



Original Article

Prevalence of and factors associated with trauma surgeons' referral and patients' willingness to acupuncture treatment after traumatic rib fractures: A single-center cross-sectional study



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ABSTRACT

Background: Pain after traumatic rib fractures (TRF) detrimentally affects the injured. Multidisciplinary pain management is crucial for patient care. There is little empirical evidence on acupuncture as a multidisciplinary treatment for patients with TRF. This study aimed to illustrate the characteristics of the patients referred for or received acupuncture and explore the associated factors.

Methods: We conducted a cross-sectional study of Korean Trauma Data Bank and electronic medical records of patients aged 19 or older with TRF from August 2016 to October 2021 in the regional trauma center of Pusan National University Hospital. The sociodemographic and clinical characteristics of patients referred for acupuncture by trauma surgeons and those who received acupuncture were analysed descriptively. In multivariable logistic regression analyses, associations between covariates and either surgeon referrals for or patient willingness to receive acupuncture were quantitatively estimated.

Results: Among 2,937 injured patients, trauma surgeons referred 178 (6.1 %) to acupuncture. Among the referred patients, 111 (72.1 %) underwent acupuncture. Patients with polytrauma (aOR 0.46; 0.30 to 0.68) were less likely to be referred to acupuncture, whereas female patients (aOR 3.92, 1.31 to 11.77) were most likely to receive acupuncture.

Conclusions: A small proportion of patients with TRF were referred for acupuncture, but the referred patients were more likely to receive acupuncture. Polytrauma may be an important criterion for referral to acupuncture services from the perspective of trauma surgeons, while the willingness to receive acupuncture may be associated with gender-related factors. Further studies are warranted to investigate the role of acupuncture in the postinjury care of patients with TRF.

1. Introduction

Chest trauma is one of the most common injuries after head and limb trauma and are the second leading cause of trauma-related deaths.¹⁻³ Traumatic rib fractures (TRF) are a common type of chest injury with significant morbidity and mortality across a range of severities, from simple isolated fractures to flail chest.^{2,4} Pain after TRF is often se-

vere and refractory to the existing management.⁵ Acute pain related to damage to the thorax or underlying structures can affect respiratory dynamics and delay recovery, leading to complications such as respiratory failure and pneumonia.^{6,7} Chronic chest wall pain, which is prevalent after traumatic chest injuries, may induce breathing difficulties, physical dysfunction, and impaired quality of life.⁸⁻¹⁰ As pain is associated with clinical outcomes of recovery both in acute and chronic phase after

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trauma, appropriate pain management takes high priority for recovery after TRF.⁵ A wide range of pharmacological and non-pharmacological interventions for pain have been provided, although evidence on their efficacy remains incomplete.^{5,11} Due to the central role of pain in the complexity of recovery trajectory after TRF, multidisciplinary pain management has been suggested as a critical component of care.¹²⁻¹⁴ Despite evidence supporting its role in both acute and chronic pain management,^{15,16} acupuncture is rarely included as a multidisciplinary component of care after TRF.

Acupuncture is commonly practiced for pain and other chronic conditions in South Korea. The National Health Insurance program in South Korea has reimbursed acupuncture treatments since 1987.¹⁷ Under the South Korea's dual healthcare system, Korean medicine doctors (KMDs) are exclusively authorized to perform acupuncture among healthcare professionals in South Korea. For provision of acupuncture as a component of multidisciplinary patient care, therefore, inclusion of KMDs as one of the key players in the multidisciplinary team and referrals between Western and Korean medicine doctors are essential.^{15,18,19} In Pusan National University Hospital, Korean Medicine service was provided as a part of major trauma care, creating an unique opportunity of multidisciplinary care for addressing gaps between the unmet needs of recovery and underuse of acupuncture in patients after TRF.

The primary aim of this study was to describe the characteristics of patients with TRF who had been referred to or received acupuncture treatment at a regional trauma center in Busan, South Korea. The secondary aim was to investigate the factors associated with the surgeon's referral of patients for acupuncture and the referred patient's willingness to receive acupuncture.

2. Methods

2.1. Study design and setting

This cross-sectional study used data from the Korean Trauma Data Bank (KTDB) and electronic medical records (EMR). The KTDB is a prospective nationwide trauma registry that systematically collects the clinical characteristics of patients with traumatic injuries admitted to regional trauma centers across South Korea since 2013 to inform research and policymaking regarding trauma prevention and management.²⁰ The Pusan National University Hospital (PNUH) Regional Trauma Center was established in November 2015 to reduce the preventable trauma death rate due to major physical trauma and to provide both acute and chronic management of traumatised patients.²¹ In the PNUH, the Department of Korean Medicine was established in April 2012 to provide clinical services for acupuncture, herbal medicine, and other co-interventions in Korean medicine. The provision of Korean medicine interventions at the PNUH regional trauma center was initiated in August 2016 for both outpatients and inpatients. Totally five thoracic trauma surgeons referred patients to a KMD.

2.2. Eligibility criteria

Eligible patients included those aged ≥ 19 years at the time of admission to the PNUH regional trauma center due to the traumatic event and who were enrolled to the KTDB registry. Those who were not registered in the KTDB but visited the outpatient department of the regional trauma center and were referred to the Department of Korean Medicine for Acupuncture treatment were also eligible. Patients who arrived at the study trauma center and died before admission to the inpatient care wards were excluded. Patients who participated in clinical research on acupuncture were excluded both in the descriptive analysis of the patients receiving acupuncture and in the analysis for exploring factors associated with patients' willingness to receive acupuncture, as analyses of interest were regarding acupuncture consultation in a real clinical setting, rather than in a research context.^{22,23}

2.3. Data collection

Two researchers (MHK and YKS) extracted data from the PNUH KTDB and EMR using a predefined data extraction sheet. The demographic and clinical characteristics of the eligible patients were extracted from the KTDB. Clinical information not available in the KTDB was further sought from the EMR, including both physician and nursing records. Any disagreement or ambiguity during data extraction was resolved through discussion with the arbiters (KHK and SHK). Details of Korean medicine treatments, including acupuncture, herbal medicine, and other co-interventions provided by a Korean medicine doctor (KHK), were extracted from the EMR. Information on the Korean medicine treatments received in non-study clinics was not sought.

2.4. Primary and secondary analyses

The primary analysis was a descriptive summary of the sociodemographic and clinical characteristics of patients with TRF and those who received acupuncture. Information on the acupuncture and co-interventions performed at the study center is also summarised. Two secondary analyses were also conducted. First, factors associated with the trauma surgeons' referral of patients to acupuncture treatment were investigated among those registered with the KTDB. Second, factors associated with the patients' willingness to receive acupuncture treatment were explored among those referred to the Department of Korean Medicine for clinical purposes.

2.5. Measurement of referral and willingness to acupuncture treatment

The trauma surgeon's referral for acupuncture treatment was ascertained by the referral note of a patient to the Department of Korean Medicine at PNUH from August 2016 to October 2021, regardless of whether acupuncture was performed. Irrelevant referrals such as issuing medical certificates were not considered valid for acupuncture treatment. If two or more referral notes were identified with at least 6-month intervals between each referral in the same patient, the one which deemed most informative and relevant to the given clinical context of trauma was selected through discussion between the authors. If two or more referral notes were identified within six months, they were classified as the same episode of referrals, and the earliest referral note was selected for analysis. Patients were considered willing to receive acupuncture when there was at least one session of non-study acupuncture treatment after the surgeon's referral.

2.6. Measurement of covariates

Information on age at traumatic injury; sex; injury severity score (ISS); abbreviated injury scale (AIS) of each body part, including the head, face, chest, abdomen, extremity, and others; calendar year of the onset of trauma; mechanism of injury; and type of reimbursement insurance were extracted from the KTDB.

Information on smoking, alcohol intake, body mass index, area of residence, maximum pain intensity during admission, and level of physical activity at discharge was extracted from the EMR for patients who received acupuncture, as data were not available in the KTDB.

Polytrauma was defined as having at least two body parts with AIS score equal to or greater than 3.^{24,25} An AIS ≥ 3 was regarded as an indicator of serious injury to the respective body part (e.g. AIS of chest ≥ 3 indicates serious chest trauma).^{26,27} A score of ISS ≥ 16 was regarded as an indicator of severe physical injury.^{28,29} A numeric rating scale of maximum pain intensity during admission ≥ 4 on a 0 to 10 score was regarded as moderate or severe pain.^{30,31}

2.7. Statistical analysis

Clinical and sociodemographic characteristics are descriptively summarised as frequency (percentage) and mean (standard deviation [SD])

or median (interquartile range [IQR]) depending on the type of variable and the normality of value distribution. Univariate analyses were conducted to identify crude associations between referral to or receiving acupuncture and each covariate using the Mantel-Haenszel method. A priori covariates, including age, sex, insurance, severe physical injury, and polytrauma, were selected regardless of the statistical significance of the association for multivariate analysis. Multivariable logistic regression was performed to estimate 1) the association between the surgeon's referral for acupuncture and a priori covariates and 2) the association between patients' willingness to receive acupuncture and a priori covariates. Likelihood ratio tests were performed to compare the fitness of age at trauma and the sex-adjusted model (i.e. Model 1) and those of the all-covariate-adjusted model (i.e. Model 2; adjusted for age at trauma, sex, type of insurance, severe trauma, and polytrauma) in each analysis. Multicollinearity was examined by exploring whether considerable changes in the standard error of the ORs and 95 % CI were observed between Models 1 and 2.

A sensitivity analysis was performed to investigate 1) whether the inclusion of each local injury (AIS of each area) would change the covariate estimates of multivariate models of referral for acupuncture, and

2) whether the inclusion of smoking, alcohol consumption, maximum pain level, area of residence, comorbidity, and level of physical activity alters the estimates of covariates in the multivariable model for patients' willingness to receive acupuncture.

The sample size was not calculated as the primary aim of this study was to provide a descriptive summary of the characteristics of patients with TRF who were referred for or received acupuncture. We used Stata (version 17.0; Stata Corp, College Station, TX, USA) for the statistical analyses. Missing data were not imputed.

3. Results

Of the 11,928 patients included in the dataset, 2,937 were eligible. Among these, 178 patients (6.1 %) were referred to the Korean medicine clinic by trauma surgeons, either for research recruitment ($n = 24$; 13 %) or clinical purposes ($n = 154$; 87 %), of which 111 patients (72.1 %) underwent acupuncture in a non-research context. (Fig. 1)

The sociodemographic and clinical characteristics of the patients are shown in Table 1. The mean age of the patients was 58 years. Approximately half of the patients were middle-aged (45–65 years old). Ap-

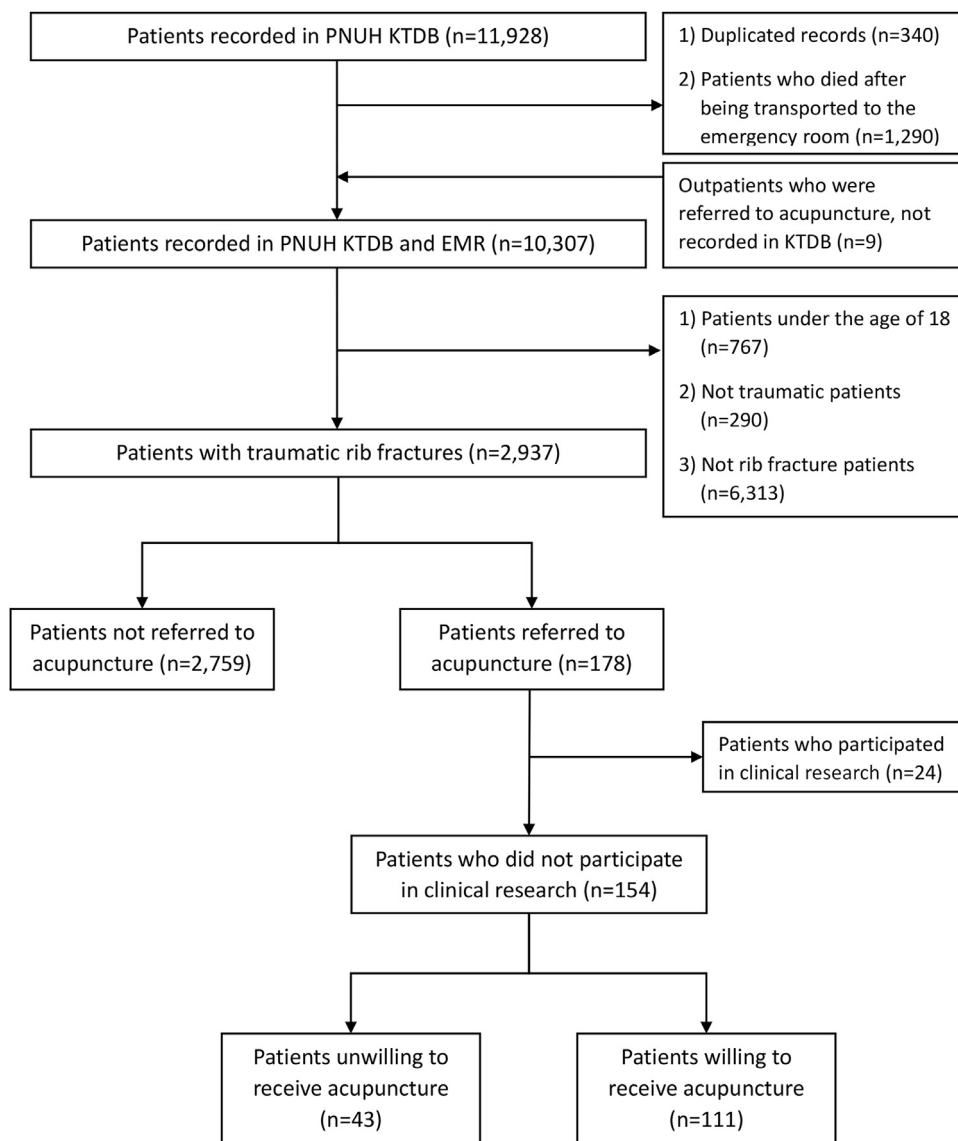


Fig. 1. Study flowchart

EMR, Electronic medical record; KTDB, Korean trauma data bank; PNUH, Pusan national university hospital; TRF, traumatic rib fractures.

Table 1
Characteristics of the study population by trauma status ($n = 2937$).

Variable	Total ($n = 2937$)	Not referred to acupuncture ($n = 2759$)	Referred to acupuncture ($n = 178$)	p-value	Total ($n = 154$)	Accepted acupuncture ($n = 111$)	Not accepted acupuncture ($n = 43$)	p-value
Age (y) [n (%)]				0.083				0.348
19 to 44	586 (20.0 %)	559 (20.3 %)	27 (15.2 %)		25 (16.2 %)	21 (18.9 %)	4 (9.3 %)	
45 to 65	1377 (46.9 %)	1280 (46.4 %)	97 (54.5 %)		80 (52.0 %)	56 (50.5 %)	24 (55.8 %)	
≥ 65	974 (33.2 %)	920 (33.4 %)	54 (30.3 %)		49 (31.8 %)	34 (30.6 %)	15 (34.9 %)	
Sex [n (%)]				0.516				0.036
Male	2221 (75.6 %)	2090 (75.8 %)	131 (73.6 %)		110 (71.4 %)	74 (66.7 %)	36 (83.7 %)	
Female	716 (24.4 %)	669 (24.3 %)	47 (26.4 %)		44 (28.6 %)	37 (33.3 %)	7 (16.3 %)	
Insurance [n (%)]				0.127				0.258
NHI	1515 (51.6 %)	1410 (51.1 %)	105 (59.0 %)		92 (59.7 %)	63 (56.8 %)	29 (67.4 %)	
Vehicle	957 (32.6 %)	903 (32.7 %)	54 (30.3 %)		46 (29.9 %)	38 (34.2 %)	8 (18.6 %)	
Occupational	145 (4.9 %)	138 (5.0 %)	7 (3.9 %)		7 (4.6 %)	4 (3.6 %)	3 (7.0 %)	
Others	320 (10.9 %)	308 (11.2 %)	12 (6.7 %)		9 (5.8 %)	6 (5.4 %)	3 (7.0 %)	
ISS (median [IQR])	18 [13, 27]	19 [13, 27]	17 [13, 22]		17 [13, 22]	17 [13, 22]	17 [14, 24]	
ISS ≥ 16 (severe) [n (%)]	1920 (65.4 %)	1820 (66.0 %)	100 (56.2 %)	<0.001	87 (56.5 %)	63 (56.8 %)	24 (55.8 %)	0.346
AIS ≥ 3 (serious) [n (%)]								
Head	796 (27.1 %)	778 (28.2 %)	18 (10.1 %)	<0.001	17 (11.0 %)	14 (12.6 %)	3 (7.0 %)	0.243
Face	14 (0.5 %)	14 (0.5 %)	0	<0.001	0	0	0	0.153
Chest	2308 (78.6 %)	2146 (77.8 %)	162 (91.0 %)	<0.001	140 (90.9 %)	102 (91.9 %)	38 (88.4 %)	0.308
Abdomen	629 (21.4 %)	598 (21.7 %)	31 (17.4 %)	<0.001	25 (16.2 %)	20 (18.0 %)	5 (11.6 %)	0.257
Limbs	588 (20.0 %)	572 (20.7 %)	16 (9.0 %)	<0.001	15 (9.7 %)	9 (8.1 %)	6 (14.0 %)	0.173
External	4 (0.1 %)	4 (0.1 %)	0	<0.001	0	0	0	0.153
Polytrauma (n (%))	1319 (44.9 %)	1268 (46.0 %)	51 (28.7 %)	<0.001	44 (28.6 %)	32 (28.8 %)	12 (27.9 %)	0.358
Surgery (all) [n (%)]	1867 (63.6 %)	1759 (63.8 %)	108 (60.7 %)	0.408	115 (74.7 %)*	87 (78.4 %)*	28 (65.1 %)*	0.090*
Calendar year of injury [n (%)]				<0.001				<0.001
≤ 2016	288 (9.8 %)	258 (9.4 %)	30 (16.9 %)		28 (18.2 %)	20 (18.0 %)	8 (18.6 %)	
2017	613 (20.9 %)	590 (21.4 %)	23 (12.9 %)		21 (13.6 %)	14 (12.6 %)	7 (16.3 %)	
2018	565 (19.2 %)	492 (17.8 %)	73 (41.0 %)		53 (34.4 %)	28 (25.2 %)	25 (58.1 %)	
2019	604 (20.6 %)	558 (20.2 %)	46 (25.8 %)		46 (29.9 %)	43 (38.7 %)	3 (7.0 %)	
2020	498 (17.0 %)	494 (17.9 %)	4 (2.3 %)		4 (2.6 %)	4 (3.6 %)	0	
2021	369 (12.6 %)	367 (13.3 %)	2 (1.1 %)		2 (1.8 %)	2 (1.8 %)	0	
Mechanism of injury [n (%)]				<0.001				0.150
Road trauma	1494 (50.9 %)	1413 (51.2 %)	81 (45.5 %)		69 (44.8 %)	54 (48.7 %)	15 (34.9 %)	
Falling	904 (30.8 %)	841 (30.5 %)	63 (35.4 %)		56 (39.5 %)	39 (35.1 %)	17 (39.5 %)	
Others	502 (17.1 %)	477 (17.3 %)	25 (14.0 %)		26 (16.9 %)	15 (13.5 %)	11 (25.6 %)	
Missing	37 (1.3 %)	28 (1.0 %)	9 (5.1 %)		3 (2.0 %)	3 (2.7 %)	0	
Area of the accident [n (%)]				0.443				0.509
Busan	1458 (49.6 %)	1372 (49.7 %)	86 (48.3 %)		77 (50.0 %)	58 (52.3 %)	19 (44.2 %)	
Gyeongsangnam-do	682 (23.2 %)	646 (23.4 %)	36 (20.2 %)		25 (16.2 %)	17 (15.3 %)	8 (18.6 %)	
Seoul / metropolitan cities	15 (0.5 %)	15 (0.5 %)	0		0	0	0	
Other provinces	55 (1.9 %)	52 (1.9 %)	3 (1.7 %)		3 (2.0 %)	3 (2.7 %)	0	
Missing	727 (24.8 %)	674 (24.4 %)	53 (29.8 %)		49 (31.8 %)	33 (29.7 %)	16 (37.2 %)	
Discharge referral to KM institution [n (%)]	25 (0.9 %)	21 (0.8 %)	4 (2.3 %)	0.104	3 (2.0 %)	3 (2.7 %)	0	0.479

AIS, abbreviated injury scale; ISS, injury severity score; IQR, interquartile range; KM, Korean medicine; NHI, national healthcare insurance.

proximately one-fourth of the patients were female, and the male-to-female ratio was slightly inconsistent between those who accepted and those who did not. The median ISS score was 18 for all patients [IQR 13, 27] and showed similar results in the two subgroups. More than half of patients had severe injury (i.e., ISS ≥ 16) (ranged from 56.2 to 66.0 %). Proportion of patients with serious chest injuries (i.e., AIS ≥ 3) was higher in the referral group (91.0 %) than in the non-referral group (77.8 %). The proportion of patients with serious injuries to other body parts was higher in the non-referral group than in the referral group. The proportion of patients with polytrauma was significantly lower in the acupuncture referral subgroup (28.7 %) than in the non-referral subgroup (46.0 %), while those figures became similar between patients who accepted acupuncture (28.8 %) and those not accepted (27.9 %). A small proportion of patients referred for acupuncture were transferred to a Korean medicine hospital or clinic after discharge from the PNUH trauma center (2.3 % compared to 0.8 % among the non-referred patients).

Table 2 illustrates the behavioural and clinical characteristics of the patients referred for acupuncture ($n = 154$). Over two-thirds (77.9 %) of patients reported moderate or severe level of pain (i.e., NRS ≥ 4) during admission.

The reasons for patients' decline to receive acupuncture are summarised in Appendix 1. 'Patients' or caregivers' refusal' was the most common, followed by 'missed KM clinic visit by the patient' or 'missed reply between the KMD and the trauma surgeons'. Patients who received acupuncture showed a significantly higher proportion of moderate or severe pain than in those who declined acupuncture treatment (83.8% vs. 62.8 %) (Table 2). The median number of acupuncture sessions was three [IQR 1, 7], and most patients (82.9 %) received <10 treatments. Manual and electroacupuncture (EA) treatment were the most common interventions, followed by transcutaneous electrical acupoint stimulation (TEAS) (Appendix 2).

In the crude and multivariate analyses, age, sex, and insurance type were not associated with acupuncture referral (Table 3). There was weak evidence of a protective association between severe physical injury (i.e. ISS >16) and referral for acupuncture in the crude analysis (uOR 0.74; 95 % CI 0.54, 1.01) but not in the multivariable analysis (aOR, 1.20; 0.82, 1.76). Polytrauma showed a strong protective association against referral for acupuncture in both crude (uOR 0.50; 95 % CI 0.36, 0.70) and multivariable analyses (aOR 0.46; 95 % CI 0.30, 0.68).

Among those referred to acupuncture services, injury severity, polytrauma, and type of injury showed no association with receiving

Table 2
Additional characteristics of the study population who referred to acupuncture ($n = 154$).

Variable	Total ($n = 154$)	Accepted ($n = 111$)	Not accepted ($n = 43$)	p-value
Smoking [n (%)]				0.094
Current	48 (31.2 %)	29 (26.1 %)	19 (44.2 %)	
Past/never	102 (66.2 %)	79 (71.2 %)	23 (53.5 %)	
Missing	4 (2.6 %)	3 (2.7 %)	1 (2.3 %)	
Alcohol consumption [n (%)]				0.870
Yes	70 (45.5 %)	49 (44.1 %)	21 (48.8 %)	
No	80 (52.0 %)	59 (53.2 %)	21 (48.8 %)	
Missing	4 (2.6 %)	3 (2.7 %)	1 (2.3 %)	
BMI (kg/m^2) [median (IQR)]	23.3 [21.8, 25.5]	23.3 [21.8, 25.5]	23.3 [21.8, 25.7]	
Occupation [n (%)]				0.892
Employed	114 (74.0 %)	83 (74.8 %)	31 (72.1 %)	
Domestic labor	17 (11.0 %)	11 (9.9 %)	6 (14.0 %)	
Unemployed	20 (13.0 %)	15 (13.5 %)	5 (11.6 %)	
Missing	3 (2.0 %)	2 (1.8 %)	1 (2.3 %)	
Area of residence [n (%)]				0.434
Pusan	100 (64.9 %)	70 (63.1 %)	30 (69.8 %)	
Other	54 (35.1 %)	41 (36.9 %)	13 (30.2 %)	
Maximum pain* [median (IQR)]	6.0 [5.0, 7.0]	6.0 [6.0, 7.0]	5.5 [3.0, 6.0]	
Maximum pain* [n (%)]				0.041
1–3 (mild)	31 (20.1 %)	16 (14.4 %)	15 (34.9 %)	
4–6 (moderate)	80 (52.0 %)	62 (55.9 %)	18 (41.9 %)	
7–10 (severe)	40 (26.0 %)	31 (27.9 %)	9 (20.9 %)	
Missing	3 (2.0 %)	2 (1.8 %)	1 (2.3 %)	
Level of physical activity [n (%)]				0.896
Completely passive	19 (12.3 %)	15 (13.5 %)	4 (9.3 %)	
Bed ridden	48 (31.2 %)	36 (32.4 %)	12 (27.9 %)	
Assisted	20 (13.0 %)	14 (12.6 %)	6 (14.0 %)	
Actively	64 (41.6 %)	44 (39.6 %)	20 (46.5 %)	
Missing	3 (2.0 %)	2 (1.8 %)	1 (2.3 %)	

BMI, body mass index; IQR, interquartile range; NRS, numerical rating scale.

Table 3
Univariable and multivariable logistic regression analysis of factors associated with acupuncture referral ($n = 2937$).

Characteristics	Unadjusted	P-value	Adjusted for age and sex ($n = 2937$)	P-value	Fully adjusted* ($n = 2922$)	P-value
Age at trauma (year)	1.00 (0.99, 1.01)	0.4471 (0.449)	1.00 (0.99, 1.01)	0.499	1.00 (0.99, 1.01)	0.720
Sex		0.5196				
Male	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Female	1.12 (0.79, 1.58)	0.516	1.10 (0.78, 1.56)	0.584	1.11 (0.77, 1.60)	0.576
Insurance		0.1072				
NHI	1.00 (Ref)				1.00 (Ref)	
Vehicle	0.80 (0.57, 1.13)	0.204			0.91 (0.64, 1.29)	0.587
Occupational	0.68 (0.31, 1.49)	0.338			0.86 (0.39, 1.91)	0.712
Other	0.52 (0.28, 0.96)	0.037			0.59 (0.32, 1.10)	0.096
Severe trauma (ISS \geq 16)	(missing $n = 9$)	0.0595				
No	1.00 (Ref)				1.00 (Ref)	
Yes	0.74 (0.54, 1.01)	0.057			1.20 (0.82, 1.76)	0.357
Polytrauma	(missing $n = 15$)	<0.001				
No	1.00 (Ref)				1.00 (Ref)	
Yes	0.50 (0.36, 0.70)	<0.001			0.46 (0.30, 0.68)	<0.001

ISS, injury severity score; NHI, national healthcare insurance.

* Adjusted for age group, sex, insurance, severe trauma, polytrauma.

acupuncture in both the crude and multivariate analyses (Table 4). Age was weakly associated with fewer odds of receiving acupuncture in the multivariate analysis, but the difference was not statistically significant. Female sex was consistently associated with higher odds of receiving acupuncture than in male sex in both the crude (OR 2.57; 1.04, 6.33) and multivariable analyses (aOR 3.92; 1.31, 11.77).

In the sensitivity analyses, neither the inclusion of each local injury score (i.e. AIS of each body part) (Appendix 3) nor the inclusion of smoking, alcohol consumption, maximum pain level in the nursing records, area of residence, comorbidity, and level of physical activity at discharge (Appendix 4) significantly altered the estimates of covariates in the multivariable logistic regression model for patients' willingness to receive acupuncture.

4. Discussion

4.1. Summary of findings

Our study found that trauma surgeons referred only a small proportion (6.1 %) of patients with TRF for acupuncture, which might imply the presence of barriers to acupuncture consultation. More than two-thirds of the referred patients (72.1 %) received acupuncture, potentially indicating a high level of acceptance of acupuncture from the patient's perspective. Polytrauma was a significant risk factor for referral to acupuncture by trauma surgeons. Among the referred, female patients showed almost 4 times higher odds of accepting the offer of acupuncture compared to the male patients, while neither severe physical in-

Table 4
Univariable and multivariable logistic regression analysis of factors associated with willing to receive acupuncture (n = 154).

Characteristics	Unadjusted	P-value	Adjusted for age and sex (n = 154)	P-value	Fully adjusted* (n = 146)	P-value
Age at trauma (year)	0.99 (0.96, 1.01)	0.3439 (0.348)	0.98 (0.95, 1.01)	0.149	0.97 (0.94, 1.00)	0.053
Sex		0.0292				
Male	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Female	2.57 (1.04, 6.33)	0.040	2.99 (1.17, 7.63)	0.022	3.92 (1.31, 11.77)	0.015
Insurance		0.2400				
NHI	1.00 (Ref)				1.00 (Ref)	
Vehicle	2.19 (0.91, 5.27)	0.082			1.53 (0.60, 3.93)	0.378
Occupational	0.61 (0.13, 2.92)	0.540			0.49 (0.09, 2.57)	0.399
Other	0.92 (0.22, 3.94)	0.911			0.53 (0.11, 2.61)	0.435
Severe trauma (ISS \geq 16)	(Missing n = 8)	0.7716				
No	1.00 (Ref)				1.00 (Ref)	
Yes	0.89 (0.42, 1.90)	0.772			0.80 (0.31, 2.04)	0.636
Polytrauma	(Missing n = 8)	0.9200				
No	1.00 (Ref)				1.00 (Ref)	
Yes	0.96 (0.43, 2.13)	0.920			0.99 (0.37, 2.69)	0.988

ISS, injury severity score; NHI, national healthcare insurance.

* Adjusted for age group, sex, insurance, severe trauma, polytrauma.

jury (i.e., ISS \geq 16) nor polytrauma was associated with willingness to receive acupuncture. These findings collectively indicate a potential discrepancy between trauma surgeons' perspectives and patients' views on the role of acupuncture after TRF. Acupuncture, with or without electrical stimulation, and TEAS were the most frequently used interventions, reflecting the feasibility of delivering acupuncture in severe acute trauma care settings.

4.2. Interpretation of the findings based on existing evidence

Few information specifically focused on the use of Traditional, Complementary and Integrative Medicine (TCIM) for patients with TRF in the thoracic trauma field is available. In our study, only 6.1 % of the patients with TRF had been referred to acupuncture by trauma surgeons, which is similar to the low referrals (i.e. 2.4 %) conducted in Western Medicine institutions,³² while other findings reported a higher level of usage of TCIM, possibly including acupuncture. For instance, two surveys of U.S. physicians consistently reported a favourable positive attitude and high willingness towards acupuncture referrals for chronic pain management.^{33,34} A recent systematic review regarding the prevalence of the acceptance and usage of complementary and alternative medicine (CAM) among medical specialists revealed that the proportion of general surgeons using CAM was 26 %, which was lower than that of other medical specialties (e.g. 68 % of obstetricians/gynaecologists and 63 % of family medicine doctors), but still significantly higher than those in our study.³⁵ One might explain that the different levels of knowledge on acupuncture and other TCIM or the perceived level of evidence of TCIM by Western medicine physicians are responsible for the observed heterogeneous referral patterns.^{33,35,36} Different clinical settings (e.g. thoracic trauma versus other clinical disciplines), healthcare systems (e.g. dual medical system in South Korea versus others), and methodological heterogeneity (e.g. use of acupuncture versus use of CAM, including a wide range of therapies) might also be attributable to the differences in referral patterns between South Korea and other countries. Whether and how these factors affect the integration of acupuncture into trauma care settings remain largely unknown and warrant further investigation.

Once referred, more than two-thirds of patients received acupuncture. In a German medical center setting, a cross-sectional survey of 457 orthopaedic and trauma surgical patients found that 30 % of the respondents were currently using CAM.³⁷ Another German multicenter cross-sectional survey conducted in the departments of general, visceral, and thoracic surgery of three university medical centers also revealed that 44 % of the patient respondents had a lifetime experience of complementary medicine (CM) use, and 51 % had a strong interest in CM counselling for their current disease.³⁸ These findings indicate that patients

with trauma and/or surgery may have an overall high level of experience with, and demand for, TCIM. The observed heterogeneous figures of TCIM usage between studies might be due to the different motivations for use (i.e. surgeon recommendation versus voluntary use), methods of ascertainment (i.e. data extraction from the EMR versus self-disclosure through questionnaire), types of insurance (i.e. whether acupuncture is covered or not), and the difference in the modalities (i.e. acupuncture versus CAM including a wide range of therapies). Discrepancies between patients' high willingness to receive or use TCIM and low referral rates by trauma surgeons may indicate the role of physicians as gatekeepers or significantly influential players in patients' decision-making processes, as reported by previous studies.^{39,40}

Manual acupuncture, electroacupuncture, and TEAS were the most commonly used interventions. In line with our previous reports,^{22,23} this finding suggests that acupuncture may have sufficient feasibility and safety in the multidisciplinary management of patients with TRF and may also be considered a viable component of care for major trauma patients. The analgesic effects of TEAS have been postulated in persistent and injury-related pain,⁴¹⁻⁴⁴ and its non-penetrative stimulation characteristics may justify its use where invasive interventions, such as acupuncture, are deemed inappropriate.^{45,46} In this study, the treatments were delivered in the inpatient trauma ward or outpatient bed in the Korean medicine clinic within the context of a tertiary academic hospital setting, where the provision of the relevant co-treatments such as cupping, and herbal medicine was difficult or impossible due to lack of resources such as ventilation facility for moxibustion smoke or prescription-distribution system for herbal medicine. In most cases, the total number of acupuncture sessions was <10 , which may be deemed insufficient to achieve clinically meaningful outcomes in patients with major trauma. Potential barriers to the continuity of acupuncture treatment include changes in primary surgeons (e.g. from trauma surgeons to orthopaedic surgeons) who are less familiar with acupuncture, especially in patients with polytrauma, as well as early referral to secondary hospitals once the patient's condition is stabilised. Further research is required to develop an optimal acupuncture protocol for acute trauma care settings.

Patients with polytrauma had significantly less than half the odds of being referred for acupuncture by trauma surgeons, whereas the association disappeared when factors related to willingness to receive acupuncture among the referred were investigated. In contrast, female patients were almost four times more likely to accept the offer of acupuncture than male patients, whereas injury-related factors showed no association. Trauma surgeons may perceive injuries to multiple body parts as contraindications for acupuncture. The association may be artefactual; however, the decision to refer might have been affected by the atti-

tudes of other medical staff who may have different views on acupuncture. From the patient's perspective, the severity of injury or polytrauma may not be a barrier. Instead, female gender-associated issues might be a strong facilitator of acupuncture. In previous studies, female were found to be more likely to use acupuncture or other CAM modalities for various acute and chronic conditions,⁴⁷⁻⁵¹ and several biological and socioeconomic risk factors have been suggested.⁵²⁻⁵⁴ As our models included limited variables and methodological weaknesses, the findings should be considered exploratory and hypothesis-generative.

4.3. Strengths and limitations

To the best of our knowledge, this is the first study to descriptively investigate patient characteristics associated with acupuncture treatment for TRF in a specialised major trauma center in South Korea. As regional trauma centers are designated and supported by the Korean government to primarily accommodate acute major trauma patients to reduce the preventable trauma death rate in their region,⁵⁵ we perceive that data extracted from a prospective trauma registry (i.e. KTDB), as well as the EMR generated from the study trauma center, are less prone to selection bias. Important clinical and behavioural variables, such as the level of pain, smoking, and alcohol consumption which were not available in the KTDB, were extracted from the EMR which complemented the efficiency of the analysis. Although the risk of coding errors cannot be completely eliminated when extracting data from large datasets, standardised data collection processes employing predefined data extraction tools are likely to prevent the risk of error and information bias. We analysed acupuncture consultations in clinical trauma care settings rather than in the research context; thus, our findings reflect real-world collaborative settings between Korean medicine and the conventional trauma care pathway.

The potential limitations of this study are as follows. First, information in the KTDB and the EMR is primarily for administrative or clinical purposes; thus, it may pose issues, including misclassification bias due to non-standardised records and selection bias due to missing variables or data in our findings. Second, acupuncture was performed at a tertiary hospital by a single KMD with over 13 years of experience in acupuncture practice and research at the time of treatment delivery, which may have limited the generalisability of our findings. Third, the number of referral caseloads by each trauma surgeon which may flag potential selection bias during referral process due to the differences in surgeon's perceptions toward acupuncture was not illustrated, although our focus was on referral patterns between departments rather than between individuals. Fourth, we could not analyse whether the referral or acceptance pattern of acupuncture was associated with a patient's level of education, income, or perception of the use of acupuncture due to a lack of data, although these were suggested as factors of traditional, complementary, and integrative medicine use in previous literature.^{48,49,56} These unmeasured variables may pose the risk of residual confounding factors in the regression analyses. Fifth, a small number of patients received acupuncture and were included in the analyses compared to the relatively larger number of trauma patients registered in the KTDB; thus, the estimation of association with acupuncture referral might be overly precise, while those with acceptance of acupuncture might be imprecise and at risk of inadequate power to detect the true association.

4.4. Implications for clinical practice, public health and future research

Our findings provide empirical evidence of acupuncture for patients with TRF in a specialised tertiary trauma center, which can inform the design of future scaled-up multicenter prospective studies to investigate whether the provision of acupuncture and Korean medicine services is feasible and beneficial for recovery from TRF. The different patterns between surgeons' referrals and patients' acceptance of acupuncture call for future research on the potential barriers and facilitators of acupuncture in traumatised patients. The characteristics of

the patients and records of the different acupuncture modalities and Korean medicine interventions may serve as baseline information for developing institutional- or national-level clinical practice guidelines of acupuncture for the affected population. Whether acupuncture and relevant co-interventions are feasible for other types of major traumatic injuries, such as orthopaedic, neurological, or abdominal injuries, needs to be further investigated. Perceptions and attitudes of patients, caregivers, acupuncture providers, trauma surgeons, and/or other relevant care stakeholders (e.g. nursing staff, physiotherapists, general physicians, or specialists) towards the integration of acupuncture and other traditional, complementary, and integrative medicines into different stages of care for major traumatic injuries need to be explored to understand the potential barriers and facilitators of integrated care.

4.5. Conclusions

In a single regional trauma center in South Korea, trauma surgeons referred a small proportion of patients with TRF to acupuncture services; however, most of the referred patients were willing to receive acupuncture. Polytrauma may be an important criterion against referral for acupuncture from the trauma surgeon's perspective, while female gender may be associated with the willingness to receive acupuncture. Future studies are needed to investigate the role of acupuncture in the postinjury care of patients with TRF.

Author contributions

Conceptualization: MHK, HMC, SHK, YK, YKS, KHK. Methodology: MHK, HMC, SHK, YK, YKS, KHK. Software: MHK, KHK. Validation: MHK, KHK, HMC, SHK. Formal analysis: MHK, KHK. Investigation: MHK, YKS, KHK. Resources: HMC, SHK, YK, YKS, KHK. Data curation: MHK, KHK. Writing – Original Draft: MHK, KHK. Writing – Review & Editing: HMC, SHK, YK, KHK. Visualization: MHK, KHK. Supervision: KHK. Project administration: KHK. Funding acquisition: KHK

Declaration of competing interest

None to declare

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Ethical statement

This research was reviewed and approved by the institutional review board of Pusan National University Hospital (registration number 2111-012-108). The requirement for written informed consent was waived by the ethics committee, as this study was a retrospective chart review using anonymised clinical records and produced aggregated summary results which are highly unlikely to breach the privacy of individuals.

Data availability

The data that has been used is confidential and cannot be shared.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.imr.2024.101096](https://doi.org/10.1016/j.imr.2024.101096).

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