BMC Geriatrics

RESEARCH Open Access

Medication-based profiling of older orthopedic patients: a multicenter cross-sectional study

Takayuki Hirono[1,2†], Mitsuhiro Morita[1†], Takehiro Michikawa[3], Risa Tobe[4], Takao Tobe[4], Koki Kato[4], Soya Kawabata[1], Akihito Oya[2], Yusuke Kawano[1], Kazue Hayakawa[1], Shinjiro Kaneko[5], Morio Matsumoto[2], Masaya Nakamura[2], Shigeki Yamada[4] and Nobuyuki Fujita[1*]

Abstract

Background Managing medication use in older orthopedic patients is imperative to extend their healthy life expectancy in an aging society. However, the actual situation regarding polypharmacy, the intake of potentially inappropriate medications (PIMs), and fall risk-increasing drugs (FRIDs) among older orthopedic patients is not well characterized. This study aimed to investigate the medication-based profiles of older orthopedic patients to highlight the critical points of concern.

Methods We retrospectively reviewed the clinical data of consecutive patients aged ≥ 65 years who underwent orthopedic surgery at two acute care hospitals between April 2020 and March 2021. The cutoff number of prescribed drugs for polypharmacy was set at 6. According to the specified guidelines, 19 categories of drugs were identified as PIMs, and 10 categories were classified as FRIDs.

Results A total of 995 older patients with orthopedic surgery were assessed, of which 57.4% were diagnosed with polypharmacy, 66.0% were receiving PIMs, and 41.7% were receiving FRIDs. The prevalence of FRID intake did not significantly differ among patients with degenerative spinal disease ($n = 316$), degenerative disease of extremities ($n = 331$), and fractures ($n = 272$). Compared with patients with degenerative disease of the extremities, the multivariable-adjusted prevalence ratios (PRs) of polypharmacy and PIM intake were significantly higher in patients with degenerative spinal disease (1.26 [confidence intervals (CI): 1.11–1.44] and 1.12 [CI: 1.00–1.25]), respectively. Use of antiemetic drugs (adjusted PR, 13.36; 95% CI: 3.14–56.81) and nonsteroidal anti-inflammatory drugs (adjusted PR, 1.37; 95% CI: 1.05–1.78) was significantly higher in patients with degenerative spinal disease. Among patients with degenerative spinal disease, the prevalence of antiemetic drug intake was 8.7% in lumbar spinal patients and 0% in cervical spinal patients.

†Takayuki Hirono and Mitsuhiro Morita contributed equally to this work.

*Correspondence:
Nobuyuki Fujita
nfujita2007@gmail.com

Full list of author information is available at the end of the article

Conclusions More than half of the orthopedic patients in this study were affected by polypharmacy, and approximately two-thirds were prescribed some form of PIMs. Patients with degenerative spinal disease showed a significantly higher prevalence of polypharmacy and PIM use compared with other orthopedic diseases. Particular attention should be paid to the high frequency of antiemetic drugs and nonsteroidal anti-inflammatory drugs intake among patients with degenerative lumbar spine conditions.

Keywords Orthopedic surgery, Polypharmacy, Potentially inappropriate medications, Fall risk-increasing drugs, Antiemetic drugs, Nonsteroidal anti-inflammatory drugs, Degenerative spinal disease, Fracture, Older people

Background

Globally, the increased life expectancy in recent decades has contributed to a progressive increase in the proportion of older adults in the population [1]. Increasing healthy life expectancy is one of the key objectives in an aging society to improve overall societal productivity and mitigate social burdens such as rising healthcare costs [2]. The progressive population aging has also contributed to an increased incidence of orthopedic conditions, such as osteoarthritis, low back pain, and fragility fractures, which significantly reduce the quality of life of older adults [3, 4]. Therefore, the prevention and management of orthopedic conditions are imperative to extend healthy life expectancy.

The practice of taking multiple medications (referred to as polypharmacy) is a significant problem in an aging society which has both medical and socio-economic repercussions [5]. Polypharmacy increases the risk of adverse drug events with the increase in the frequency of potentially inappropriate medications (PIMs) [5, 6]. PIMs refer to the potential drugs that pose more risks than benefits, especially in older adults [6]. These medications are often identified using criteria such as the Beers Criteria or the STOPP/START criteria, which list specific drugs or drug classes that may be inappropriate for use in older populations because of their high risk of causing adverse drug reactions, drug-disease interactions, or unnecessary duplication in drug therapy [7–9]. Therefore, identifying and reducing the use of PIMs is a crucial aspect of geriatric care to improve patient safety and overall health outcomes. In addition, fall risk-increasing drugs (FRIDs) are a category of medications that can increase the risk of falls, particularly in older adults [10, 11]. These drugs may increase the likelihood of a fall by affecting balance, cognition, or blood pressure [10, 11]. Common examples of FRIDs include hypnotics, antipsychotics, antidepressants, and some classes of antihypertensive drugs [10, 11]. Since falls are a leading cause of injury and morbidity in older adults, identification and management of FRIDs is an essential aspect of care in this population.

To extend healthy life expectancy, managing the medication of older orthopedic patients is extremely important. In a previous study, the prevalence of polypharmacy in older patients with musculoskeletal disorders was reported to be >50% [12]. Among older orthopedic patients, polypharmacy is significantly more prevalent in those with hip fractures or lumbar spine disorders [12, 13]. Furthermore, older fracture patients are expected to have a high frequency of FRID intake. However, the actual situation regarding polypharmacy, intake of PIMs, and FRIDs among older orthopedic patients is not well characterized. Considering that previous studies suggested that polypharmacy negatively influenced the outcomes of fracture treatment [14, 15], understanding the pharmacological profile of these patients is beneficial. Therefore, this study conducted a comprehensive medication survey among older patients who had undergone orthopedic surgery in two acute care hospitals. The objective was to assess the medication-based profiles of older orthopedic patients and highlight the critical points of concern in these patients.

Methods

Subjects

We retrospectively collected the clinical data of consecutive patients aged ≥ 65 years who underwent orthopedic surgery at two acute care hospitals between April 2020 and March 2021. One hospital has approximately 400 beds with 800 orthopedic surgeries per year, while the other hospital has approximately 1300 beds with 1700 orthopedic surgeries per year.

Ethics approval and consent to participate

This study was approved by the institutional ethics committee. Informed consent with the ethics committee was obtained in the form of opt-out. All study methods were conducted in accordance with the principles set out in the Declaration of Helsinki.

Data acquisition

The following data were retrieved for analysis: age; body mass index (BMI); sex; diagnosis; surgical procedure; medical history (including hypertension, dyslipidemia, diabetes, stroke, heart disease, and malignancy); preoperative prescribed drugs; and serum albumin levels. Decline in physical function, nutrition, oral function, activities of daily living (ADL), memory, and mood were diagnosed based on the responses to 10 questions extracted from the Kihon Checklist upon admission [16]. This checklist of 10 questions was used as a standard

procedure at the time of admission of all older orthopedic patients in these two hospitals (Supplementary Table S1). Patients who responded "no" to Q1 or "yes" to Q2 were determined to have physical function decline. Those who responded "yes" to Q3 were considered to have a decline in nutrition. Those who responded "yes" to Q4 or "yes" to Q5 were considered to have a decline in oral function. Those who responded "no" to Q6 were considered to have ADL decline. Those who responded "yes" to Q7 or "yes" to Q8 were considered to have memory decline. Those who responded "yes" to Q9 or "yes" to Q10 were determined to have a mood decline. In addition, the Charlson Comorbidity Index (CCI) for each patient was investigated.

Polypharmacy, potentially inappropriate medications, and fall risk-increasing drugs

The preoperative prescribed drugs were primarily investigated by pharmacists as part of the home therapy when the patients were admitted. Polypharmacy was defined as six or more medications [5, 12, 13]. According to the guidelines [7–9], the following 19 categories were considered PIMs requiring special caution when prescribing: antipsychotics, hypnotics, antidepressants, sulpiride, antiparkinsonian drugs, steroids, antithrombotic drugs, digitalis, diuretics, β-blockers, α-blockers, first-generation antihistamines, H_2-receptor antagonists, antiemetic drugs, laxatives, antidiabetic drugs, insulin, overactive bladder medications, and nonsteroidal anti-inflammatory drugs (NSAIDs). Among the 19 categories of PIMs, the following were considered FRIDs based on guidelines [9]: antipsychotics, hypnotics, antidepressants, sulpiride, antiparkinsonian drugs, diuretics, α-blockers, antiemetic drugs, antidiabetic drugs, and insulin.

Statistical analyses

Continuous variables are expressed as mean±standard deviation, while categorical variables are expressed as frequency (percentage). Between-group differences were assessed for statistical significance using the *t*-test, analysis of variance, or chi-square test, as appropriate. The prevalence of polypharmacy, intake of PIMs, FRIDs,

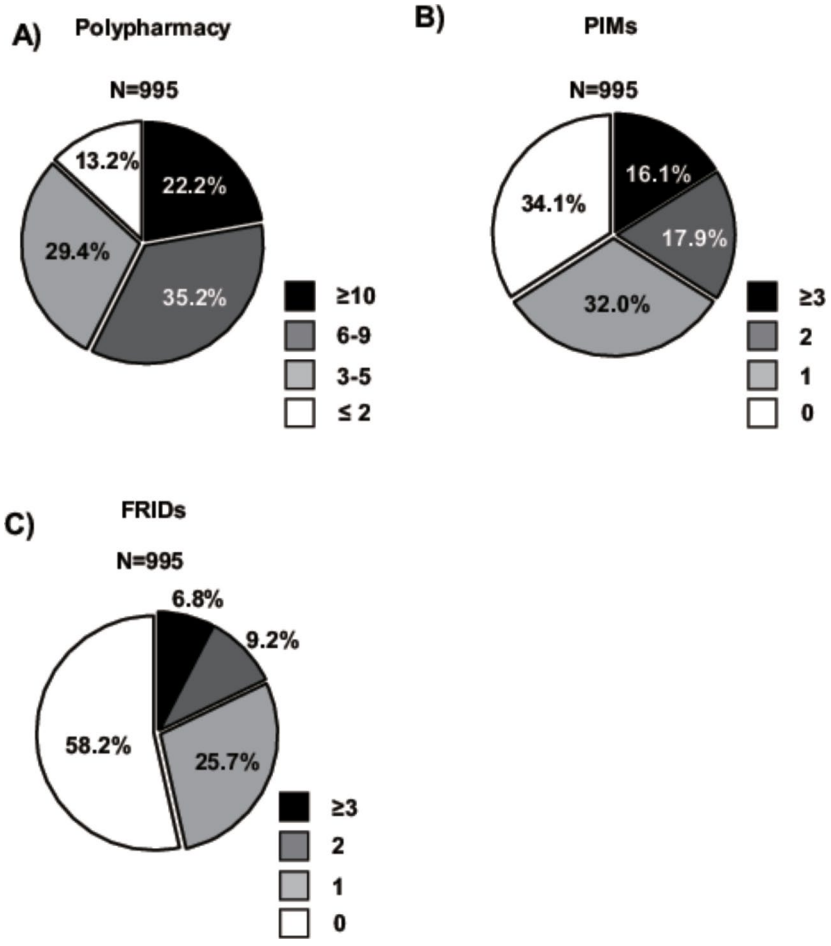

Fig. 1 Distribution of the numbers of total prescription drugs (**A**), potentially inappropriate medications (PIMs) (**B**), and fall risk-increasing drugs (FRIDs) (**C**) among older orthopedic patients

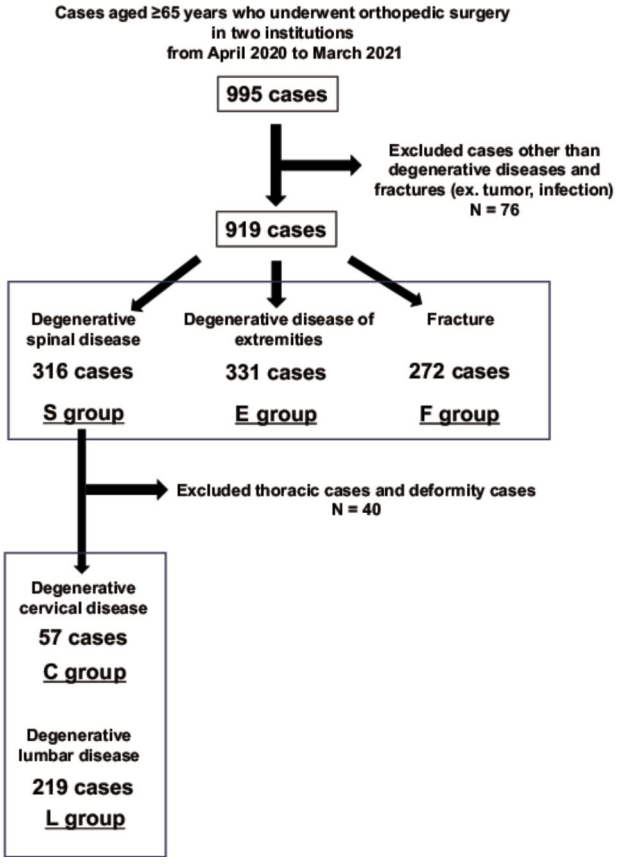

Fig. 2 Flow diagram showing the patient classification for each analysis in this study

and each category of PIMs among two or three groups were compared using Poisson regression models, and the results were reported as prevalence ratios (PRs) and 95% confidence intervals (CIs). The models were adjusted for baseline characteristics whose distributions differed among the three groups in the univariate analysis. Poisson regression was performed using STATA16 software (Stata Corporation, College Station, TX, USA). P values of <0.05 were considered indicative of statistical significance.

Results

A total of 995 older patients who underwent orthopedic surgery were included in this study. Figure 1A shows the distribution of the number of prescribed drugs in all patients. Among them, 22.2% were prescribed ≥10 drugs, 35.2% were prescribed 6–9 drugs, 29.4% were prescribed 3–5 drugs, and 13.2% were prescribed ≤2 drugs (Fig. 1A). The distribution of the number of categories of PIMs and FRIDs prescribed to the patients is shown in Fig. 1B and C, respectively.

Orthopedic conditions can be broadly divided into injuries and illnesses. Among injuries, fractures often require surgical treatment, while among illnesses, osteoarthritis and spondylosis are representative conditions frequently treated with surgery. Therefore, out of the total 995 patients, 76 patients with tumors and infections were excluded (Fig. 2). The remaining 919 cases were categorized into three groups: degenerative spinal disease (S group, $n=316$), degenerative disease of extremities (E group, $n=331$), and fractures (F group, $n=272$) (Fig. 2). The distribution of patients according to their surgical

Table 1 Comparison of baseline characteristics among three groups

		Degenerative spinal disease (S group, $n=316$)	Degenerative disease of extremities (E group, $n=331$)	Fracture (F group, $n=272$)	*P* value
Age		75.9 ± 6.3	75.2 ± 5.8	80.6 ± 8.1	< 0.001
Sex	Male	165 (52.2%)	83 (25.1%)	74 (27.2%)	< 0.001
	Female	151 (47.8%)	248 (74.9%)	198(72.8%)	
BMI (kg/m^2)		23.8 ± 3.2	24.5 ± 4.2	21.4 ± 4.1	< 0.001
Medical history	Hypertension	198 (62.3%)	207 (62.5%)	155 (57.0%)	0.28
	Dyslipidemia	120 (38.0%)	107 (32.3%)	47 (17.3%)	< 0.001
	Diabetes	92 (29.1%)	62 (18.7%)	57 (21.0%)	0.005
	Stroke	39 (12.3%)	42 (12.7%)	38 (14.0%)	0.83
	Heart disease	61 (19.3%)	63 (19.0%)	37 (13.6%)	0.13
	Malignancy	55 (17.4%)	54 (16.3%)	42 (15.4%)	0.81
Functional decline	Physical function	145 (45.9%)	146 (44.1%)	208 (76.5%)	< 0.001
	Nutrition	12 (3.8%)	8 (2.4%)	14 (5.1%)	0.21
	Oral function	14 (4.4%)	19 (5.7%)	27 (9.9%)	0.02
	Activities of daily living	28 (8.9%)	19 (5.7%)	51 (18.8%)	< 0.001
	Memory	16 (5.1%)	14 (4.2%)	71 (26.1%)	< 0.001
	Mood	7 (2.2%)	8 (2.4%)	12 (4.4%)	0.23
Serum albumin levels (g/dL)		4.0 ± 0.5	3.9 ± 0.4	3.5 ± 0.6	< 0.001
Charlson comorbidity index		5.2 ± 1.7	4.8 ± 1.3	5.4 ± 1.5	< 0.001

*Analysis of variance (ANOVA), **Chi-square test

procedures is shown in Supplementary Table S2. First, baseline characteristics were compared among the three groups. Age was significantly higher in the F group, the proportion of males was significantly higher in the S group, and BMI was significantly higher in the E group (Table 1). In terms of medical history, the frequency of dyslipidemia and diabetes was significantly higher in the S group (Table 1). In the survey using the Kihon Checklist [14], the frequency of decline in physical function, oral function, and memory was significantly higher in the F group (Table 1). Additionally, compared to the other two groups, the F group had the lowest serum albumin level and the highest CCI (Table 1). The Poisson regression model was used to compare the prevalence of polypharmacy and the intake of PIMs and FRIDs among the three groups. After adjusting for age, sex, BMI, albumin, dyslipidemia, diabetes, physical function, oral function, ADL, and memory, the PRs of polypharmacy and PIM intake were significantly higher in the S group at 1.26 (CI: 1.11–1.44) and 1.12 (CI: 1.00–1.25), respectively, when using the E group as a reference (Table 2). Meanwhile, the prevalence of FRID intake did not significantly differ among three groups (Table 2). In addition, for each category of PIMs, the prevalence of hypnotics and laxatives was lower in the F group (multivariable-adjusted PR for hypnotics, 0.67; 95% CI: 0.45–0.99; multivariable-adjusted PR for laxatives, 0.58; 95% CI: 0.38–0.90), whereas that of antiemetic drugs and NSAIDs was higher in the S group (multivariable-adjusted PR for antiemetic drugs, 13.36; 95% CI: 3.14–56.81; multivariable-adjusted PR for NSAIDs, 1.37; 95% CI: 1.05–1.78) (Table 3).

Among the three groups, we focused on the S group, which was characterized by polypharmacy and PIMs. After excluding patients who had thoracic and spinal deformity cases, it was divided into two subgroups: cervical spinal cases (C group, $n=57$) and lumbar spinal cases (L group, $n=219$) (Fig. 2). On comparing the baseline characteristics between the two groups, BMI was significantly higher in the L group, while the frequency of functional decline in memory was significantly higher and the serum albumin level was significantly lower in the C group (Table 4). However, there was no significant difference in CCI between the groups. The prevalence of polypharmacy and the intake of PIMs and FRIDs did not differ between the two subgroups (Table 5). Among the categories of PIMs, antidiabetic drugs had a significantly lower PR in the L group than in the C group (multivariable-adjusted PR for antidiabetic drugs, 0.38; 95% CI: 0.20–0.73) (Table 6). For antiemetic drugs, the prevalence of prescriptions was 8.7% in the L group and 0% in the S group (Table 6).

Discussion

Our findings underline the need to exercise caution against polypharmacy and the intake of PIMs and FRIDs among older patients undergoing orthopedic surgery due to its high prevalence. Among older orthopedic conditions, hip fractures, which particularly cause dysfunction and poor vital prognosis [17, 18], have been reported to be associated with polypharmacy-related postoperative delirium and mortality [14, 15]. Therefore, special attention should be given to older patients with hip fractures. Meanwhile, although the results suggested that the prevalence of FRIDs intake does not depend on the disease, contrary to our expectations, the significantly higher frequency of polypharmacy and PIMs intake among patients with degenerative spinal disease indicates the need for close monitoring of adverse drug events in these patients. In a previous study of older patients with degenerative musculoskeletal disorders, those with degenerative lumbar disorders had a significantly higher proportion of analgesic usage, which is consistent with our current findings [12]. The frequent prescription of NSAIDs to patients with degenerative lumbar spinal disease is likely due to the severe pain associated with these conditions. However, considering the well-known side

Table 2 Poisson regression model of polypharmacy, PIMs, and FRIDs among three groups

		Degenerative spinal disease (S group, $n=316$)	Degenerative disease of extremities (E group, $n=331$)	Fracture (F group, $n=272$)
Polypharmacy	Number of polypharmacy	214	169	134
	Prevalence of polypharmacy (%)	67.7	51.1	49.3
	Prevalence ratio (95% confidence interval)*	1.26 (1.11–1.44)	Reference	0.90 (0.76–1.07)
PIMs	Number of PIMs	232	210	160
	Prevalence of PIMs (%)	73.4	63.4	58.8
	Prevalence ratio (95% confidence interval)*	1.12 (1.00-1.25)	Reference	0.88 (0.77–1.01)
FRIDs	Number of FRIDs	143	125	105
	Prevalence of FRIDs (%)	45.3	37.8	38.6
	Prevalence ratio (95% confidence interval)*	1.09 (0.91–1.30)	Reference	0.88 (0.71–1.10)

*Adjusted for age, sex, body mass index, serum albumin levels, dyslipidemia, diabetes, physical function, oral function, activities of daily living and memory

PIMs, potentially inappropriate medications; FRIDs, fall risk-increasing drugs

Table 3 Poisson regression model of each category in PIMs among three groups

		Degenerative spinal disease (S group, *n* = 316)	Degenerative disease of extremities (E group, *n* = 331)	Fracture (F group, *n* = 272)
Antipsychotics	Prevalence of prescription (%)	1.9	2.1	4.4
	Prevalence ratio (95% confidence interval)*	0.88 (0.29–2.66)	Reference	1.14 (0.43–3.01)
Hypnotics	Prevalence of prescription (%)	21.5	19.9	16.9
	Prevalence ratio (95% confidence interval)*	1.13 (0.83–1.54)	Reference	0.67 (0.45–0.99)
Antidepressants	Prevalence of prescription (%)	2.2	2.1	1.5
	Prevalence ratio (95% confidence interval)*	1.00 (0.37–1.70)	Reference	0.54 (0.18–1.61)
Sulpiride	Prevalence of prescription (%)	0.6	0.6	0.4
	Prevalence ratio (95% confidence interval)*	2.26 (0.28–18.38)	Reference	2.33 (0.18–30.38)
Antiparkinsonian agents	Prevalence of prescription (%)	0.3	0	0.7
	Prevalence ratio (95% confidence interval)*	n.a.	Reference	n.a.
Steroids	Prevalence of prescription (%)	4.8	4.2	2.0
	Prevalence ratio (95% confidence interval)*	1.19 (0.55–2.59)	Reference	0.55 (0.22–1.39)
Antithrombotic drugs	Prevalence of prescription (%)	8.2	3.3	7.0
	Prevalence ratio (95% confidence interval)*	1.67 (0.75–3.68)	Reference	1.68 (0.76–3.72)
Digitalis	Prevalence of prescription (%)	0.6	0	0.7
	Prevalence ratio (95% confidence interval)*	n.a.	Reference	n.a.
Diuretics	Prevalence of prescription (%)	4.8	7.0	10.7
	Prevalence ratio (95% confidence interval)*	0.61 (0.32–1.18)	Reference	1.10 (0.60–2.01)
β-Blockers	Prevalence of prescription (%)	0	0.9	0.4
	Prevalence ratio (95% confidence interval)*	n.a.	Reference	0.52 (0.04–6.96)
α-Blockers	Prevalence of prescription (%)	3.2	2.7	1.8
	Prevalence ratio (95% confidence interval)*	0.91 (0.30–2.79)	Reference	0.34 (0.10–1.23)
First-generation antihistamines	Prevalence of prescription (%)	0.6	0.6	0
	Prevalence ratio (95% confidence interval)*	0.98 (0.21–4.46)	Reference	n.a.
H2-receptor antagonists	Prevalence of prescription (%)	3.5	7.0	4.0
	Prevalence ratio (95% confidence interval)*	0.44 (0.20–0.94)	Reference	0.49 (0.20–1.22)
Antiemetic drugs	Prevalence of prescription (%)	6.7	0.6	1.1
	Prevalence ratio (95% confidence interval)*	13.36 (3.14–56.81)	Reference	1.65 (0.26–10.67)
Laxatives	Prevalence of prescription (%)	15.8	15.4	14.0
	Prevalence ratio (95% confidence interval)*	0.95 (0.65–1.39)	Reference	0.58 (0.38–0.90)
Antidiabetic drugs	Prevalence of prescription (%)	13.9	9.7	10.3
	Prevalence ratio (95% confidence interval)*	1.00 (0.69–1.43)	Reference	1.14 (0.79–1.67)
Insulin	Prevalence of prescription (%)	2.9	0.9	2.2
	Prevalence ratio (95% confidence interval)*	1.89 (0.51-7.00)	Reference	1.45 (0.35–5.98)
Overactive bladder medications	Prevalence of prescription (%)	4.1	3.9	2.6
	Prevalence ratio (95% confidence interval)*	1.20 (0.55–2.61)	Reference	0.50 (0.19–1.33)
NSAIDs	Prevalence of prescription (%)	30.4	23.3	14.0
	Prevalence ratio (95% confidence interval)*	1.37 (1.05–1.78)	Reference	0.73 (0.49–1.07)

*Adjusted for age, sex, body mass index, serum albumin levels, dyslipidemia, diabetes, physical function, oral function, activities of daily living and memory

PIMs, potentially inappropriate medications; NSAIDs, non-steroidal anti-inflammatory drugs

effects of NSAIDs, such as gastrointestinal disorders and renal dysfunction, unnecessary or long-term prescriptions should be avoided [7–9]. Furthermore, patients with degenerative lumbar spinal disease showed a particularly high prevalence of taking antiemetic drugs. Some pain relief medications, such as tramadol formulations, may cause nausea, necessitating the concurrent use of antiemetic drugs [19, 20]. However, antiemetics, including metoclopramide and prochlorperazine, have been shown to be associated with the emergence or worsening of Parkinsonian symptoms [7–9]. Therefore, their use should also be minimized as much as possible. The frequent use of antiemetic drugs in patients with degenerative lumbar diseases may be attributed to the high prevalence of tramadol formulation intake, which in turn is associated with the frequent use of pain relief medication [21]. Older patients with kyphotic deformities tend to have a high incidence of gastroesophageal reflux disease due to postural abnormalities [22, 23]. Similarly, patients with degenerative lumbar disease tend to adopt a

Table 4 Comparison of baseline characteristics among two groups

		Cervical spine (C group, *n* = 57)	Lumbar spine (L group, *n* = 219)	*P* value
Age		77.0 ± 6.5	75.8 ± 6.0	0.18
Sex	Male	30 (52.6%)	116 (53.0%)	0.96
	Female	27 (47.4%)	103 (47.0%)	
BMI (kg/m^2)		22.9 ± 3.2	24.0 ± 3.1	0.02
Medical history	Hypertension	38 (66.7%)	137 (62.6%)	0.57
	Dyslipidemia	17 (29.8%)	92 (42.0%)	0.09
	Diabetes	17 (29.8%)	59 (26.9%)	0.66
	Stroke	7 (12.3%)	27 (12.3%)	0.99
	Heart disease	12 (21.1%)	46 (21.0%)	0.99
	Malignancy	7 (12.2%)	37 (16.9%)	0.4
Functional decline	Physical function	34 (59.6%)	85 (38.8%)	0.005
	Nutrition	3 (5.2%)	6 (2.7%)	0.34
	Oral function	0 (0%)	8 (3.7%)	0.14
	Activities of daily living	8 (14.0%)	17 (7.8%)	0.14
	Memory	7 (12.3%)	7 (3.2%)	0.005
	Mood	0 (0%)	4 (1.8%)	0.3
Serum albumin levels (g/dL)		3.9 ± 0.5	4.1 ± 0.4	0.01
Charlson comorbidity index		5.0 ± 1.2	5.0 ± 1.4	0.81

T-test or Chi-square test

Table 5 Poisson regression model of polypharmacy, PIMs, and FRIDs among two subgroups

		Cervical spine (C group, *n* = 57)	Lumbar spine (L group, *n* = 219)
Polypharmacy	Number of polypharmacy	36	151
	Prevalence of polypharmacy (%)	63.2	69.0
	Prevalence ratio (95% confidence interval)*	Reference	1.14 (0.91–1.41)
PIMs	Number of PIMs	41	161
	Prevalence of PIMs	71.9	73.5
	Prevalence ratio (95% confidence interval)*	Reference	1.11 (0.91–1.35)
FRIDs	Number of FRIDs	27	99
	Prevalence of FRIDs	47.4	45.2
	Prevalence ratio (95% confidence interval)*	Reference	1.03 (0.74–1.45)

*Adjusted for age, sex, body mass index, serum albumin levels, dyslipidemia, diabetes, physical function, oral function, activities of daily living and memory

PIMs, potentially inappropriate medications; FRIDs, fall risk-increasing drugs

forward-leaning posture [24]. Considering these previous reports, the frequent use of antiemetic drugs in patients with degenerative lumbar diseases may in part be attributable to nausea due to postural abnormalities. Considering that it has been reported that surgery for lumbar spinal stenosis, one of representative degenerative lumbar diseases, improved polypharmacy in older patients by reducing analgesic usage and the concomitant use of gastrointestinal medications [25], orthopedic surgeries as a whole may also have the potential to improve polypharmacy and the intake of PIMs in older patients.

In this study, we identified distinct differences between each pathological condition with respect to patient background as well as medication use. Compared to patients with degenerative spinal disease or degenerative disease of the extremities, patients with fractures were found to have the lowest BMI, and exhibit the greatest decline in physical function, oral function, ADL, and memory. Moreover, the serum albumin level was also lowest in patients with fractures, suggesting that among these three conditions, patients with fractures are more likely to exhibit frailty [26]. Considering that previous reports have stated that frailty affected surgical outcomes in older patients with fractures [27, 28], it is advisable to assess frailty before performing fracture surgery on older patients. Meanwhile, patients with degenerative spinal disease had the highest proportion of males, higher BMI, and highest frequency of dyslipidemia and diabetes. Especially, patients with degenerative lumbar spinal disease had a higher BMI, and although not statistically significant, a higher frequency of dyslipidemia compared to those with degenerative cervical spinal disease. Our results align with earlier research that has identified a link between degenerative lumbar disease and lifestyle-related diseases [29, 30]. Summarizing these findings, degenerative lumbar spine diseases are more closely associated with metabolic syndrome among orthopedic

Table 6 Poisson regression model of each drug in PIMs among two subgroups

		Cervical spine (C group, *n* = 57)	Lumbar spine (L group, *n* = 219)
Antipsychotics	Prevalence of prescription (%)	3.5	1.8
	Prevalence ratio (95% confidence interval)*	Reference	1.07 (0.19–6.15)
Hypnotics	Prevalence of prescription (%)	24.6	21.5
	Prevalence ratio (95% confidence interval)*	Reference	0.88 (0.49–1.57)
Antidepressants	Prevalence of prescription (%)	0	2.7
Sulpiride	Prevalence of prescription (%)	0	0.9
Antiparkinsonian agents	Prevalence of prescription (%)	0	0.5
Steroids	Prevalence of prescription (%)	3.5	5.5
	Prevalence ratio (95% confidence interval)*	Reference	1.74 (0.50–6.11)
Antithrombotic drugs	Prevalence of prescription (%)	10.5	6.9
	Prevalence ratio (95% confidence interval)*	Reference	0.78 (0.32–1.89)
Digitalis	Prevalence of prescription (%)	3.5	0
Diuretics	Prevalence of prescription (%)	7.0	5.0
	Prevalence ratio (95% confidence interval)*	Reference	0.62 (0.20–1.92)
β-Blockers	Prevalence of prescription (%)	0	0
α-Blockers	Prevalence of prescription (%)	3.5	2.7
	Prevalence ratio (95% confidence interval)*	Reference	1.11 (0.23–5.39)
First-generation antihistamines	Prevalence of prescription (%)	1.8	0.5
	Prevalence ratio (95% confidence interval)*	Reference	0.16 (0.01–3.27)
H2-receptor antagonists	Prevalence of prescription (%)	1.8	3.2
	Prevalence ratio (95% confidence interval)*	Reference	2.59 (0.36–18.42)
Antiemetic drugs	Prevalence of prescription (%)	0	8.7
Laxatives	Prevalence of prescription (%)	17.5	13.7
	Prevalence ratio (95% confidence interval)*	Reference	0.87 (0.44–1.71)
Antidiabetic drugs	Prevalence of prescription (%)	22.8	10.5
	Prevalence ratio (95% confidence interval)*	Reference	0.38 (0.20–0.73)
Insulin	Prevalence of prescription (%)	1.8	2.7
	Prevalence ratio (95% confidence interval)*	Reference	2.11 (0.68–6.53)
Overactive bladder medications	Prevalence of prescription (%)	3.5	3.7
	Prevalence ratio (95% confidence interval)*	Reference	1.08 (0.23–5.06)
NSAIDs	Prevalence of prescription (%)	21.1	32.0
	Prevalence ratio (95% confidence interval)*	Reference	1.45 (0.83–2.55)

*Adjusted for age, sex, body mass index, serum albumin levels, dyslipidemia, diabetes, physical function, oral function, activities of daily living and memory

PIMs, potentially inappropriate medications; NSAIDs, non-steroidal anti-inflammatory drugs

conditions, suggesting that managing metabolic syndrome may be important for older patients with these conditions.

Some limitations of this study should be considered while interpreting the results. First, the two hospitals included in this study were both high-volume centers for acute care. Despite the similar distribution of diseases in these hospitals, our findings may not necessarily be generalizable to orthopedic patients treated in other types of hospitals. Second, orthopedic patients who did not undergo surgery were not included in this study. However, a large proportion of orthopedic diseases are treated conservatively. Therefore, the findings of this study are based on orthopedic patients who required surgery and hospitalization. Third, we used 10 questions extracted from the Kihon Checklist for functional evaluation of the patients on admission [16]. Although the selection of these questions generally does not deviate from the original intent, this may have introduced an element of bias. Fourth, because we had scare information on the proportion of polypharmacy among older orthopedic patients, a sample size calculation was difficult. Therefore, we performed an exploratory analysis using all data within the available time frame. Nevertheless, to the best of our knowledge, this study is the first to provide a detailed profile, including medication information, of older orthopedic patients who underwent surgery in acute care hospitals. We believe that this study will shed new light on the characteristics of orthopedic patients through the filter of medication information. Establishing a standard approach to polypharmacy and the intake of PIMs and FRIDs in older orthopedic patients is still challenging. However, we advise that orthopedic surgeons should recognize that polypharmacy and the intake of PIMs

and FRIDs are common among older patients undergoing orthopedic surgery. Moreover, we recommend that they make an effort to reduce medications when possible using their own judgment and, for those medications that cannot be reduced, be aware of the potential adverse drug events that each medication might cause. Such interventions may improve surgical outcomes for older orthopedic patients. To demonstrate this, it is important to prospectively compare surgical outcomes between patients who receive preoperative interventions and those who do not. This remains a future research task.

In conclusion, more than half of the older orthopedic patients undergoing surgery were on polypharmacy, and approximately two-thirds were taking PIMs. Among these patients, those with degenerative spinal disease showed a significantly higher prevalence of polypharmacy and PIM use than those with other diseases. In particular, attention should be paid to the high frequency of antiemetic drugs and NSAIDs intake among patients with degenerative lumbar spine conditions.

Abbreviations

BMI	Body mass index
ADL	Activities of daily living
PIMs	Potentially inappropriate medications
FRIDs	Fall risk-increasing drugs
NSAIDs	Nonsteroidal anti-inflammatory drugs
PR	Prevalence ratio
CI	Confidence interval

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-024-05284-8.

Supplementary Material 1

Supplementary Material 2

Acknowledgements
The authors would like to thank Ms. Satoko Okada and Ms. Yukari Kuno for their technical support.

Author contributions
N.F. and S.Y. designed the study. T.H., M.M. (Mitsuhiro Morita), R.T., T.T., K.K., A.O., Y.K., K. H., S.K. (Shinjiro Kaneko)., M.M. (Morio Matsumoto), and M.N. contributed to the analysis and interpretation of the data. S.K. (Soya Kawabata) and T.M. performed the statistical analysis. T.H., S.K. (Soya Kawabata), T.M., and N.F. wrote the initial draft of the manuscript. M.M. (Mitsuhiro Morita), R.T., T.T., K.K., A.O., Y.K., K.H., S.K. (Shinjiro Kaneko)., M.M. (Morio Matsumoto), M.N., and S.Y. critically reviewed the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding
This study received no external funding.

Data availability
The datasets generated and/or analyzed during the current study are not publicly available due to the limitations of ethical approval involving patient data and anonymity; however, they are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This research was approved by the Fujita Health University Ethics Committee (approval no. HM20-055). Informed consent was waived by the Fujita Health University Ethics Committee. The Fujita Health University Ethics Committee also approved our use of the opt-out method for obtaining consent, indicating that all eligible patients were included in the present study unless they contacted us to opt out.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Orthopaedic Surgery, Fujita Health University, 1-98 Dengakugakubo, Kutsukake-cho, Toyoake 470-1192, Aichi, Japan
[2]Department of Orthopaedic Surgery, Keio University School of Medicine, Tokyo, Japan
[3]Department of Environmental and Occupational Health, School of Medicine, Toho University, Tokyo, Japan
[4]Department of Clinical Pharmacy, School of Medicine, Fujita Health University, Aichi, Japan
[5]Department of Spine and Spinal Cord Surgery, Fujita Health University, Aichi, Japan

Received: 26 February 2024 / Accepted: 5 August 2024
Published online: 09 August 2024

References

1. Ageing WHO. and health. 2022. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Accessed 01 October 2022.
2. Beltrán-Sánchez H, Soneji S, Crimmins EM. Past, present, and future of healthy life expectancy. Cold Spring Harb Perspect Med. 2015;5:a025957.
3. McGrath R, Al Snih S, Markides K, Hall O, Peterson M. The burden of health conditions for middle-aged and older adults in the United States: disability-adjusted life years. BMC Geriatr. 2019;19:100.
4. Ritsuno Y, Kawado M, Morita M, Yamada H, Kanaji A, Nakamura M, et al. Impact of musculoskeletal disorders on healthy life expectancy in Japan. BMC Musculoskelet Disord. 2021;22:661.
5. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. BMC Geriatr. 2017;17:230.
6. Cannon KT, Choi MM, Zuniga MA. Potentially inappropriate medication use in elderly patients receiving home health care: a retrospective data analysis. Am J Geriatr Pharmacother. 2006;4:134–43.
7. By the 2023 American Geriatrics Society Beers Criteria® Update Expert Panel. American Geriatrics Society 2023 updated AGS Beers Criteria for potentially inappropriate medication use in older adults. J Am Geriatr Soc. 2023;71(7):2052–81.
8. O'Mahony D, Cherubini A, Guiteras AR, Denkinger M, Beuscart JB, Onder G, et al. STOPP/START criteria for potentially inappropriate prescribing in older people: version 3. Eur Geriatr Med. 2023;14(4):625–32.
9. Kojima T, Mizukami K, Tomita N, Arai H, Ohrui T, Eto M, et al. Screening tool for older persons' appropriate prescriptions for Japanese: report of the Japan Geriatrics Society Working Group on Guidelines for medical treatment and its safety in the elderly. Geriatr Gerontol Int. 2016;16:983–1001.
10. Hart LA, Phelan EA, Yi JY, Marcum ZA, Gray SL. Use of fall risk-increasing drugs around a fall-related injury in older adults: a systematic review. J Am Geriatr Soc. 2020;68:1334–43.
11. Osman A, Kamkar N, Speechley M, Ali S, Montero-Odasso M. Fall risk-increasing drugs and gait performance in community-dwelling older adults: a systematic review. Ageing Res Rev. 2022;77:101599.
12. Sato K, Inagaki R, Michikawa T, Kawabata S, Ito K, Morita M, et al. Prescription drug survey of elderly patients with degenerative musculoskeletal disorders. Geriatr Gerontol Int. 2022;22:121–6.
13. Taniguchi T, Inagaki R, Michikawa T, Kawabata S, Yoshida M, Kawano Y, et al. Polypharmacy of older surgical patients with extremity fractures. Geriatr Orthop Surg Rehabil. 2024;15:21514593241234431.

14. Chen Y, Liang S, Wu H, Deng S, Wang F, Lunzhu C, et al. Postoperative delirium in geriatric patients with hip fractures. Front Aging Neurosci. 2022;14:1068278.
15. Al-Khatib Y, Dasari K. Hip fracture post-operative mortality and polypharmacy: a New Risk Predictor? Cureus. 2023;15:e47089.
16. Arai H, Satake S. English translation of the Kihon Checklist. Geriatr Gerontol Int. 2015;15:518–9.
17. Nguyen ND, Center JR, Eisman JA, Nguyen TV. Bone loss, weight loss, and weight fluctuation predict mortality risk in elderly men and women. J Bone Min Res. 2007;22(8):1147–54.
18. Suzuki T, Yoshida H. Low bone mineral density at femoral neck is a predictor of increased mortality in elderly Japanese women. Osteoporos Int. 2010;21(1):71–9.
19. Dowell D, Haegerich TM, Chou R. CDC guideline for prescribing opioids for chronic Pain–United States, 2016. JAMA. 2016;315:1624–45.
20. Barakat A. Revisiting tramadol: a multi-modal agent for pain management. CNS Drugs. 2019;33:481–501.
21. Imai T, Nagai S, Michikawa T, Inagaki R, Kawabata S, Ito K, et al. Impact of lumbar surgery on pharmacological treatment for patients with lumbar spinal canal stenosis: a single-center retrospective study. J Clin Med. 2023;12:2385.
22. Hosogane N, Watanabe K, Yagi M, Kaneko S, Toyama Y, Matsumoto M. Scoliosis is a risk factor for gastroesophageal reflux disease in adult spinal deformity. Clin Spine Surg. 2017;30:E480–4.
23. Ohba T, Ebata S, Koyama K, Haro H. Prevalence and key radiographic spinal malalignment parameters that influence the risk for gastroesophageal reflux disease in patients treated surgically for adult spinal deformity. BMC Gastroenterol. 2018;18:8.
24. Hikata T, Watanabe K, Fujita N, Iwanami A, Hosogane N, Ishii K, et al. Impact of sagittal spinopelvic alignment on clinical outcomes after decompression surgery for lumbar spinal canal stenosis without coronal imbalance. J Neurosurg Spine. 2015;23:451–8.
25. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol Biol Sci Med Sci. 2001;56:M146–56.
26. Nagai S, Inagaki R, Michikawa T, Kawabata S, Ito K, Hachiya K, et al. Efficacy of surgical treatment on polypharmacy of elderly patients with lumbar spinal canal stenosis: retrospective exploratory research. BMC Geriatr. 2023;23(1):169.
27. Bartosch P, Malmgren L, Kristensson J, McGuigan FE, Akesson KE. In community-dwelling women frailty is associated with imminent risk of osteoporotic fractures. Osteoporos Int. 2021;32(9):1735–44.
28. Kennedy CC, Ioannidis G, Rockwood K, Thabane L, Adachi JD, Kirkland S, et al. A Frailty Index predicts 10-year fracture risk in adults age 25 years and older: results from the Canadian Multicentre osteoporosis study (CaMos). Osteoporos Int. 2014;25:2825–32.
29. Uesugi K, Sekiguchi M, Kikuchi S, Konno S. Relationship between lumbar spinal stenosis and lifestyle-related disorders: a cross-sectional multicenter observational study. Spine. 2013;38:E540–5.
30. Fujita N. Lumbar spinal canal stenosis from the perspective of locomotive syndrome and metabolic syndrome: a narrative review. Spine Surg Relat Res. 2021;5:61–7.

Publisher's Note