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The effect of acupuncture on reducing postoperative complications in fracture patients: A retrospective analysis using the TriNetX database

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ABSTRACT

Background: Bone fracture is a common orthopedic condition that affects millions of people worldwide. The management frequently involves surgery, which requires hospitalization. Patients with fractures often have a risk of developing complications, including pain, inflammation, infection, delayed healing, thrombosis, and organ failure. Acupuncture is widely used for conditions such as pain, respiratory issues, urinary system disorders, and gastrointestinal discomfort.

Methods: In this retrospective study, we evaluated the effectiveness of acupuncture in reducing postoperative complications in fracture patients. Using the TriNetX platform, we identified individuals hospitalized for their first fracture surgery and performed 1: 1 propensity score matching. Patients who received three or more acupuncture treatments within one week ($n = 433$) were compared to those who received none (n = 433), with matching based on age, sex, race, BMI, comorbidities, and medications (standardized mean differences). Postoperative complications within 180 days were analyzed using risk percentages, risk ratios, odds ratios, Kaplan-Meier analysis with log-rank tests, and hazard ratios, all reported with 95 % confidence intervals and *P*-values.

Results: Fourteen patients in the acupuncture group experienced respiratory failure with a risk of 3.2 %, while 29 patients in the non-acupuncture group developed respiratory failure with a risk of 6.7 %. The risk ratio was 0.48 (95 % CI 0.26–0.90) and the OR was 0.47 (95 % CI 0.24–0.89). The Kaplan-Meier analysis found a significantly higher survival probability in the acupuncture group (log-rank test $P = 0.01$; HR 0.44, 95%CI 0.23–0.83).

Conclusions: Acupuncture appeared to have the potential to reduce postoperative complications in bone fracture patients. Further large-scale studies are needed to provide stronger evidence.

1. Introduction

Bone fracture is a common orthopedic condition that affects millions of people worldwide. The management of fractures often involves surgery, which requires hospitalization. According to the literature, there were 178 million new fractures worldwide in 2019, with males accounting for about 102 million of these cases. The number of years of disability reached 25.8 million, resulting in a heavy financial burden (Lancet Healthy Longev, 2019). Patients with fractures often have a risk of developing complications, including pain, inflammation, infection, delayed healing, thrombosis and organ failure, which influence quality of life and increases the burden of medical care expenses(Iliaens et al., 2021). Acupuncture, a traditional Chinese medical practice, is most commonly used for pain management in U.S. clinics(Wang et al., 2018). Research in Japan has also demonstrated its benefits in improving exercise tolerance and reducing dyspnea on exertion(Suzuki et al., 2012). We hypothesize that acupuncture treatment may be associated with a reduction in the incidence of postoperative complications in fracture patients. To test this hypothesis, we conducted the retrospective database analysis to evaluate the potential association between acupuncture and postoperative outcomes.

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2. Material and methods

2.1. Data source

TriNetX is a US-based global health research network that enables sharing of real-world data across regions and institutions from over 120 healthcare organizations (HCOs). The TriNetX platform provides data on >250 million patients, which can be used to conduct clinical and observational studies. The database includes electronic medical records (EMR), as well as medical and pharmacy data, and it has been used to publish research in numerous journals. This study is a retrospective database analysis utilizing TriNetX. Due to privacy protection policies, the database system records any patient count fewer than 10 as 10. This constraint may influence the interpretation of outcomes with low incidence.

2.2. Study design

We collected data from the TriNetX platform on November 24, 2024, covering the retrospective period from May 1, 2004 to April 30, 2024, and included individuals aged 18 years and older. In this period, any of the following diagnoses were included in the analysis, with the exception of patients with a record of hospitalization within 6 months prior to sustaining a fracture: Fracture of skull and facial bones; Fracture of cervical vertebra and other parts of neck; Fracture of ribs, sternum and thoracic spine; Fracture of lumbar spine and pelvis; Fracture of lumbar and upper arm; Fracture of forearm; Fracture at wrist and hand level; Fracture of femur; Fracture of lower leg, including ankle; and Fracture of foot and toe, except ankle (ICD-10-CM codes: S02, S12, S22, S32, S42, S52, S62, S72, S82, S92). First hospital inpatient and observation care services and any surgery occurring within 1 week on or after the first event of bone fracture were included in the study. These patients are were allocated into two groups. One group received any acupuncture procedure ≥3 times (with no limit on the number of needles, with or without electrical stimulation) within 7 days of fracture, but the other group did not receive acupuncture. We chose a duration of 7 days or less following the occurrence of fracture because it was a suitably short period and it allowed for a sufficient number of treatments to assess the effectiveness of acupuncture.

Patients whose index event occurred 20 years or more ago were excluded. The study flowchart is presented in Fig. 1. In order to minimize confounding factors and selection biases, two cohorts were propensity score-matched based on gender, index of age, and BMI, and also matched based on comorbidities using the following ICD-10-CM codes: essential hypertension (I10), hyperlipidemia (E78.5), diabetes mellitus (E08-E13), neoplasms (C00-D49), chronic lower respiratory diseases (J40-J4A), Osteoarthritis (M15-M19), Chronic kidney disease (N18), Osteoporosis without current pathological fracture (M81), Inflammatory polyarthropathies (M05-M14), as well as medications, i.e., glucocorticoids, antilipemic agents, ACE inhibitors, angiotensin II inhibitor, oral hypoglycemic agents, and alendronate, the most commonly prescribed bisphosphonates which we choose only for osteoporosis(Brown et al., 2013)(**Supplementary appendix**). This study was approval by the institutional review board(IRB) committee of Taichung Veterans General Hospital (TCVGH-IRB: CE24608A).

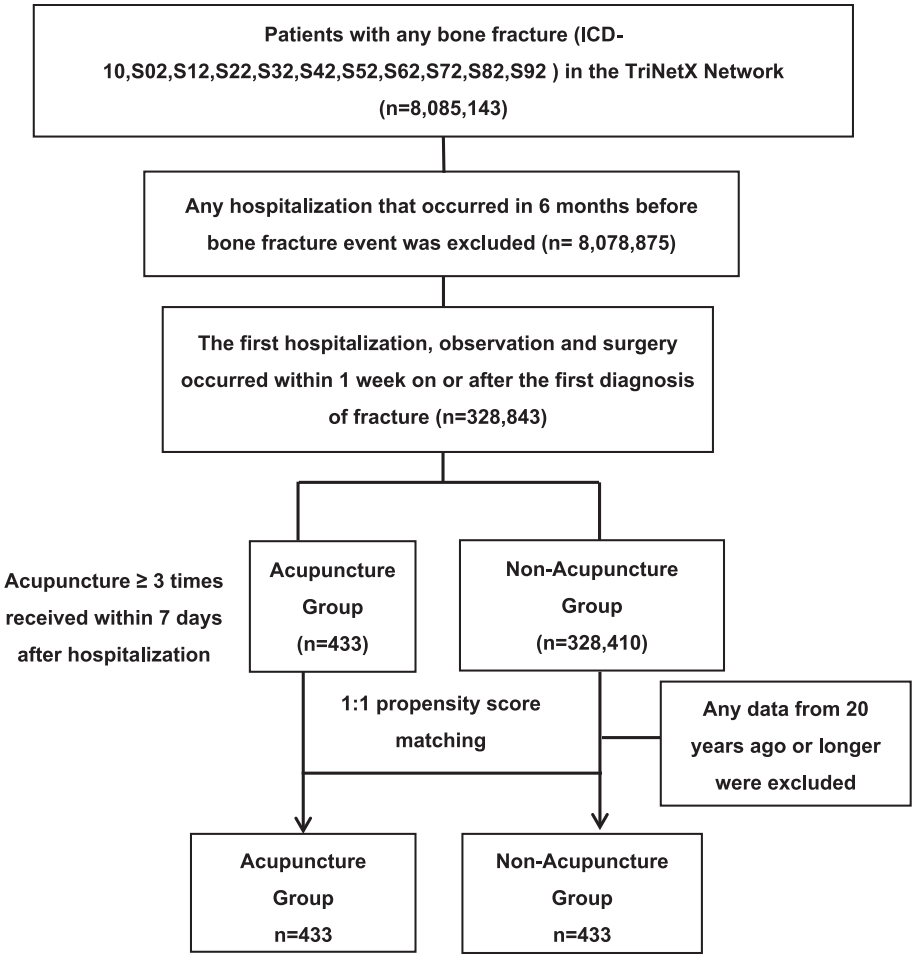

Fig. 1. Flow diagram of study.

2.3. Outcome measures

We conducted this study to compare the risk of complications, including gastrointestinal hemorrhage, pain, acute kidney failure, urinary tract infection, osteomyelitis, pulmonary embolism, acute embolism, and thrombosis of deep veins (DVT) of lower extremity, pressure ulcer, ileus, cerebral infarction, respiratory failure, pneumonia, and death in patients who were hospitalized for bone fractures with acupuncture compared to the group that did not receive acupuncture. This study analyzed the incidence of complications 180 days after receiving acupuncture treatment at least 3 times or no acupuncture treatment.

2.4. Statistical analysis

We compared the baseline characteristics of the acupuncture and non-acupuncture cohorts before and after with 1:1 propensity score matching and with logistic regression. We matched for age, sex, race, BMI, comorbidities, and medications using standardized mean differences (SMD), with a caliper of <0.1 considered well matched between two cohorts. We subsequently computed measures of association, including risk percentage, risk ratio, and odds ratio, along with their corresponding 95 % confidence intervals (CIs) and *P*-values. A P-value of <0.05 was considered statistically significant. To further assess the risk of complications, we utilized measures of association, Kaplan-Meier analysis with a log-rank test, and calculated the hazard ratios with corresponding 95 % CI and *P*-values.

3. Results

3.1. Patients' characteristics

In total, 8,085,143 patients had any diagnosis of bone fracture and 8,078,875 were left following the exclusion of patients without a hospitalization record before the occurrence of bone fracture. A further 328,843 patients were included as their first hospital inpatient and observation care services and surgery occurred on the day or within 1 day of the first event of fracture.

Baseline characteristics of the study populations are outlined in Table 1. The acupuncture group comprised 276 males (63.7 %) and 157 females (36.3 %), with a mean age of 47.3 years (SD ± 20.1), while the comparison group consisted of 174,077 males (57.6 %) and 112,478 females (37.2 %), with a mean age of 52.6 years (SD ± 23.0). We also found many differences between the two groups. Propensity score matching was done, resulting in successful matching of a cohort of 433 patients who had received acupuncture procedure at least 3 times a week with a cohort of 433 patients who had not received any acupuncture treatment. After matching for age, sex, ethnicity, comorbidities, and medications, we found there were no statistically significant differences between the two cohorts.

3.2. Complications

3.2.1. Pain

We found that the acupuncture group experienced higher rates. Sixty-six patients from this cohort had pain complications, with a risk of 1.52 %. Twenty-eight patients from the non-acupuncture group had pain complications, with a risk of 0.65 %. Risk ratio was 2.54 (95 % CI 1.55–3.59) (shown in Fig. 2), and the OR was 2.60 (95 % CI 1.64–4.14). Hazard ratio was 2.251 (95 % CI 1.45–3.50) and the Kaplan-Meier analysis found a significant survival probability (log-rank test $P < 0.001$) (Fig. 3).

3.2.2. Acute kidney failure

We found that 13 patients in the acupuncture group developed acute kidney failure, with a risk of 3 %, while 24 patients in the non-acupuncture group experienced acute kidney failure, with a risk of 5.5 %. The risk ratio was 0.54 (95 % CI 0.28–1.05), which was non-significant, and the OR was 0.53 (95 % CI 0.27–1.05). The Kaplan-Meier analysis demonstrated a higher survival probability in the acupuncture group (log-rank test $P = 0.035$; HR 0.49, 95 % CI 0.25–0.97).

Table 1
Baseline characteristics and before and after propensity score matching.

Characteristics	Before matching				After matching			
	ACUP group (n = 433)	Non-acup group (*n* = 303,313)	P-Value	SMD	ACUP group (n = 433)	Non-acup group (n = 433)	P-Value	SMD
Age at Index	47.3 ± 20.1	52.6 ± 23.0	<0.001	0.245	47.3 ± 20.1	49.1 ± 21.4	0.205	0.086
Male	276(63.7 %)	174,077(57.6 %)	0.010	0.125	276(63.7 %)	272(62.8 %)	0.778	0.019
Female	157(36.3 %)	112,478(37.2 %)	0.673	0.020	157(36.3 %)	161(37.2 %)	0.778	0.019
BMI	27.7 ± 6.6	27.3 ± 6.8	0.181	0.067	27.7 ± 6.6	27.3 ± 6.3	0.370	0.062
Not Hispanic or Latino	269(62.1 %)	208,469(69.0 %)	0.002	0.146	269(62.1 %)	279(64.4 %)	0.481	0.048
Hispanic or Latino	157(36.3 %)	29,399(9.7 %)	<0.001	0.664	157(36.3 %)	149(34.4 %)	0.570	0.039
White	221(51 %)	208,951(69.2 %)	<0.001	0.377	221(51.0 %)	238(55.0 %)	0.247	0.079
Asian	60(13.9 %)	6203(2.1 %)	<0.001	0.447	60(13.9 %)	54(12.5 %)	0.546	0.041
Black or African American	10(2.3 %)	33,131(11 %)	<0.001	0.353	10(2.3 %)	10(2.3 %)	1.000	<0.001
Other Race	96(22.2 %)	12,922(4.3 %)	<0.001	0.548	96(22.2 %)	84(19.4 %)	0.315	0.068
Unknown Race	44(10.2 %)	39,680(13.1 %)	0.067	0.093	44(10.2 %)	45(10.4 %)	0.911	0.008
Essential hypertension	135(31.2 %)	64,535(21.4 %)	<0.001	0.224	135(31.2 %)	149(34.4 %)	0.311	0.069
Hyperlipidemia, unspecified	84(19.4 %)	32,358(10.7 %)	<0.001	0.245	84(19.4 %)	88(20.3 %)	0.733	0.023
Diabetes mellitus	64(14.8 %)	27,193(9.0 %)	<0.001	0.179	64(14.8 %)	66(15.2 %)	0.849	0.013
Neoplasms	56(12.9 %)	12,853(4.3 %)	<0.001	0.313	56(12.9 %)	51(11.8 %)	0.606	0.035
Chronic lower respiratory diseases	45(10.4 %)	23,430(7.8 %)	0.041	0.092	45(10.4 %)	44(10.2 %)	0.911	0.008
Osteoarthritis	40(9.2 %)	16,199(5.4 %)	<0.001	0.149	40(9.2 %)	51(11.8 %)	0.223	0.083
Chronic kidney disease (CKD)	28(6.5 %)	12,571(4.2 %)	0.016	0.103	28(6.5 %)	28(6.5 %)	1.000	<0.001
Osteoporosis without current pathological fracture	13(3.0 %)	9180(3.0 %)	0.964	0.002	13(3.0 %)	14(3.2 %)	0.845	0.013
Inflammatory polyarthropathies	16(3.7 %)	7375(2.4 %)	0.091	0.073	16(3.7 %)	17(3.9 %)	0.859	0.012
Glucocorticoids	331(76.4 %)	30,354(10.0 %)	<0.001	1.805	331(76.4 %)	352(81.3 %)	0.080	0.119
Antilipemic agents	109(25.2 %)	30,786(10.2 %)	<0.001	0.400	109(25.2 %)	110(25.4 %)	0.938	0.005
ACE inhibitors	56(12.9 %)	15,180(5.0 %)	<0.001	0.279	56(12.9 %)	56(12.9 %)	1.000	<0.001
Angiotensin ii inhibitor	50(11.5 %)	9706(3.2 %)	<0.001	0.323	50(11.5 %)	61(14.1 %)	0.263	0.076
Oral hypoglycemic agents	43(9.9 %)	8321(2.8 %)	<0.001	0.298	43(9.9 %)	45(10.4 %)	0.822	0.015
Alendronate	17(3.9 %)	1429(0.5 %)	<0.001	0.237	17(3.9 %)	12(2.8 %)	0.345	0.064

Complications	Numbers of complications				Odds Ratio (95% CI)	P-value
	ACUP groups	risk	Non-acup groups	risk		
GI hemorrhage	10/433	0.023	10/433	0.023	1.00 (0.41-2.43)	1.000
Pain	66/433	0.152	28/433	0.065	2.60 (1.64-4.14)	< 0.001
Acute kidney failure	13/433	0.030	24/433	0.055	0.53 (0.27-1.05)	0.065
Urinary tract infection	28/433	0.065	21/433	0.048	1.36 (0.76-2.43)	0.303
Osteomyelitis	12/433	0.028	10/433	0.023	1.21 (0.52-2.82)	0.666
Pulmonary embolism	10/433	0.023	11/433	0.025	0.91 (0.38-2.16)	0.825
DVT of lower extremity	12/433	0.028	14/433	0.032	0.85 (0.39-1.87)	0.690
Pressure ulcer	12/433	0.028	10/433	0.023	1.21 (0.52-2.82)	0.666
Ileus	10/433	0.023	10/433	0.023	1.00 (0.41-2.43)	1.000
Cerebral infarction	12/433	0.028	10/433	0.023	1.21 (0.52-2.82)	0.666
Respiratory failure	14/433	0.032	29/433	0.067	0.47 (0.24-0.89)	0.019
Pneumonia	10/433	0.023	19/433	0.044	0.52 (0.24-1.12)	0.089
Death	0/433	0.000	10/433	0.023	-	0.001

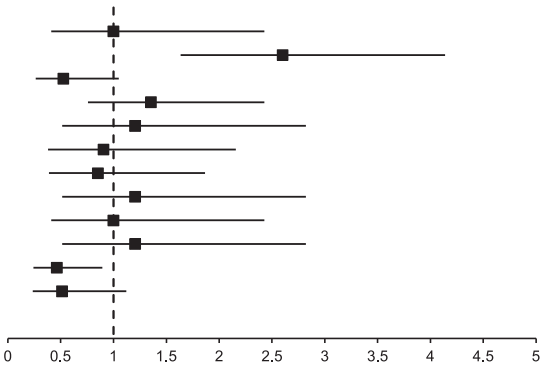

Fig. 2. Comparative analysis of complications in people with Acupuncture vs. Non-acupuncture
Abbreviations: n, number; –, incalculable.

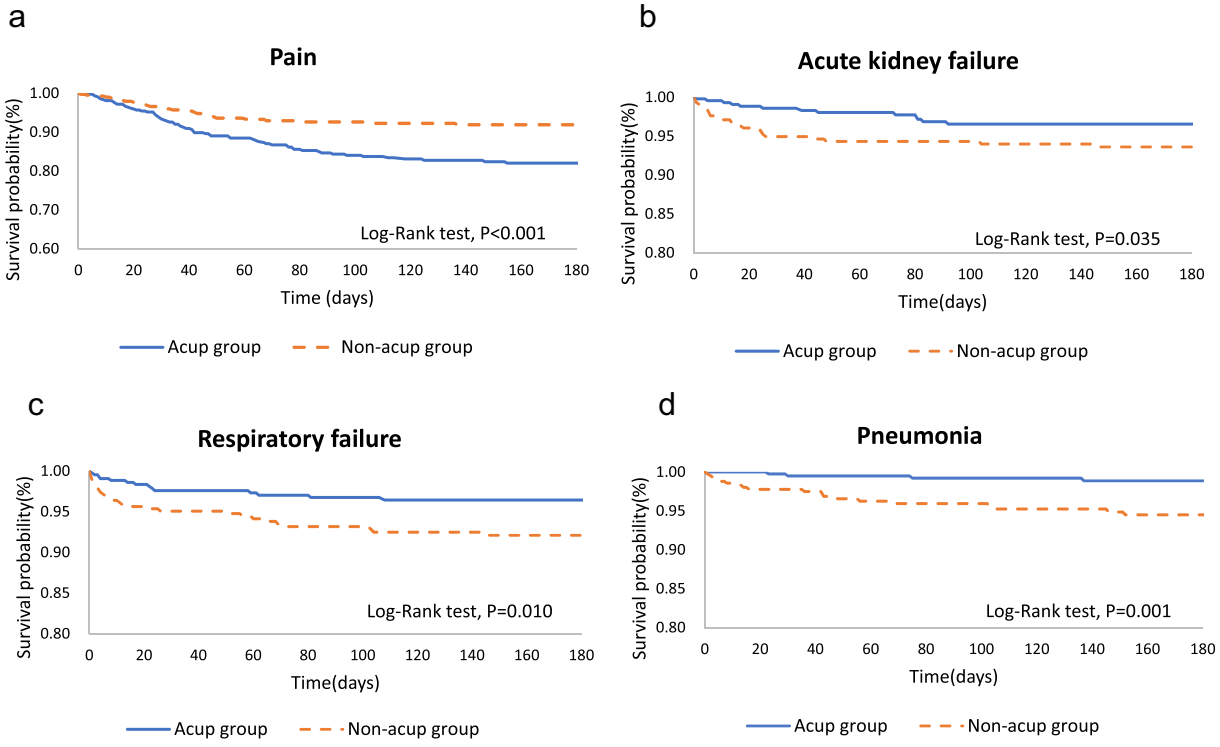

Fig. 3. Comparative Kaplan-Meier method of Acupuncture and Non-acupuncture complications.

3.2.3. *Respiratory failure*

Fourteen patients in the acupuncture group experienced respiratory failure, with a risk of 3.2 %, while 29 patients in the non-acupuncture group developed respiratory failure, with a risk of 6.7 %. The risk ratio was 0.48 (95 % CI 0.26–0.90) and the OR was 0.47(95 % CI 0.24–0.89). The Kaplan-Meier analysis found a significantly higher survival probability in the acupuncture group (log-rank test $P = 0.01$; HR 0.44, 95 %; CI 0.23–0.83).

3.2.4. *Pneumonia*

There were 10 patients in the acupuncture group who developed pneumonia, with a risk of 2.3 %, compared with 19 patients in the non-acupuncture group who experienced pneumonia, with a risk of 4.4 %. The risk ratio was 0.53 (95 % CI 0.25–1.12) and the OR was 0.52(95 % CI 0.24–1.12). The Kaplan-Meier analysis found a significantly higher survival probability in the acupuncture group (log-rank test $P = 0.001$), with a hazard ratio of 0.19 (0.07–0.56).

4. Discussion

Despite previous literature has suggested that acupuncture may alleviate postoperative pain by reducing the need for analgesic use(Wu et al., 2016), our study showed a higher incidence of reported pain among patients who received acupuncture. Notably, the acupuncture group also exhibited a lower risk of postoperative respiratory failure. One possible explanation is that patients receiving acupuncture may have presented with more severe pain or sustained more complex fractures, potentially prompting the use of acupuncture as an adjunctive therapy. Moreover, acupuncture may contribute to improved pulmonary function by mitigating declines in FEV1% and enhancing the FEV1/FVC

ratio(Xu et al., 2024). Prior study has also indicated that acupuncture may reduce the mean of rapid shallow breathing (RSB) by 16.02 (SD 60.8), whereas it rose by 17.84 (SD 39.38) in the control group ($p = 0.036$) following 12 sessions of acupuncture, which could further support respiratory stability during recovery(Chen et al., 2023).

Acupuncture is commonly used for various musculoskeletal and neurological conditions. According to the WHO report, its indications include pain disorders (e.g., low back pain, osteoarthritis, headache, postoperative pain), neurological conditions (e.g., stroke, sciatica), gastrointestinal disorders (e.g., nausea, epigastric pain), allergic rhinitis, dysmenorrhea and depression(Organization, 2002). Early studies have suggested that acupuncture may reduce both mortality and hospital readmission rates following hip fracture(Lin et al., 2020). In addition, acupuncture therapy near the greater trochanter and Xuehai (SP10) acupoints for seven days in elderly patients with intertrochanteric fractures was associated with reduced pain, lower CRP and TNF-α levels by postoperative days 5 and 7, and improved Barthel Index scores two months after surgery(Li et al., 2021). These studies have been constrained by regional data sources. In contrast, our study utilized a global database to comprehensively examine the association between acupuncture and postoperative complications following fracture surgery. The use of Real-world data from a large, multinational cohort enhances the clinical relevance of our findings and supports their broader clinical outcomes. Most prior studies have focused on acupuncture for COPD. A systematic review reported that acupuncture improves maximal inspiratory pressure and accessory respiratory muscle activity, enhancing diaphragmatic strength and exercise capacity(Liu et al., 2024), particularly when applied to bilateral Dingchuan (Ex-B1), Pishu (BL20), Feishu (BL13), and Shenshu (BL23) acupoints(Xu et al., 2024). In contrast, this study emphasizes the risk of respiratory failure after fracture surgery with acupuncture intervention, with a 6-month follow-up. While no specific respiratory failure assessment tools were used, another study found acupuncture beneficial during acute exacerbations, improving CAT scores (MD −3.25 (95 % CI: −3.73 to −2.78, $P < 0.001$) and arterial blood gases(Yang et al., 2024), which may support the observed trends in our study. In addition, postoperative pneumonia is frequently caused by *Escherichia coli*, *Klebsiella pneumoniae*, and *Staphylococcus aureus* and can progress to respiratory failure(Yu and Zheng, 2022). In our study did not show significant difference in odds ratio of pneumonia. However, patients who received six or more acupuncture sessions showed a notable decrease in the risk of pneumonia (HR 0.77; 95 % CI 0.73–0.82) when compared to those who had four sessions (HR 0.88; 95 % CI 0.78–0.99)(Chang et al., 2018). The potential benefits of acupuncture on renal function were also among the outcomes of interest in our study. We acknowledge that the 95 % confidence interval of the odds ratio (OR) for the acute kidney failure outcome crosses 1, indicating that the result was close to, but did not reach statistical significance. However, this may not account for the cumulative differences over time. We discovered patients receiving acupuncture had a notably reduced risk of experiencing acute renal failure in the Kaplan-Meier analysis, with this benefit persisting for up to 180 days. While individuals with a prior complication were not included in the study, 10 patients in the acupuncture group developed acute renal failure, and there was no significant difference between the two groups (**Supplementary appendix**). However, the findings suggest that acupuncture may be beneficial for individuals with existing acute kidney failure. Indeed, in some studies, it was found that acupuncture may be helpful for chronic kidney disease by reducing serum creatinine, increasing estimated glomerular filtration rate (eGFR), and alleviating other symptoms such as malaise, pain, depression, fatigue, and uremic pruritus, which are common in end-stage renal disease (ESRD) and hemodialysis patients(Kim et al., 2010; Kim et al., 2016; Yu et al., 2017).

The length of hospital stay is an important issue and can vary significantly, typically averaging around 5.1 days(Weycker et al., 2016). Hospitalized patients who stay longer than 13 days have a significantly higher risk of readmission compared to those with shorter stays of 2 to 4 days. In another study, extended length of stay was linked to higher mortality within 30 days of discharge and a greater likelihood of readmission due to cardiovascular issues(Ek et al., 2022). Therefore, in this study, we chose a treatment period occurring within 7 days of the fracture event, with treatment consisting of hospital inpatient and observation care and surgery. We also found that the acupuncture group used more non-opioid analgesics and non-steroidal anti-inflammatory analgesics compared to the non-acupuncture group. However, after excluding individuals who had previously used these medications, we observed that the acupuncture group had an advantage in use of non-opioid analgesics (**Supplementary appendix**). Prior research has shown that acupuncture can significantly reduce ICU length of stay (MD −1.45 (−11.94,−10.97); $P < 0.001$;I^2, 56 %) and 28-day mortality (OR 0.61 (0.48,0.780; $P < 0.001$; $I^2 = 0$ %) (Ben-Arie et al., 2023). Interestingly, our research showed that there were no deaths in the acupuncture group, while another study reported that mortality rates at 30 days and 6 months after surgery were 23 % and 34 %(Delgadillo et al., 2024). Despite our study showing no significant differences, when patients with a prior complication were excluded, the results revealed that none of those who received acupuncture developed ileus (**Supplementary appendix**).

Several potential mechanisms may underlie the effects of acupuncture observed in this study. They involve modulation of the neuroimmune axis to exert anti-inflammatory effects. First, stimulation of ST36 using electroacupuncture (EA) can activate the vagal–adrenal axis, promoting catecholamine release via vagus nerve–adrenal interaction, which has been shown to reduce systemic inflammation in a cecal ligation and puncture (CLP)-induced rat model of sepsis(Villegas-Bastida et al., 2014). Second, acupuncture has showed an ability to regulate the cholinergic anti-inflammatory pathway (CAIP) in a rat model of COPD. Electroacupuncture (EA) at ST36 and BL13 significantly downregulated inflammatory cytokine levels, reduced pulmonary inflammation, and improved lung function(Wang et al., 2023). Third, it may exert its immunoregulatory effects via modulation of the Hypothalamic-Pituitary-Adrenal axis. Acupuncture at GV14, ST36, and BL13 was found to elevate serum levels of ACTH and cortisol, suppress the production of IL-2 and TNF-α, and markedly decrease eosinophil and lymphocyte counts in bronchoalveolar lavage fluid in an asthmatic rat model(Zhao et al., 2021). In conclusion, acupuncture demonstrates the potential to reduce airway inflammation and regulate hypersensitive immune responses. In addition to conventional treatments, acupuncture can help alleviate the physiological symptoms of chronic respiratory diseases, such as asthma and chronic obstructive pulmonary disease, including dyspnea, coughing, and poor exercise tolerance(Yeh and Horwitz, 2017), serving as a non-pharmacological intervention.

While the findings of this study are promising, several limitations should be acknowledged. Due to the limitations of the database used in this study, we were unable to access the patients' datasets, such as the types of surgeries they underwent, the acupuncture points used, the number of needles applied, the retention time of the needles or whether the patients received additional acupuncture treatments after completing the initial treatment. Despite this, our study still offers important population evidence on the potential association between acupuncture and reduced complications after bone fractures, highlighting the need for future prospective research with more detailed treatment information.

5. Conclusion

This study explored whether acupuncture could reduce postoperative complications. A broad range of fracture types was investigated due to the limited number of available databases. Our findings suggest that acupuncture may reduce the risk of respiratory failure following fracture surgery and could serve as an adjuvant treatment for postoperative complications. Accordingly, further studies with a larger sample size are required to assess the therapeutic benefits of

acupuncture in postoperative fracture patients.

CRediT authorship contribution statement

Yi-Pin Chang: Writing – original draft, Visualization, Data curation. **Hsin-Hua Chen:** Formal analysis, Conceptualization. **Jui-Ju Tseng:** Conceptualization. **Chia-I Tsai:** Writing – review & editing, Supervision.

Declaration of Generative AI and AI-assisted technologies in the writing process

While preparing this article, the authors utilized ChatGPT-4o to improve language coherence and reduce grammatical errors. It was not used for research design or creating charts and graphs.

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Declaration of competing interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bonr.2025.101842.

Data availability

The data were used under licensed of TriNeTx for current study, so that are not public applications.

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