REVIEW ARTICLE

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A systematic review regarding clinical characteristics, complications, and outcomes of surgical and non-surgical patients with fragility fracture of the pelvis

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ABSTRACT

We conducted this systematic review to clarify the clinical characteristics, complications, and outcomes of surgical and non-surgical patients with fragility fracture of the pelvis (FFP). We searched PubMed, Google Scholar, Cochrane Library, Web of Science, and MEDLINE for English language articles on FFP. We calculated pooled odds ratios (ORs) or mean differences (MDs) of surgical patients in comparison to non-surgical patients for clinical characteristics (Rommens FFP classification, age, sex, dementia, osteoporosis, diabetes mellitus, pulmonary disease, cardiovascular disease, and malignancy), complications (pneumonia, urinary tract infection, cardiac event, thrombosis, pulmonary embolism, pressure ulcer, multiple organ failure, anemia caused by surgical bleeding, and surgical site infection), and outcomes (hospital mortality and one-year mortality). Five studies involving 1,090 patients with FFP (surgical patients, $n = 432$; non-surgical patients, $n = 658$) were included. FFP type III and IV (OR = 8.44; 95% confidence interval [CI] 5.99 to 11.88; $p<0.00001$), a younger age (MD = –3.29; 95% CI –3.83 to –2.75; $p<0.00001$), the absence of dementia (OR = 0.36; 95% CI 0.23 to 0.57; $p<0.0001$), and the presence of osteoporosis (OR = 1.74; 95% CI 1.29 to 2.35; $p = 0.0003$) were significantly associated with the surgical patients. Urinary tract infection (OR = 2.06; 95% CI 1.37 to 3.10; $p = 0.0005$), anemia caused by surgical bleeding (OR = 4.55; 95% CI 1.95 to 10.62; $p = 0.0005$), and surgical site infection (OR = 16.74; 95% CI 3.05 to 91.87; $p = 0.001$) were significantly associated with the surgical patients. There were no significant differences in the outcomes between the surgical and non-surgical patients. Our findings may help to further understand the treatment strategy for FFP and improve clinical outcomes.

Keywords: fragility fracture of the pelvis, review, complication, mobility, surgery

Abbreviations:
FFP: fragility fracture of the pelvis
OR: odds ratio
MD: mean difference
CI: confidence interval
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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INTRODUCTION

Fragility fracture of the pelvis (FFP) is a common injury caused by low-energy trauma (eg, fall from standing height or lower) in the elderly with loss of bone mineral density.[1-6] The prevalence has been rising with the aging of the world's population.[7-9] Nevertheless, the treatment strategy for FFP remains the subject of ongoing debate.[10-18] Rommens et al[10-13] recently developed a radiographic classification of FFP and a management protocol (Fig. 1): conservative therapy is efficacious for FFP types I (anterior lesions only) and II (non-displaced posterior lesions). If conservative therapy fails after days or weeks in FFP type I, magnetic resonance imaging is performed to rule out occult sacral fractures. If conservative therapy fails within days in FFP type II, surgical stabilization is recommended. In contrast, surgical stabilization is recommended for FFP types III (displaced unilateral posterior lesions) and IV (displaced bilateral posterior lesions). Surgery is performed after obtaining written informed consent from the patient or their relatives in all cases. This treatment strategy is one of the most commonly applied classifications and management protocols for FFP.[10-18] To further understand the treatment strategy of FFP described by Rommens et al[10-13] and to improve the clinical outcomes, the clinical characteristics,

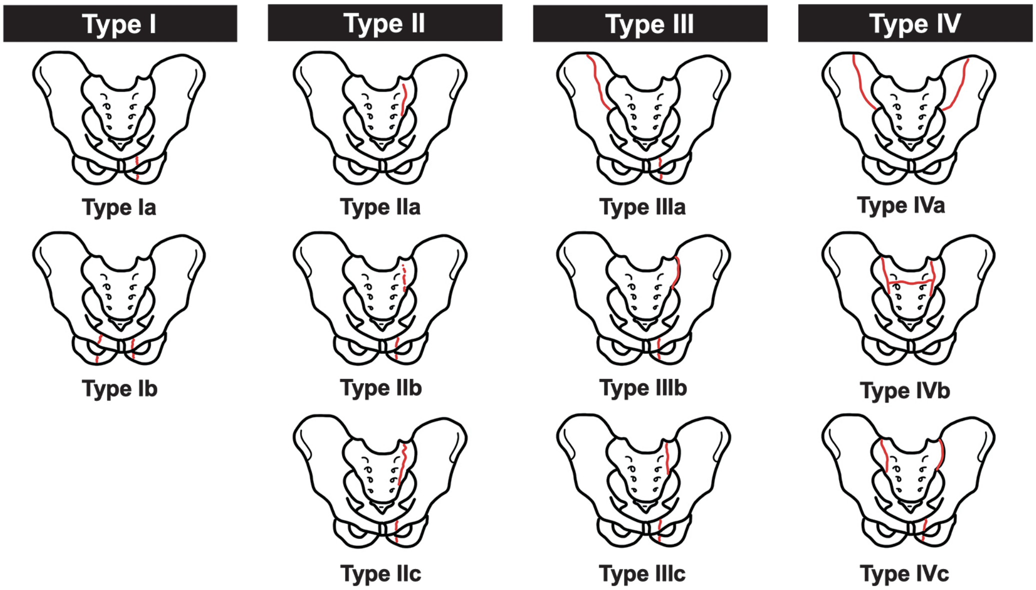

Fig. 1 Rommens classification of fragility fractures of the pelvis (FFP)[10–13]
FFP type Ia: unilateral anterior pelvic ring disruption
FFP type Ib: bilateral anterior pelvic ring disruption
FFP type IIa: dorsal non-displaced posterior injury only
FFP type IIb: sacral crush with anterior disruption
FFP type IIc: non-displaced sacral, sacroiliac, or iliac fracture with anterior disruption
FFP type IIIa: displaced unilateral iliac fracture and anterior disruption
FFP type IIIb: displaced unilateral sacroiliac disruption and anterior disruption
FFP type IIIc: displaced unilateral sacral fracture together with anterior disruption
FFP type IVa: bilateral iliac fractures or bilateral sacroiliac disruptions together with anterior disruption
FFP type IVb: spinopelvic dissociation together with anterior disruption
FFP type IVc: combination of various posterior instabilities together with anterior disruption
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complications, and outcomes of surgical and non-surgical patients with FFP should be clarified.[16-24] We therefore conducted the present systematic review.

MATERIALS AND METHODS

Search strategy and criteria

The protocol of the systematic review was registered at the International Prospective Register of Systematic Reviews (PROSPERO registration no. CRD42021276549). This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[25,26] PubMed, Google Scholar, Cochrane Library, Web of Science, and MEDLINE were searched for relevant English language articles that compared the clinical characteristics, complications, and outcomes between surgical and non-surgical FFP patients, who were treated according to the strategy described by Rommens et al.[10-13] All searches were conducted on November 1, 2021. The search terms used in PubMed were as follows: (fragility fracture[Title/Abstract]) OR (osteoporotic fracture[Title/Abstract]) AND (pelvis[Title/Abstract]). The other databases were searched using similar search strategies. We excluded articles that did not investigate this topic, as well as review articles, case reports ($n<3$), commentaries, editorials, insights articles, and proceedings. We searched for unpublished or gray literature in this systematic review. We screened websites, organizations, or the reference lists of records identified through the database search. Two researchers (TK and TA) independently evaluated the eligibility of retrieved articles and any disagreements were resolved based on a discussion. No ethics committee or institutional review board approval was required for this systematic review.

Quality assessment

Quality assessment was performed according to the Newcastle–Ottawa Scale,[27] as the eligible studies were not randomized trials (prospective or retrospective cohort studies). Two researchers (TK and TA) independently screened the extracted literature and extracted the data to ensure the consistency of the results; any disagreements were resolved with a discussion.

Data extraction

The following data were extracted: first author, publication year, study type, patient (ie, number of patients, Rommens FFP classification,[10-13] age, and sex), surgical patients (ie, number of patients, age, sex, and surgical treatment), non-surgical patients (ie, number of patients, age, sex), clinical characteristics (ie, Rommens FFP classification, age, sex, dementia, osteoporosis, diabetes mellitus, pulmonary disease, cardiovascular disease, and malignancy), complications (ie, pneumonia, urinary tract infection, cardiac event, thrombosis, pulmonary embolism, pressure ulcer, multiple organ failure, anemia caused by surgical bleeding, and surgical site infection), and outcomes (hospital mortality and one-year mortality). Two researchers (TK and TA) independently extracted the data.

Data analysis and statistical methods

This systematic review was performed using the Review Manager software program (version 5.3; The Cochrane Collaboration, Oxford, United Kingdom). The number of events was entered for binary variables and the number of subjects, as well as the mean value and standard deviation of continuous variables and the number of subjects. The X^2 test and I^2 statistic were performed to assess the heterogeneity level: insignificant (I^2 0% to <25%), low (I^2 25% to <50%), and significant (I^2 50–100%). If significant heterogeneity was observed ($p<0.10$ and $I^2>50\%$), a random-effects model was used for the analysis. Otherwise, a fixed-effects model was used.

Binary variables were evaluated using odds ratios (ORs) with 95% confidence intervals (CIs). Continuous variables were evaluated using mean difference (MDs) with 95% CIs. *P* values of <0.05 were considered to indicate statistical significance. One researcher (TK) performed all of the statistical analyses.

RESULTS

Search results

Figure 2 shows the PRISMA flow chart for our systematic review. The initial database search identified 376 records. After screening, 7 records underwent full-text review. Two full-text records

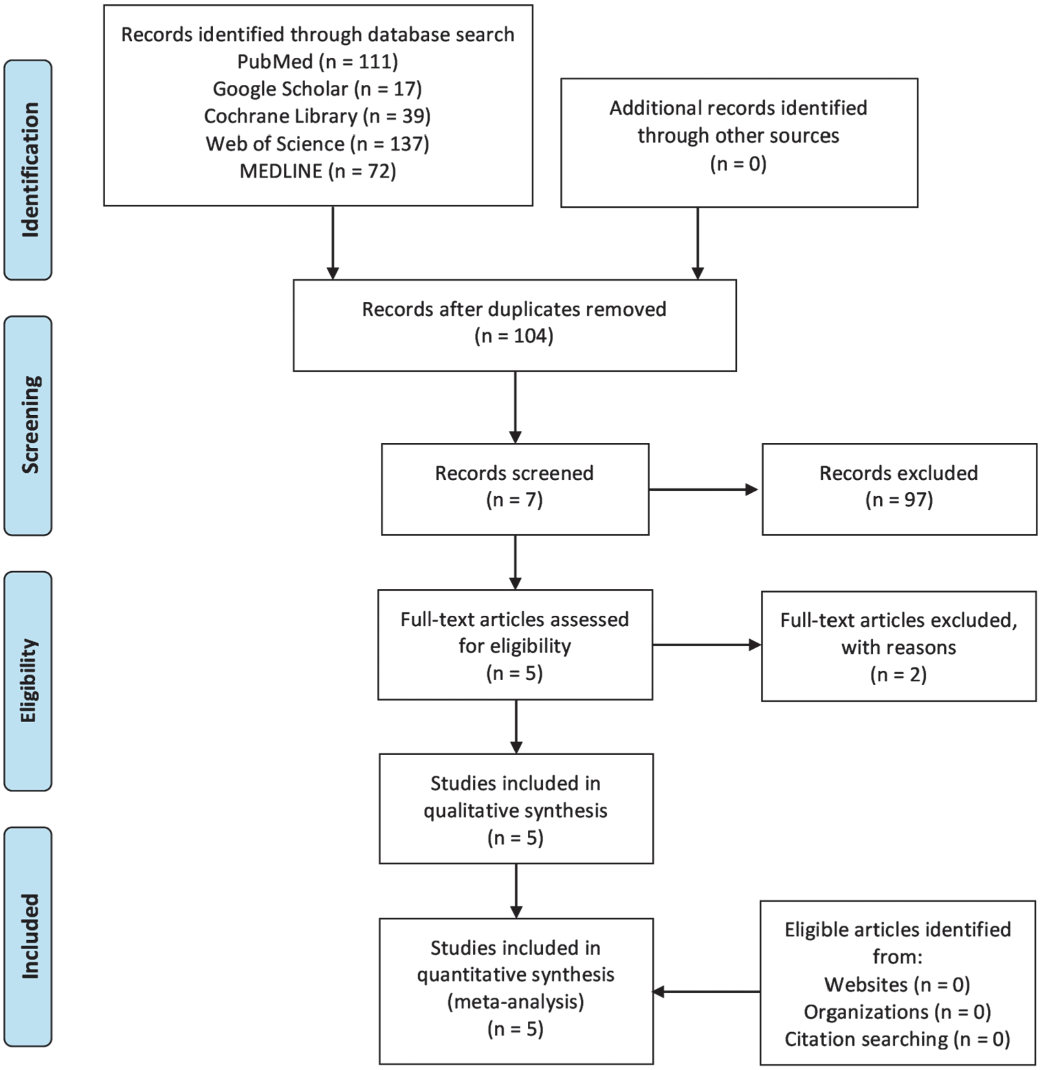

Fig. 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart describing article selection

Table 1 Summary of selected studies

Author, Year	Study design	Patient	Surgical patient	Non-surgical patient	Characteristic	Complication	Outcome
Oberkircher et al, 2021[20]	Prospective	FFP, 134 (type I, 41; type II, 81; type III, 10; type IV, 2) Age (years), 79.9 ± 7.7 Gender (men/women), 52/82	Surgical treatment, 48 (percutaneous surgery, 35; ORIF, 13) Age (years), 78.5 ± 7.0 Gender (men/women), N/A	Non-surgical treatment, 86 Age (years), 80.7 ± 7.6 Gender (men/women), N/A	Rommens FFP classification and age	Pneumonia, urinary tract infection, cardiac event, pulmonary embolism, multiple organ failure, anemia caused by surgical bleeding, and surgical site infection	Hospital mortality
Gericke et al, 2021[21]	Retrospective	FFP, 379 (type I, 56; type II, 200; type III, 58; type IV, 65) Age (years), 81.3 ± 7.5 Gender (men/women), 74/305	Surgical treatment, 168 (percutaneous surgery, 74; ORIF, 94) Age (years), 79.4 ± 6.6 Gender (men/women), 38/130	Non-surgical treatment, 211 Age (years), 82.8 ± 7.8 Gender (men/women), 36/175	Rommens FFP classification, age, sex, dementia, osteoporosis, diabetes mellitus, pulmonary disease, cardiovascular disease, and malignancy	Pneumonia, cardiac event, thrombosis, pulmonary embolism, multiple organ failure, anemia caused by surgical bleeding, and surgical site infection	N/A
Rommens et al, 2021[22]	Retrospective	FFP, 362 (type II, 238; type III/IV, 124) Age (years), 81 Gender (men/women), 48/314	Surgical treatment, 138 (percutaneous surgery, 118; ORIF, 20) Age (years), 79 Gender (men/women), 15/123	Non-surgical treatment, 224 Age (years), 82 Gender (men/women), 33/191	Rommens FFP classification, sex, dementia, osteoporosis, diabetes mellitus, pulmonary disease, cardiovascular disease, and malignancy	Pneumonia, urinary tract infection, cardiac event, thrombosis, pulmonary embolism, and pressure ulcer	Hospital mortality and one-year mortality
Saito et al, 2021[23]	Retrospective	FFP, 64 (type III, 40; type IV, 24) Age (years), 82.6 ± 6.4 Gender (men/women), 6/58	Surgical treatment, 20 (N/A) Age (years), 81.6 ± 5.6 Gender (men/women), 0/20	Non-surgical treatment, 44 Age (years), 83.1 ± 6.7 Gender (men/women), 6/38	Age and sex	Pneumonia, urinary tract infection, cardiac event, and pressure ulcer	One-year mortality
Nuber et al, 2021[24]	Prospective	FFP, 151 (type I, 12; type II, 81; type III, 11; type IV, 47) Age (years), 81.8 ± 2.4 Gender (men/women), 20/131	Surgical treatment, 58 (N/A) Age (years), 79.7 ± 1.9 Gender (men/women), 6/52	Non-surgical treatment, 93 Age (years), 83.1 ± 1.6 Gender (men/women), 14/79	Age and sex	Pneumonia, urinary tract infection, thrombosis, anemia caused by surgical bleeding, and surgical site infection	One-year mortality

FFP: fragility fracture of the pelvis
ORIF: open reduction and internal fixation
N/A: not available
Values (age) are expressed as the mean ± standard deviation or the median.

were excluded due to a lack of comparison (ie, non-surgical cases).[16,19] No eligible articles were identified from websites, organizations, or the reference lists. Finally, we found 5 published studies[20-24] involving 1,090 patients with FFP (surgical patients, $n = 432$; non-surgical patients, $n = 658$) that were eligible for inclusion in the present systematic review (Table 1).

Risk-of-bias assessment

Table 2 shows the Newcastle–Ottawa Scale scores for the selected studies. The scores ranged from 6 to 7. We therefore considered the present systematic review to be of acceptable quality.

Risk of publication bias

Figure 3 shows a funnel plot of age. All values were inside the range of acceptability and close to the no-effect line. Thus, we considered that this systematic review was associated with an acceptable degree of publication bias.

Table 2 Assessment of the quality of studies according to the Newcastle–Ottawa Scale for cohort studies

Study	Selection	Comparability	Outcome	Score
Oberkircher et al, 2021[20]	★★★	★	★★	6
Gericke et al, 2021[21]	★★★		★★★	6
Rommens et al, 2021[22]	★★	★	★★★	6
Saito et al, 2021[23]	★★	★	★★★	6
Nuber et al, 2021[24]	★★★	★	★★★	7

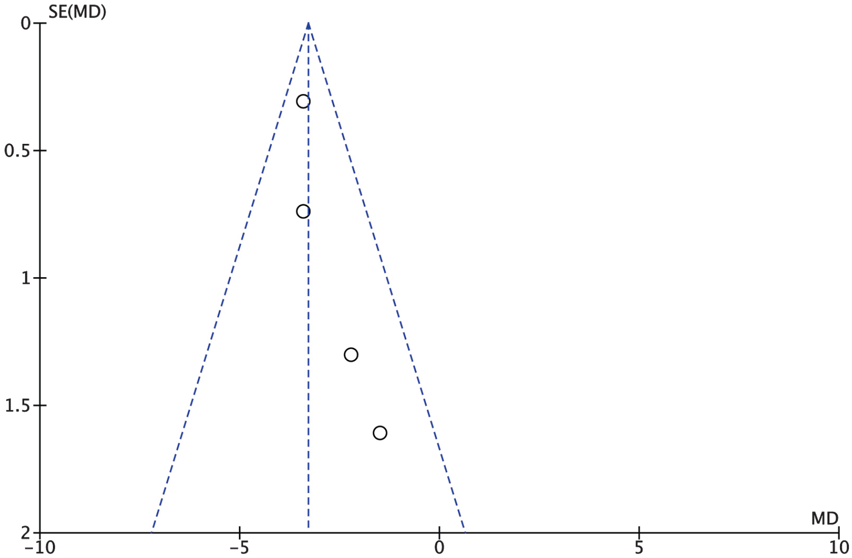

Fig. 3 Funnel plot of age

Main results

Regarding the clinical characteristics, nine factors were identified in this systematic review (Figs. 4 and 5). We found no heterogeneity in FFP type III and IV ($I^2=0\%$, $p=0.93$), age ($I^2=0\%$, $p=0.55$), female ($I^2=44\%$, $p=0.15$), dementia ($I^2=0\%$, $p=0.92$), osteoporosis ($I^2=16\%$, $p=0.28$), diabetes mellitus ($I^2=0\%$, $p=0.45$), pulmonary disease ($I^2=0\%$, $p=0.95$), cardiovascular disease ($I^2=0\%$, $p=0.40$), or malignancy ($I^2=0\%$, $p=0.52$). Therefore, a fixed model was used. FFP type III and IV (OR=8.44; 95% CI 5.99 to 11.88; $p<0.00001$), younger age (MD=–3.29; 95% CI –3.83 to –2.75; $p<0.00001$), absence of dementia (OR=0.36; 95% CI 0.23 to 0.57; $p<0.0001$), and presence of osteoporosis (OR=1.74; 95% CI 1.29 to 2.35; $p=0.0003$) were associated with the surgical patients. No significant differences existed in the other clinical characteristics of the surgical and non-surgical patients.

Regarding the complications, nine factors were identified in this systematic review (Figs. 6 and 7). We found no heterogeneity in pneumonia ($I^2=0\%$, $p=0.90$), urinary tract infection ($I^2=9\%$, $p=0.35$), cardiac event ($I^2=0\%$, $p=0.91$), thrombosis ($I^2=19\%$, $p=0.29$), pulmonary

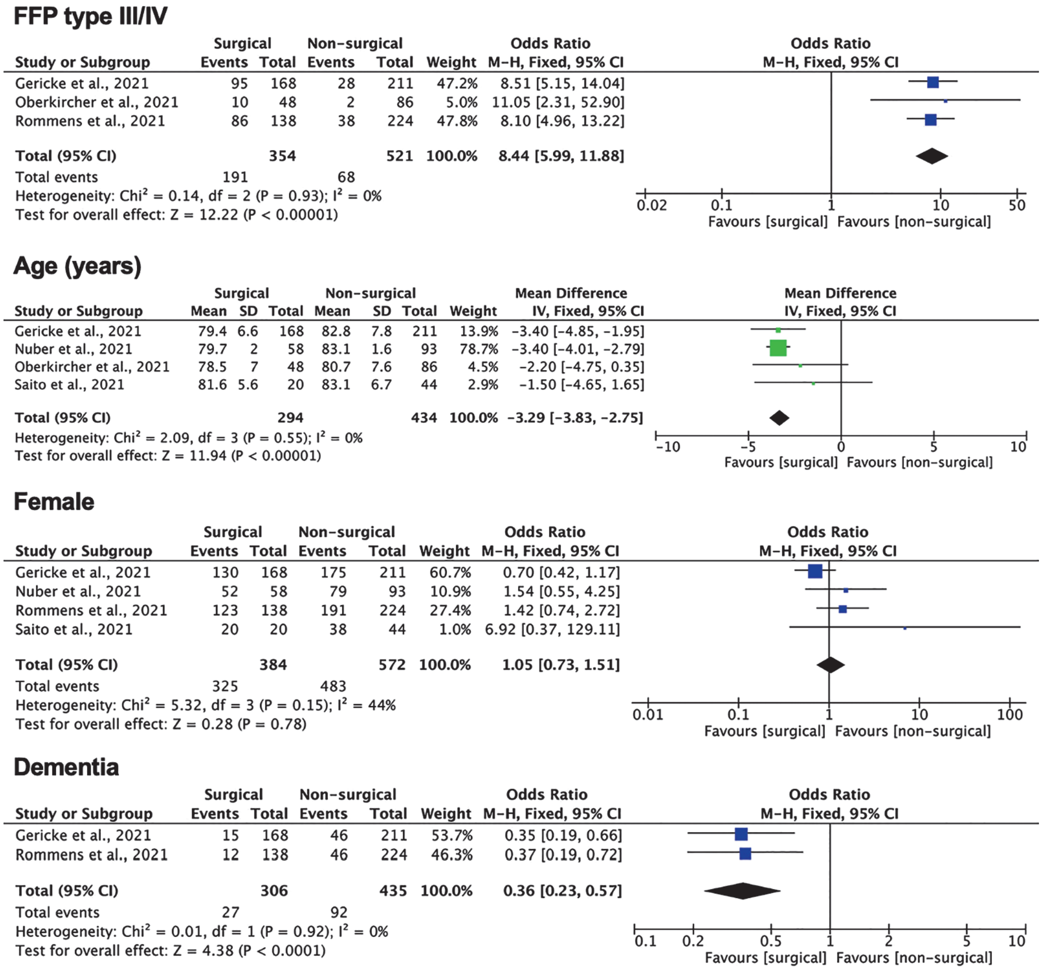

Fig. 4 Forest plot of the clinical characteristics

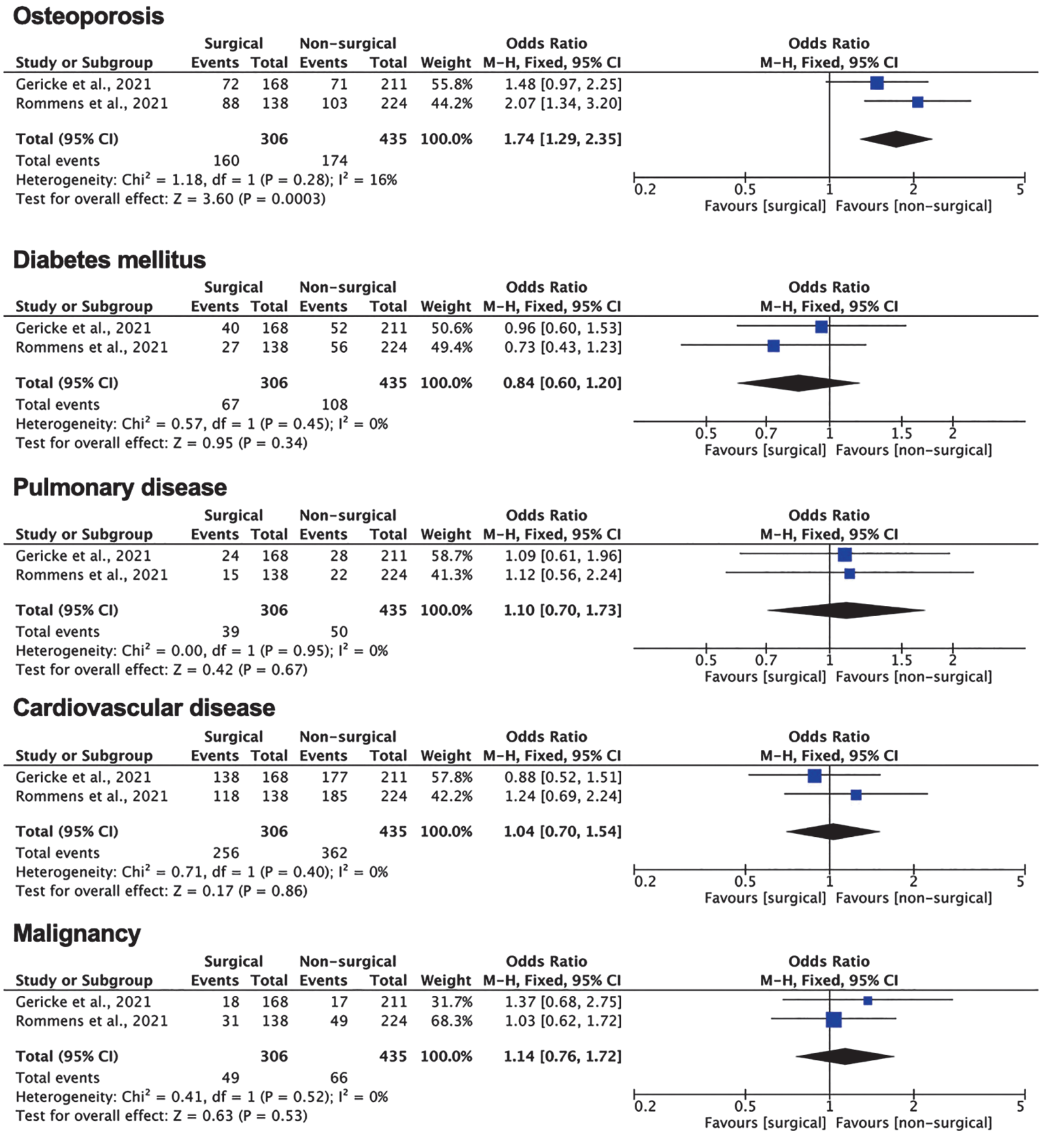

Fig. 5 Forest plot of the clinical characteristics (continued)

embolism ($I^2=0\%$, $p=0.54$), pressure ulcer ($I^2=34\%$, $p=0.22$), multiple organ failure ($I^2=0\%$, $p=0.93$), anemia caused by surgical bleeding ($I^2=0\%$, $p=0.87$), or surgical site infection ($I^2=0\%$, $p=0.62$). According to these results, a fixed model was used. Urinary tract infection (OR=2.06; 95% CI 1.37 to 3.10; $p=0.0005$), anemia caused by surgical bleeding (OR=4.55; 95% CI 1.95 to 10.62; $p=0.0005$), and surgical site infection (OR=16.74; 95% CI 3.05 to 91.87; $p=0.001$) were associated with the surgical patients. No significant differences were observed in the other complications of the surgical and non-surgical patients.

Regarding the outcomes, two factors were identified in this systematic review (Fig. 7). We found no heterogeneity in hospital mortality ($I^2=0\%$, $p=0.52$). According to these results, a fixed model was used. In contrast, we found a significant heterogeneity in one-year mortality ($I^2=84\%$, $p=0.002$), and therefore used a random model. No significant differences were observed in the outcomes of the surgical and non-surgical patients.

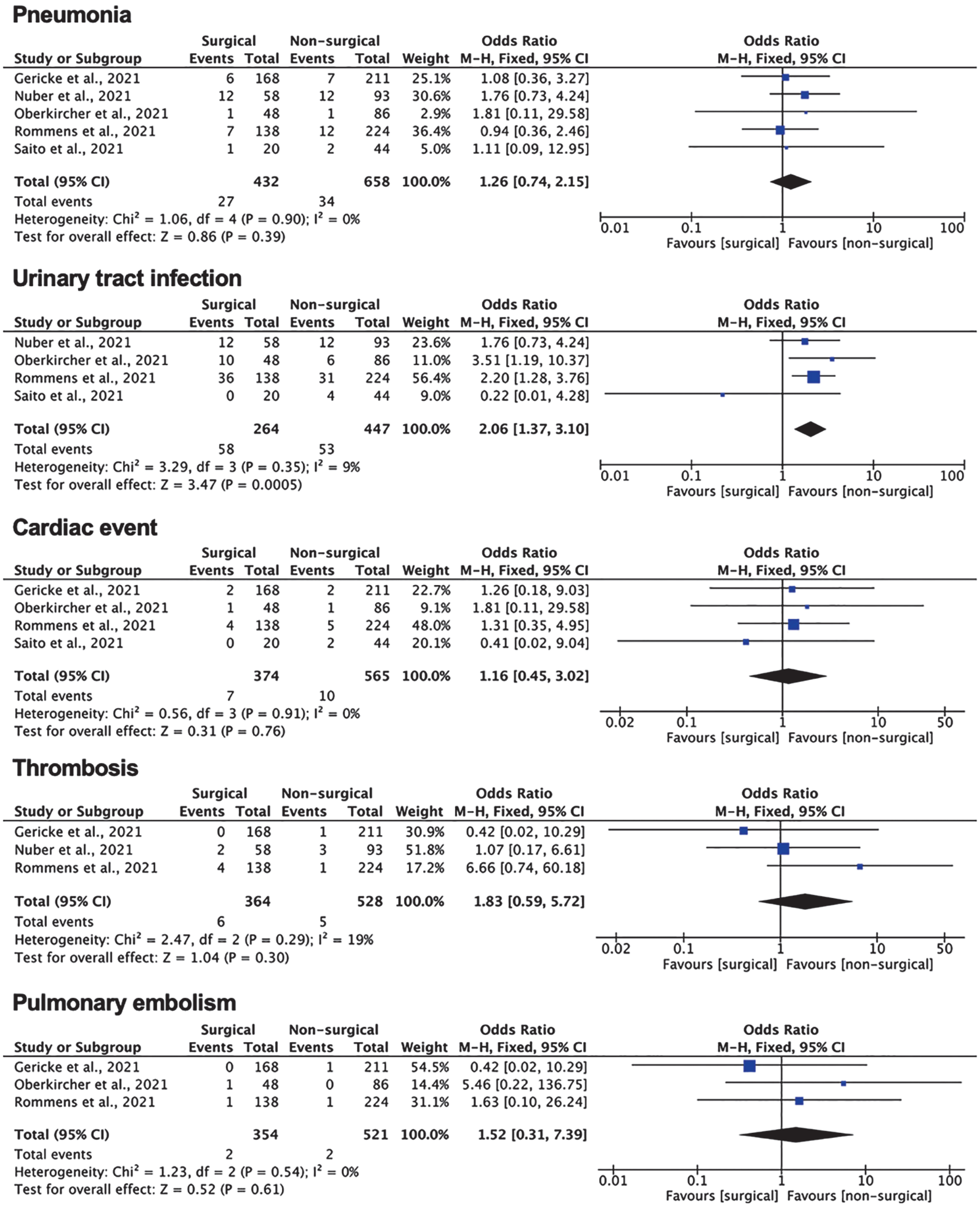

Fig. 6 Forest plot of the complications

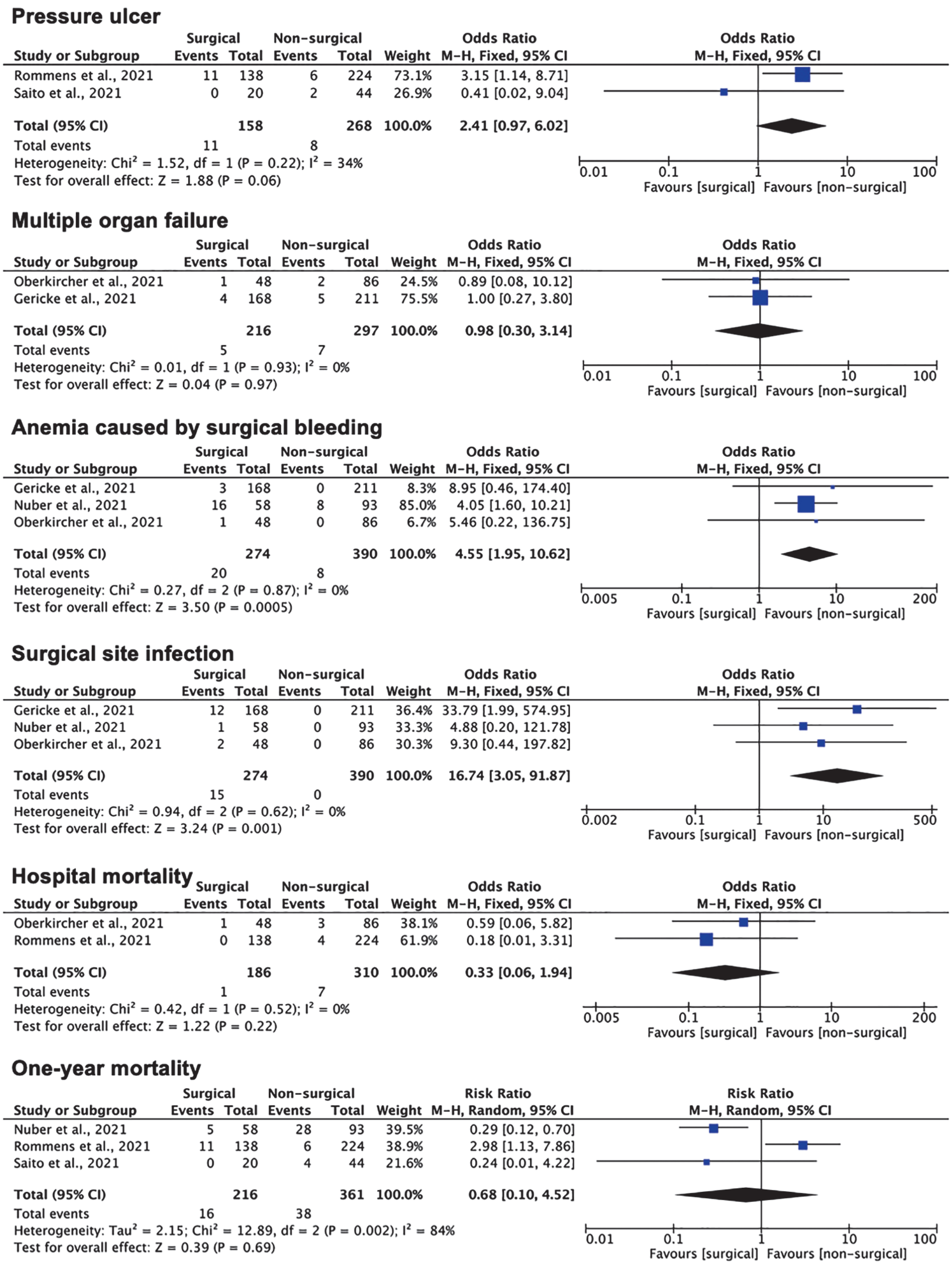

Fig. 7 Forest plot of the complications (continued) and outcomes

DISCUSSION

This systematic review extensively analyzed the clinical characteristics, complications, and outcomes of FFP patients treated with and without surgery. Nine clinical characteristics were included in the systematic review, four of which were found to be statistically significant: FFP type III and IV, younger age, absence of dementia, and presence of osteoporosis. Nine complications were included in the systematic review, three of which were identified as statistically significant: urinary tract infection, anemia caused by surgical bleeding, and surgical site infection. Two outcomes were included in the systematic review, none of which were found to be statistically significant.

We found that a younger age, the absence of dementia, and the presence of osteoporosis were associated with the surgical patients having FFP. Interestingly, FFP type III and IV itself is reported to be related to younger age,[14,22] absence of dementia,[22] and presence of osteoporosis.[28] This may be due to the hypothesis proposed in previous studies[22,29-31] that a younger age and the absence of dementia, as well as higher mobility, result in higher stresses on the posterior pelvis, leading to more unstable fracture types, especially in patients with osteoporosis. Therefore, we feel that the presence of these clinical characteristics (ie, FFP type III and IV, younger age, absence of dementia, and presence of osteoporosis) is a viable basis which recommends surgical treatment for FFP. Furthermore, the osteological diagnosis and possibly anti-osteoporotic therapy are important in not only non-surgical patients but also surgical patients with FFP. The administration of anti-osteoporosis medications (eg, calcium and vitamin D supplementation, bisphosphonates, and teriparatide) have a positive effect on healing and provide pain relief for FFP,[32-35] and the failure to administer anti-osteoporosis therapy could result in additional osteoporotic fractures at secondary sites (eg, hip and vertebrae) within a few years in patients with FFP.[36]

We found that urinary tract infection, anemia caused by surgical bleeding, and surgical site infection were associated with the surgical patients with FFP. Urinary tract infection may be a complication related to longer length of hospital stay.[21-23] Indeed, surgical patients with FFP were reported to be associated with longer length of hospital stay than non-surgical patients (surgical patients, mean 18.1–32.7 days; non-surgical patients mean 8.9–23.1 days).[20-24] Nevertheless, it was reported that sepsis was not associated with the surgical patients with FFP.[21] Therefore, urinary tract infection should be a minor complication in most cases, if treated appropriately. Anemia caused by surgical bleeding is a surgery-related complication.[20,21,24] Notably, no significant difference in anemia caused by surgical bleeding was reported between patients who received percutaneous and open procedures for FFP.[21,37] Surgical site infection is also a surgery-related complication, especially in patients who undergo open reduction and internal fixation for FFP[21,38]; this may occur when the large wound is contaminated by long-term postoperative bed rest and bed rest excretion. Therefore, minimally invasive surgical treatment (eg, a percutaneous procedure) and getting out of bed early should be prioritized.[14,21,39-52]

Importantly, other surgery-related complications that have been reported in previous studies could not be analyzed in this systematic review, including: implant malpositioning (2–7%),[16,21,24] superior gluteal artery damage (1%),[53] nerve damage (2–15%),[21,24] ureteral damage (2%),[16,53] bowel damage,[54] wound healing problems,[37] instrumentation failure (17–45%),[55-57] soft tissue irritation requiring implant removal,[16,38] and cerebrospinal fluid leakage.[54] Thus, surgeons should keep in mind these surgery-related complications and apply appropriate prophylaxis and follow-up.

There was no significant difference in the rate of hospital and one-year mortality between the surgical and non-surgical patients. Furthermore, a previous study reported no significant difference in two-year or five-year mortality between surgical and non-surgical patients.[22] Thus, the mortality of surgical patients may not be inferior to those of non-surgical patients in the treatment strategy for FFP.

We could not analyze mobility in this systematic review due to the data of the studies. In past studies, the improvement in mobility from admission to discharge in surgical patients was greater than that in non-surgical patients.[20,22] Further investigations on this topic will be required.

It is important to clarify the differences between our systematic review and other systematic reviews on FFP. Booth et al[58] searched the literatures on surgical treatment for lateral compression type one FFP in the Young and Burgess classification of pelvic ring injuries.[59] They concluded that there was insufficient evidence on this topic. Wilson et al[17] investigated the literatures concerning the surgical treatment for FFP patients who failed a brief period of non-surgical treatment. They concluded that surgical treatment for FFP should be considered for FFP patients who failed a brief period of non-surgical treatment, as it significantly improved pain. We first focused on the literatures concerning surgical treatment for FFP with the management protocol described by Rommens et al.[10-13] We then investigated the clinical characteristics, complications, and outcomes of surgical and non-surgical patients with FFP. As mentioned above, debate is ongoing regarding the treatment strategies for FFP. It is necessary to compare the complications and clinical outcomes of these treatment strategies.

The present systematic review was associated with several limitations. First, a database bias and English language bias were present. Second, this study was limited based on the quality (selection, comparability, and outcome) of the eligible studies, as shown in Table 2. However, the quality of the present systematic review may be acceptable, as the Newcastle-Ottawa Scale scores ranged from 6 to 7. Third, there was a publication bias in this study. Although we searched the relevant unpublished or gray literature, all such studies were excluded. However, the risk of publication bias may be acceptable, since all values were inside the range of acceptability and close to the no-effect line, as illustrated in Fig. 3. Fourth, several surgical techniques of stabilization were used. Notably, the difference of surgical procedures (ie, percutaneous vs open procedures) were reported to be significantly associated with the rate of infections, surgical revisions, and mortality.[21,37] Accordingly, differences in surgical techniques for stabilization between surgeons, hospitals, and/or literatures may have affected the results. Additional studies on clinical characteristics, complications, and outcomes based on surgical techniques for stabilization are thus warranted. Fifth, the conservative treatments were not unified, which may have affected our result. For instance, pain medication managements varied among the eligible literatures, including "not mentioned",[21,22] NSAIDs or acetaminophen,[23] and the WHO analgesic ladder.[20,24] Similarly, there were variations in management for delirium among the eligible literatures, including "not mentioned"[20–23] and multidisciplinary care by trauma surgeons, geriatrics, specialists in pain management, physiotherapists, occupational therapists, and speech therapists.[24] However, the rehabilitation regimen was similar[20-24]; early mobilization with full weight bearing assisted by physiotherapists under pain control. Finally, and most importantly, current evidence on this topic is still insufficient, possibly due to the fact that the treatment strategy of FFP was first described in 2013,[11] so evidence has only recently been accumulating.[60] Further large-sample, high-quality, and well-documented investigations are necessary to support our findings.

CONCLUSION

The clinical characteristics of FFP type III and IV, younger age, absence of dementia, and the presence of osteoporosis and the complications of urinary tract infection, anemia caused by surgical bleeding, and surgical site infection were associated with the surgical patients with FFP.

There were no significant differences in the outcomes between the surgical and non-surgical patients. Our findings may help understand the treatment strategy for FFP described by Rommens et al and be useful for improving the clinical outcomes of FFP patients. The current evidence is still insufficient on this topic, and further large-sample, high-quality, and well-documented investigations are therefore necessary to support our findings.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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