these baseline factors was not excluded and may lead to mixed bias. (2) We use the outcomes from reported events retrieved to integrate the results of this meta-analysis, so it is difficult to assess the impact of these baseline characteristics on the result. (3) Due to the limitations of the included study, this study was unable to explore the interaction between sub-group analyses. (4) The detail of the intervention measures in the control group (or standard track group) was not acceptable in most articles. (5) Only 3 of the retrieved articles were published in English journals and 54 in Chinese journals. Therefore, we have correctly attempt to address this problem by assessing the quality of the studies retrieved and rating most of them B. 

This meta-analysis reveals that FTS could significantly shorten the LOS and reduce VAS, the leaving bed time, and the hospitalization costs and improve hip function. The incidence of complications (such as respiratory system infection, urinary system infection, VTE, pressure sore, incision infection, constipation, and prosthesis dislocation) also has been decreased significantly. Meanwhile, FTS improved patients’ satisfaction apparently. Its efficacy and safety were proved to be reliable.
**Fig. 13** Incidence of pressure sores between the experimental group and the control group. RR risk ratio

| Name | Year | Experimental | Control | RR (95% CI) | Weight |
|------|------|--------------|---------|-------------|--------|
| Xu   | 2016 | 1/55         | 2/55    | 0.50 (0.05, 5.36) | 1.98   |
| Zhang| 2016 | 0/56         | 7/52    | 0.06 (0.00, 1.06) | 7.68   |
| Chen 1| 2017| 2/106        | 5/92    | 0.35 (0.07, 1.75) | 5.29   |
| Fu   | 2017 | 1/40         | 1/40    | 1.00 (0.06, 15.44) | 0.99   |
| Zhang| 2017 | 1/43         | 3/43    | 0.33 (0.04, 3.08) | 2.96   |
| Li 2 | 2018 | 0/60         | 3/60    | 0.14 (0.01, 2.71) | 3.46   |
| Yang 1| 2018| 1/50         | 4/50    | 0.25 (0.03, 2.16) | 3.95   |
| Zhai | 2018 | 0/40         | 3/40    | 0.14 (0.01, 2.68) | 3.46   |
| Bai | 2019 | 1/64         | 2/64    | 0.50 (0.05, 5.38) | 1.98   |
| Bao | 2019 | 2/49         | 4/48    | 0.49 (0.09, 2.55) | 3.99   |
| He | 2019 | 1/43         | 5/53    | 0.20 (0.02, 1.64) | 4.94   |
| Jia | 2019 | 0/60         | 3/60    | 0.14 (0.01, 2.71) | 3.46   |
| Liang | 2019| 0/53        | 2/53    | 0.20 (0.01, 4.07) | 2.47   |
| Sun | 2019 | 1/45         | 2/45    | 0.50 (0.05, 5.32) | 1.98   |
| Zhu | 2019 | 0/90         | 2/90    | 0.20 (0.01, 4.11) | 2.47   |
| Borges | 2020| 48/1487       | 41/1483 | 1.17 (0.77, 1.76) | 40.56  |
| Du | 2020 | 0/50         | 4/50    | 0.11 (0.01, 2.01) | 4.45   |
| Yu | 2020 | 2/45         | 4/47    | 0.50 (0.10, 2.60) | 3.95   |
| Overall (I-squared = 13.5%, p = 0.292) |       |             |         | 0.63 (0.47, 0.86) | 100.00 |
Fig. 14 Incidence of incision infection between the experimental group and the control group. RR risk ratio.
Fig. 15 Incidence of constipation between the experimental group and the control group. RR risk ratio
Fig. 16 Incidence of dislocation of prosthesis between the experimental group and the control group. RR risk ratio.
Due to individual differences of every patient, the fast track should be adjusted clinically so that patients with special needs or high co-morbidity burden should be transferred to a safe and effective FTS [84]. A people-oriented approach is an important factor in optimizing care from surgical decisions to rehabilitation [85].

In the future, the perioperative strategy of rapid rehabilitation surgery in total hip replacement will need to extract more large samples of high quality for evidence-based analysis under a more perfect unified standard, so as to conduct more safe and effective multidisciplinary cooperation.

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Authors’ contributions
J.M. designed the study; J.M. and L.S. pooled the data; J.M. analyzed the data; J.M., L.S., D.H., and L.X. wrote the article; and B.Z. reviewed the article. The authors read and approved the final manuscript.

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Author details
1Department of Bone and Joint Surgery, The First Affiliated Hospital of Guangxi Medical University, Nanning, Guangxi, China. 2Guangxi Medical University, Nanning, Guangxi, China.

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Abbreviations
RCT: Randomized controlled trials; RR: Risk ratios; SMD: Standard mean difference; CI: Confidence intervals; HA: Hip arthroplasty; FTS: Fast track surgery; ERAS: Enhanced recovery after surgery; LOS: Length of stay; VAS: Visual analog scale
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