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Modified frailty index (mFI): is it a predictor for early postoperative complications in arthroplasty surgery?

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Abstract. – OBJECTIVE: It has been demonstrated that the modified frailty index (mFI) is a powerful and effective tool in the prediction of perioperative risk in many surgical fields. In many previous studies, mFI has been found to be successful in prediction of perioperative adverse effects. The aim of this study was to determine whether the mFI can be a predictor for early postoperative complications in arthroplasty surgery.

PATIENTS AND METHODS: 145 patients aged 45-85 undergoing primary or revision total knee and hip arthroplasty were included in this prospective study. mFI was calculated in all patients, and patients included in the current study were grouped as "Frail" (n=42) and "Nonfrail" (n=103) patients according to modified frailty index values. Postoperative complications (myocardial infarction, cardiac arrest, pulmonary embolism, septic shock, postoperative dialysis requirement, cerebrovascular event, reintubation, prolonged mechanical ventilation, surgical wound complications), duration of hospitalization, requirement for intensive care unit (ICU) admission and rehospitalization and 30-day mortality were recorded and the correlation between mFI and these parameters were evaluated.

RESULTS: The mean age was 67.58±9.35 years, and 72.4% of the patients were female. The percentage of frail patients in the current study was 28.9%. The percentage of ASA-1, ASA-2, and ASA-3 patients was 17.2%, 57.2%, and 25.5%, respectively. The rate of ICU admission, MI, septic shock, postoperative dialysis requirement, prolonged MV requirement, hospital readmission, and 30-day mortality were 45.2%, 14.3%, 16.7%, 16.7%, 14.3%, 11.9%, and 16.7%, respectively in the frail group and were 7.8%, 1%, 1.9%, 2.9, 1.9% and 3.9%, respectively in the nonfrail group. Advanced age, male gender, high ASA score and prolonged duration of surgery were found to be predictive factors for postoperative complications. Advanced age, high ASA score and prolonged duration of surgery were found to be predictive factors for ICU admission. Advanced age, male gender and high ASA score were found to be strong predictors of 30-day mortality.

CONCLUSIONS: mFI was found to be a strong predictor for postoperative complications and mortality. It is an easy, reliable, and simple method to evaluate frailty during the preoperative period. Clinical Trial Registration Number: NCT05424575.

Key Words:
Modified frailty index, Mortality, Arthroplasty.

Introduction

The age of the global population is witnessing a dramatic increase. While patients aged 65 and above accounted for 6% of the total in 1990, this ratio had increased to 9% by 2019, and it is expected to reach 16% by 2050. The number of surgical interventions required in this age group and the associated problems increases with the lifespan of older adults, with total knee and hip arthroplasty procedures being the most common elective surgical procedures in the aged population[1].

Frailty is a clinical syndrome that is characterized by a physiological decline in multi-organ systems and has emerged as a significant public health problem[2]. Whether a disease is involved or not, frailty is defined as a clinical syndrome leading to the progressive loss of physiological and mental parameters. Coupled with a decrease in physiological reserves, the individual becomes unable to maintain homeostasis, and the defense mechanisms is unable to cope with acute stress factors such as those associated with surgery. Pre-

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vious scholars[3] have shown frailty to be an independent predictor of postoperative complications and to affect the duration of hospital stay and discharge.

Frailty is very common among the aged population, although chronological age alone is a poor predictor of adverse effects following exposure to acute stress factors[3]. The frailty index is calculated based on 70 parameters identified in the National Surgical Quality Improvement Program (NSQIP) of the American College of Surgeons. This model defines frailty as a cumulative effect of individual deterioration depending on clinical symptoms, disease states, and disabilities, and allows a more accurate evaluation of aging. The 70 parameters factored in the NSQIP database were matched with 11 variables to create a modified frailty index (mFI), as detailed in Table I. Each met parameter is scored with one point, the total of the points achieved is calculated and the total score is divided by 11 to reveal an mFI value.

Frailty has been identified as an effective predictor of perioperative risk in many surgical fields, and the mFI has been identified as a cheap and easily applicable assessment tool that can be applied prospectively and retrospectively[1-4]. Several studies[4-8] to date have reported the mFI to be useful for the prediction of adverse perioperative effects. It is possible to define modifiable frailty components preoperatively and optimize comorbidities through an evaluation of frailty based on the mFI.

In the present study, we classify patients undergoing total hip and knee arthroplasty according to their mFI values and compare the frail (mFI≥0.27) and non-frail (mFI<0.27) patients in terms of morbidity, mortality and postoperative outcome (postsurgical complications such as myocardial infarction, cardiac arrest, pulmonary embolism, new onset neurological deficit or coma, septic shock, postoperative dialysis requirement, reintubation, prolonged mechanical ventilation, and wound complications such as hematoma, infection, dislocation, aseptic relaxation, periprosthetic fracture, heterotopic ossification), duration of hospitalization, ICU admission, hospital readmission, and reoperation.

Materials and Methods

In the present study, patients undergoing total hip and knee arthroplasty are classified according to the mFI. The frail (mFI≥0.27) and non-frail (mFI<0.27) patients are compared in terms of morbidity, mortality, and postoperative results (postsurgical complications such as myocardial infarction, cardiac arrest, pulmonary embolism, new onset neurological deficit or coma, septic shock, postoperative dialysis requirement, reintubation, prolonged mechanical ventilation, and wound complications such as hematoma, infection, dislocation, aseptic relaxation, periprosthetic fracture, heterotopic ossification), duration of hospitalization, ICU admission requirement, hospital readmission, reoperation, and 30-day mortality.

After obtaining Ankara University Ethics Committee approval (Ethical Committee approval number: İ2-59-19, date: 18.07.2019) and written informed consent from the patients, 158 patients aged 45-85 who were scheduled to undergo elective total knee and hip arthroplasty were enrolled for the prospective study. Excluded from the study were patients aged below 45 and above 85 years, as well as those with cognitive dysfunction and those requiring emergent surgery.

Table I. Modified frailty index (MFI).

	Present/score
1 Exacerbation of chronic obstructive pulmonary disease or history of pneumonia (within last 30 days)	1
2 Exacerbation of congestive heart failure (within last 30 days)	1
3 Diabetes mellitus (DM)	1
4 Dependant functional status (partially or totally dependant)	1
5 History of angina, percutaneous coronary intervention or coronary bypass grafting) (within last 30 days)	1
6 Medically treated hypertension (HT)	1
7 Acute impaired sensorium	1
8 History of peripheral vascular disease	1
9 History of myocardial infarction (MI) (within last 6 months)	1
10 Cerebrovascular disease (CVD) with neurological deficit	1
11 CVD without neurological deficit or transient ischemic attack (TIA)	1

In the preoperative period, the demographical variables [age, sex, body mass index (BMI), ASA score] of the patients were recorded, as well as the presence of coronary artery disease, myocardial infarction, peripheric vascular disease, cerebrovascular disease, chronic respiratory disease, dementia, malignancy, chronic renal disease, chronic alcohol use, organ transplantation, and the use of any anticoagulants, beta-blockers or antidepressant drugs. Type of anesthesia, duration of surgery, and intraoperative transfusion requirements were also recorded. mFI parameters presented in Table I were evaluated preoperatively, with each parameter being scored with 1 point. After the application of the index, the patient's total points were calculated and divided by 11 to give an mFI value. Although the mFI was not designed as a binary variable, based on the overlap of previous data at around the 0.25 mark, a cut-off value of 0.27 was used to distinguish between "frail" and "non-frail" patients, and the patients included in the present study were grouped accordingly as "frail" (n=42) (mFI≥0.27) and "non-frail" (n=103) (mFI<0.27) according to their mFI values. Postoperative complications (myocardial infarction, cardiac arrest, pulmonary embolism, septic shock, postoperative dialysis requirement, cerebrovascular event, reintubation, prolonged mechanical ventilation, surgical wound complications such as hematoma, infection, dislocation, aseptic relaxation, periprosthetic fracture, heterotopic ossification), duration of hospitalization, intensive care unit (ICU) admission or rehospitalization requirement, and 30-day mortality were recorded, and the correlation between mFI and these parameters were evaluated.

A total of 158 patients were initially recruited for the study; however, 13 patients were subsequently excluded due to gaps in postoperative data. Therefore, the study was carried out with 145 patients.

Statistical Analysis

IBM SPSS Statistics (IBM Corp., Version 25.0., Armonk, NY, USA) was used for the statistical analysis. Descriptive variables were presented as mean, standard deviation, percentages, and frequencies. The normality of distribution was determined with a Kolmogorov-Smirnov test before the comparison of continuous variables, a Mann-Whitney U test was used for between-group comparisons, and a Chi-Square test was used for nominal variables. $p<0.05$ was accepted as statistically significant.

Results

The demographical variables of the patients are presented in Table II. The comorbidities of the patients are listed in Table III. As can be seen from Table III, 80.7% of the patients (n=117) had at least one comorbidity, the most common of which were HT (82.1%), DM (38.5%), ischemic heart disease (20.5%), and chronic respiratory disease (15.4%).

The preoperative medications are detailed in Table IV, indicating that 77.9% of the patients (n=113) were utilizing at least one medication, with beta-blockers being the most prevalent (81.4%).

The intraoperative patient characteristics are presented in Table V. An evaluation of all patient groups revealed combined epidural-spinal an-

Table II. Demographical variables.

		Mean ± SD	N (%)
Age (45-85)		67.58 ± 9.35	
Gender	Female		105 (72.4%)
	Male		40 (27.6%)
BMI (Body mass index)		28.78 ± 5.51	
Primary revision	Primary THA		28 (19.3%)
	Revision THA		34 (23.4%)
	Primary TKA		48 (33.1%)
	Revision TKP		35 (24.1%)
ASA	1		25 (17.2%)
	2		83 (57.2%)
	3		37 (25.5%)

THA = Total hip arthroplasty; TKA = Total knee arthroplasty; SD = Standard deviation.

Table III. Comorbidities.

Comorbidities		N	%
Comorbidity	Absent	28	19.3
	Present	117	80.7
Diseases		**Percentage (%)**	
HT		82.1	
DM		38.5	
Ischemic heart disease/valvular disease		20.5	
Chronic respiratory disease		15.4	
Covid-19		7.7	
Migraine		7.7	
CRD		5.1	
CVE		4.3	
MI		3.4	
Cancer		1.7	
Arrhythmia or block		1.7	
Peripheral vascular disease		1.7	
Joint disease (RA, AS)		1.7	
Hypothyroidism		1.7	
Organ transplantation		0.9	
Psychiatric disease		0.9	
Dermatological disease		0.9	

HT = Hypertension; DM = Diabetes mellitus; CRD = Chronic renal disease; CVD = Cerebrovascular event; MI = Myocardial infarction; RA=Rheumatoid arthritis; AS = Ankylosing spondylitis.

esthesia as the most commonly used anesthetic technique (67.6%). A transfusion was required in 7.6% of all patients (n=11), and all transfusions were erythrocyte suspensions.

When the postoperative complications were evaluated for all patient groups, 18.6% (n=27) of the patients required ICU admission, 11% (n=16) developed surgical wound infections, 6.9% (n=10)

Table IV. Medications.

Medications		N	%
Drug use	Absent	32	22.1
	Present	113	77.9
Drugs		**Percentage (%)**	
Beta blocker and ARB*		81.4	
Oral Antidiabetic		32.7	
Antiplatelet drug		28.3	
Anticoagulant		11.5	
Inhaler		10.6	
Other antihypertensive drugs		8.0	
Levothyroxine		8.0	
Steroid		6.2	
Insulin		5.3	
Antidepressants		2.7	
Antihyperlipidemic drugs		2.7	
Analgesics		1.8	
Diuretics		0.9	
Antihistaminics		0.9	

*ARB = Angiotensin receptor blocker.

Table V. Intraoperative characteristics.

Intraoperative characteristics		Mean (± SD)	N (%)
Type of anesthesia	Epidural+Spinal (combined)		98 (67.6)
	GA+IV PCA*		32 (22.1)
	GA+Epidural		1 (0.7)
	Epidural		1 (0.7)
	Spinal		10 (6.9)
	Combined+GA		3 (2.1)
Duration of surgery (min)		158.36 ± 62.07	
Tranfusion requirement	Absent		134 (92.4)
	Present		11 (7.6)

*PCA = Patient controlled analgesia; GA = General anesthesia.

had a postoperative dialysis requirement, 5.5% (n=8) required prolonged mechanical ventilation, 4.8% (n=7) developed myocardial infarctions, 5.5% (n=8) required rehospitalization, 1.4% (n=2) suffered cardiac arrest, 2.1% (n=3) required reoperations, cerebrovascular events were observed in 2.1% (n=3), reintubation was required in 2.8% (n=4) and pulmonary thromboembolisms were observed in 2.8% (n=4). Postoperative 30-day mortality was 7.6% (n=11), and the mean duration of hospitalization was 9.03±8.24 days (Table VI).

The ASA grading, duration of hospitalization, total number of complications, and comparison of postoperative complications in frail and non-frail groups are presented in Table VII. The proportion of ASA 2 patients in the frail group (31%, n=13) was significantly lower than in the non-frail group [68.0% (n=70)] and the ASA-3 patients in the frail group [69.0% (n=29)] were significantly greater in number than in the non-frail group (7.8%, n=8) (χ^2=6.954, p=0.014).

The mean duration of hospitalization in the frail group (10.86±8.73 days) was significantly longer than in the non-frail group (8.28±7.95 days) (u=1,672.0, p=0.031).

The incidence of MI, septic shock, postoperative dialysis requirement, prolonged mechanical ventilation, ICU admission, and rehospitalization was significantly higher in the frail group than in the non-frail group (Table VII).

Table VI. Postoperative complications.

Postoperative complications	Incidence	
	N	%
ICU admission	27	18.6
Postoperative dialysis	10	6.9
Septic shock	9	6.2
Prolonged requirement for MV	8	5.5
MI	7	4.8
Pulmonary embolism	4	2.8
Reintubation	4	2.8
Cerebrovascular disease	2	2.1
Cardiac arrest	2	1.4
Mortality (30th day)	11	7.6
Surgical wound infection	16	11
Readmission	8	5.5
Reoperation	3	2.1
	Mean ± SD	
Duration of hospitalization (day)	9.03 ± 8.24	

ICU = intensive care unit.

Table VII. Comparison of postoperative complications in frail and nonfrail groups.

Complications		MFI			
		Nonfrail	Frail	χ^2	*p*
MI	-	99.0 (102)	85.7 (36)	11.512	**0.002**
	+	**1.0 (1)**	**14.3 (6)**		
Cardiac arrest	-	98.1(101)	100 (42)	0.827	0.586
	+	2.0 (2)	0 (0)		
PTE	-	99.0 (102)	92.9 (39)	4.237	0.073
	+	1.0 (1)	7.1 (3)		
Septic shock	-	98.1 (101)	83.3 (35)	11.112	**0.003**
	+	**1.9 (2)**	**16.7 (7)**		
Postoperative dialysis	-	97.1 (100)	83.3 (35)	8.790	**0.00**7
	+	**2.9 (3)**	**16.7 (7)**		
Reintubation	-	99.0 (102)	92.9 (39)	4.237	0.073
	+	1.0 (1)	7.1 (3)		
Prolonged mechanical ventilation requirement	-	98.1 (101)	85.7 (36)	8.721	**0.008**
	+	**1.9 (2)**	**14.3 (6)**		
Surgical wound infection	-	92.2 (95)	81.0 (34)	3.867	0.076
	+	7.8 (8)	19.0 (8)		
CVE	-	99.0 (102)	95.2 (40)	2.116	0.201
	+	1.0 (1)	4.8 (2)		
Reoperation	-	99.0 (102)	95.2 (40)	2.116	0.201
	+	1.0 (1)	4.8 (2)		
ICU admission	-	92.2 (95)	54.8 (23)	27.644	**< 0.001**
	+	**7.8 (8)**	**45.2 (19)**		
Rehospitalization	-	97.1 (100)	88.1 (37)	4.628	**0.045**
	+	**2.9 (3)**	**11.9 (5)**		
Mortality (30th day)	-	96.1 (99)	83.3 (35)	6.954	**0.014**
	+	**3.9 (4)**	**16.7 (7)**		
ASA	1	24.3 (25)	0.0 (0)		
	2	68.0 (70)	31.0 (13)	59.769	**< 0.001**
	3	7.8 (8)	69.0 (29)		
		Mean (± SD)	**Mean (± SD)**	**U**	***p***
Number of complications (n)		**0.20 (± 0.67)**	**1.00 (± 1.24)**	1,316.00	**< 0.001**
Duration of hospitalization (Day)		**8.28 (± 7.95)**	**10.86 (± 8.73)**	1,672.00	**0.031**

χ^2: Chi-square test, U: Mann-Whitney U Test.

Thirty-day mortality in the frail group (16.7%, n=7) was significantly higher than in the non-frail group (3.9%, n=4) (χ^2=6.954, p=0.014).

The mean number of complications in the frail group (1.00±1.24) was significantly higher than in the non-frail group (0.20±0.67) (u=1316.0, p<0.001).

No statistically significant between-group difference was noted in terms of cardiac arrest, pulmonary thromboembolism, reintubation, surgical wound infection, cerebrovascular event, and reoperation requirement.

An analysis of the number of complications and their correlation with age, sex, ASA grade, and duration of operation revealed a significantly greater number of complications in those of the male sex and ASA-3 patients (Table VIII) (u: 2.586, p=0.004; u: 19.585, p=0.001 respectively). Furthermore, a significantly positive correlation was found between the number of complications and age (r=0.311) and between the number of complications and duration of surgery (r=0.272) (p<0.001).

The correlations between ICU admission requirements and age, sex, ASA grade, and duration of operation are presented in Table IX. The number of ASA-3 patients among those requiring ICU admission [55.6% (n=15)] was significantly higher than among the patients not requiring ICU admission [18.6% (n=22)] (χ^2=17.959, p<0.001) (Table IX).

The mean age of the patients requiring ICU admission was statistically higher than that of the

Table VIII. Correlation of number of complications with age, gender, ASA grade and duration of operation.

		N	Mean ± SD	U	p	Post Hoc
Gender	Female	105	0.30 ± 0.79	2.586	**0.004**	-
	Male	40	0.77 ± 1.23			
ASA	1	25	0.04 ± 0.20	19.585	**0.001**	**1 < 3*****
	2	83	0.35 ± 0.93			**2 < 3*****
	3	37	0.90 ± 1.13			
			Number of complications			
Age	r		0.311***			
Duration of operation	r		0.272***			

U: Mann-Whitney U Test, r: Spearman Correlation coefficient, Post Hoc: Bonferroni-corrected Mann-Whitney U Test, *p <0.05, **p < 0.01, ***p < 0.001.

group not requiring ICU admission (73.63±8.54 and 66.19±9.00, respectively) (u=880.50, p<0.001) (Table IX).

The mean duration of surgery in the patients requiring ICU admission was statistically longer than the group not requiring ICU admission (191.67±70.91 and 150.74±57.52, respectively) (u=1061.50, p=0.007). There was no statistically significant difference in the sex of those requiring ICU admission (p>0.05) (Table IX).

The correlations of rehospitalization with age, sex, ASA grade, and duration of operation are presented in Table X. The rehospitalization rate among male patients [62.5% (n=5)] was significantly higher than that of the female patients [37.5% (n=3)] (χ^2=5.167, p=0.037). There was no statistically significant correlation between rehospitalization and ASA status, age or duration of operation (p>0.05) (Table X).

The correlations of mortality rate with age, sex, ASA grade, and duration of operation are presented in Table XI. The mortality rate among male patients [63.6% (n=7)] was significantly higher than that of female patients [36.4% n=4)] (χ^2=7.744, p=0.005). The ratio proportion of patients with ASA-3 [63.6% (n=79)] was significantly high among the non-surviving patients (χ^2=7.931, p=0.015). The mean age of the patients who did not survive was significantly high (74.27±7.48) (u=404.50, p=0.013).

Discussion

The present study evaluates the correlation between the mFI and postoperative complications (myocardial infarction, cardiac arrest, pulmonary embolism, septic shock, postoperative

Table IX. Correlation of requirement for ICU admission with age, gender, ASA grade and duration of operation.

		ICU admission			
		Absent % (n)	Present % (n)	χ^2	p
Gender	Female	75.4 (89)	59.3 (16)	2.874	0.090
	Male	24.6 (29)	40.7 (11)		
ASA	1	21.2 (25)	0.0 (0)	17.959	**< 0.001**
	2	60.2 (71)	44.4 (12)		
	3	18.6 (22)	55.6 (15)		
	Total	100 (118)	100.0 (27)		
		Mean (± SD)	Mean (± SD)	U	p
Age		66.19 (± 9.00)	73.63 (± 8.54)	880.50	**< 0.001**
Duration of operation		150.74 (± 57.52)	191.67 (± 70.91)	1,061.50	**0.007**

χ^2: Chi-square test, U: Mann-Whitney U Test.

Table X. Correlation of rehospitalization with age, gender, ASA and duration of operation.

		Rehospitalization			
		Absent % (n)	Present % (n)	χ^2	p
Gender	Female	74.5 (102)	37.5 (3)	5.167	**0.037**
	Male	25.5 (35)	62.5 (5)		
ASA	1	18.2 (25)	0.0(0)	2.942	**< 0.001**
	2	57.7 (79)	50.0 (0)		
	3	24.1 (33)	50.0 (0)		
	Total	100 (137)	100.0 (8)		
		Mean (± SD)	Mean (± SD)	U	p
Age		67.31 (± 9.14)	72.13 (± 12.33)	346.0	0.080
Duration of operation		155.82 (± 61.04)	201.88 (± 67.50)	329.50	0.057

χ^2: Chi-square test, U: Mann-Whitney U Test.

dialysis requirement, cerebrovascular event, reintubation, prolonged mechanical ventilation, surgical wound complications such as hematoma, infection, dislocation, aseptic relaxation, periprosthetic fracture, heterotopic ossification), hospitalization duration, ICU admission requirement, rehospitalization and 30-day mortality in patients undergoing elective knee and hip arthroplasty surgery.

The age of the global population is gradually increasing, with those aged 65 or over accounting for 6% of the population in 1990, rising to 9% in 2019, and expected to reach 16% by 2050. This increase in life expectancy has been coupled with a growing need for surgical procedures in older adults, among which total hip and knee arthroplasty are the most frequently performed elective surgical procedures[1]. This increase in the aged and comorbid surgical population has led to a greater need to determine the high-risk surgical population[9].

When evaluating older adult patient groups, chronological age alone is insufficient for the prediction of perioperative adverse effects. As such, recent years have seen the term "frail elder" being used for the older adult population. Frailty is an indicator of physiological decline and typically increases with increased age. Frailty has been defined as a clinical syndrome associated with a progressive loss of physical and mental function, regardless of whether or not a disease is present. There are different approaches to the assessment of frailty, and the most frequently used involves the application of the mFI. The MFI has proven to be invaluable for the determination of frailty and for the measurement of the patient's comor-

Table XI. Correlation of mortality rate with age, gender, ASA and duration of operation.

		Mortality			
		Survive % (n)	Exitus % (n)	χ^2	p
Gender	Female	75.4 (101)	36.4 (4)	7.744	**0.005**
	Male	24.6 (33)	63.6 (7)		
ASA	1	18.7 (25)	0.0 (0)	7.931	**0.015**
	2	59.0 (79)	36.4 (4)		
	3	22.4 (30)	63.6 (7		
	Toplam	100.0 (134)	100.0 (7)		
		Mean (± SD)	Mean (± SD)	U	p
Age		67.03 (± 9.30)	74.27 (± 7.48)	404.50	**0.013**
Duration of operation		155.24 (± 60.32)	196.36 (± 73.24)	479.50	0.054

χ^2: Chi-square test, U: Mann-Whitney U Test.

bidities and functional status, and it is a cheap, easily applicable option that can be applied both retrospectively and prospectively. To date, several studies[10-13] have reported the mFI to be useful for the prediction of postoperative outcomes.

Obeid et al[10] used the mFI with 11 variables in a retrospective study of 58,448 patients who had undergone colectomy procedures and reported frailty to be effective in the prediction of ICU-related complications and mortality.

In the retrospective study by Adams et al[11] involving 6,727 patients undergoing head and neck surgery, frailty was found to be more strongly correlated with mortality and morbidity than ASA grade and age.

In a retrospective study by Karam et al[5] analyzing 67,308 patients undergoing vascular surgery, a significant correlation was found between mFI and mortality and between mFI and wound infection. The study compared mFI with preoperative predictive factors, such as ASA grade, age and functional status, and found that mFI strongly correlated with mortality.

There have been limited studies to date analyzing the use of the mFI for predicting the outcome of orthopedic surgery. In a retrospective study by Patel et al[12] involving 697 patients aged 60 and above undergoing surgery for femoral neck fractures, a significant correlation was found between MFI and 1-year and 2-year mortality. The present study can be considered important as a prospective study evaluating the correlations between mFI, and postoperative complications and mortality in arthroplasty surgery.

In the present study, patients with an mFI below 0.27 (mFI<0.27) were considered "non-frail" while those with an mFI above 0.27 (mFI≥0.27) were accepted as "frail". The 28.9% (n=42) of the patients included in the study were frail according to this cut-off. The majority of patients in both groups were female, and ASA-3 patients were predominantly found in the frail group and ASA-2 patients in the non-frail group.

In the present study, a significant increase was noted in the postoperative complications, duration of hospitalization, ICU admission, hospital readmission, reoperation requirement and 30-day mortality in the frail group when compared to the non-frail group.

The literature contains several studies evaluating frailty in patients aged 65 and above. However, the mFI evaluates comorbidities and functional status regardless of age to identify patients at high risk of postoperative complications during the preoperative period. Therefore, the present study included patients in the 45-85 age range[13,14]. Frailty is more common in the elderly; however, chronological age is a poorer predictor than mFI of adverse effects following acute stress[15-17]. Although frailty is traditionally defined as a physical decline associated with aging, it is known that there are a few other factors that contribute to physiological aging and determine the functional reserves and reactions to stress. The determination of risk based only on age can result in unrealistic expectations related to the potential results of surgery and postoperative outcomes[18]. Several studies to date[19-21] have identified frailty as an independent predictor of postoperative complications, increased hospitalization durations, and mortality.

In the study by Bellamy et al[1] evaluating 51,582 patients undergoing total hip arthroplasty, mFI was found to be a strong predictor of postoperative outcomes and complications, regardless of age and ASA grade.

The present study revealed myocardial infarction, septic shock, postoperative dialysis requirement, and prolonged mechanical ventilation to be more common in frail patients than in the non-frail group, while there was no statistically significant difference between the groups in terms of cardiac arrest, pulmonary embolism, reintubation, surgical wound infection, CVO, and reoperation. The total number of complications was significantly higher in the frail group, and ICU admissions were also higher in the frail group, although in the present study, there were patients requiring ICU admission for issues other than postoperative complications, including such intraoperative issues as bleeding and hemodynamic instability.

Mednick et al[22] reported comorbidities, such as diabetes, chronic obstructive lung disease, coagulation disorders, previous cardiovascular surgery, and hypertension, to be associated with an increased risk of rehospitalization within 30 days following total hip arthroplasty surgery, although they disregarded functional status in their study, despite the potential postoperative effects.

In an NSQIP study involving 1,193 patients undergoing head and neck surgery between 2006 and 2013, mFI was found to be correlated with postoperative complications, while no correlation was found between mFI and rehospitalization or mortality[23].

In a retrospective study by McChesney et al[24] performed on patients undergoing radical pelvic surgery (proctectomy and radical cystectomy),

mFI was reported to be effective in the prediction of both 30-day mortality and postoperative complications.

In a retrospective study by Wahl et al[4], including 236,957 patients undergoing orthopedic, general or vascular surgery, a significant positive correlation was found between mFI and 30-day rehospitalization. This study also reported frailty to be associated with increasing age, high ASA grade (ASA-3–4), 30-day postoperative complications, prolonged hospitalization, and 30-day post-discharge mortality.

In a retrospective study by Vermillion et al[25], involving 41,455 patients undergoing gastrointestinal tumor resection, the duration of hospitalization was reported to be longer, and major complication and 30-day mortality rates were higher in frail patients. In the multi-variant analysis conducted in the study, age, male sex, high ASA grade, and mFI≥0.27 were found to be independent preoperative predictors of major complications and 30-day mortality.

In the study by Keller et al[26], involving 412 patients undergoing elective colorectal surgery, they used MFI with 5 variables (mFI-5) which were correlated with mFI-11. In this first study, to evaluate the value of mFI-5 for the prediction of postoperative complications, the mFI-5 was found to be strongly correlated with higher mortality/morbidity, although the predictive value of mFI-5 for mortality/morbidity was weak. In contrast, the mFI values were not found to be correlated with minor complications and were not found to be predictive.

In a retrospective study conducted by Tatar et al[27] involving 7,337 patients with a mean age of 65.8 undergoing colorectal cancer surgery, 11.8% of the patients were readmitted to hospital at least once within the postoperative 30-day period. The study also reported that ASA grade, mFI, preoperative history of smoking, coagulation disorders, preoperative dyspnea, and surgical approach were all associated with hospital readmission. In the present study, the rate of hospital readmission was 5.5% when all patients were included in the analysis and 11.9% when only frail patients were included.

In the current study, the mean duration of hospital stay in the frail group (10.86±8.73) was significantly higher than in the non-frail group (8.28±7.95), and the rates of readmission were 11.9% in the frail group and 2.9% in the non-frail group. This concurs with the findings of Bellamy et al[1] whose study of patients undergoing total hip arthroplasty revealed an increase in readmissions from 4.9% to 20% together with the increase in mFI. In the present study, a statistically positive correlation was noted between age, ASA grade, duration of operation and number of complications, ICU admission and mortality. Furthermore, the mean number of complications, the rate of hospital readmission and the mortality rates were significantly higher in the male patients than in the female patients, while the difference in the number of males and females requiring ICU admission was not statistically significant.

The literature contains several studies investigating the correlation between mFI and mortality and revealing an increase in mFI associated with increased mortality. In the study by Bellamy et al[1] it was demonstrated that alongside an increase in mFI, the mortality rate of 0.12% increased to 4.2%. In the present study, 30-day mortality was 16.7% in the frail group and 3.9% in the non-frail group.

In the study by McIsaac et al[28], mortality was found to be higher in frail patients 1 year after undergoing total hip arthroplasty, revealing changes in risk associated with age, while Farhat et al[29] reported a correlation between frailty and mortality in patients aged 60 and above undergoing emergent general surgery.

In the study by Belmont et al[30], 30-day mortality following total hip arthroplasty was reported to be 0.35%, with an age of 80 and above being identified as a strong predictor of mortality. In the study by Parvizzi et al[31], the 30-day mortality rate following total hip arthroplasty was found to be 0.29%, and higher in male patients, in patients with preexisting cardiovascular diseases, and in patients aged 70 and above. In the study by Doro et al[32], a 30-day mortality rate following primary hip arthroplasty of 0.16-0.29% was reported compared to 0.48-1.2% in those undergoing revision hip arthroplasty. Although the mortality rate in our study was significantly higher in frail patients when compared with the non-frail patients, when all patient groups were included, a mortality rate of 7.6% was recorded, which is higher than those reported in previous studies. However, it should be noted that the prospective nature of the study may have influenced the high mortality rates reported in our study; the small sample size and the fact that the study was conducted during the COVID-19 pandemic may be a limitation as well.

The mFI-5 was applied for the estimation of early results following colorectal surgery, taking

five variables into account, being: diabetes mellitus, congestive heart failure, chronic obstructive lung disease, hypertension, and dependent functional status. Several studies[33-36] to date have investigated the correlation of this index with postoperative results. In the study by Subramaniyam et al[33] comparing the predictive values of mFI-5 and mFI-11 for the identification of mortality, postoperative infection, and unplanned 30-day readmission, the authors concluded that both were equally effective as predictors and reported them to be valid for all surgical fields. In the study by Khamis et al[34] involving patients undergoing colorectal surgery, a significant correlation was reported between mFI-5 (mFI≥2) and hospital readmission.

In a retrospective study by Traven et al[35] on patients undergoing primary hip and knee arthroplasty, mFI-5 was found to be an independent predictor of Clavien-Dindo Grade IV complications (cardiac arrest, myocardial infarction, septic shock, pulmonary embolism, requirement for postoperative dialysis, reintubation and prolonged mechanical ventilation), surgical wound infection, hospital readmission, and 30-day mortality. A further study by Traven et al[36] involving patients who had undergone total shoulder arthroplasty reported similar results.

Elderly patients are more prone to embolic complications and periprosthetic infections, and this makes them frailer[37]. Literature contains no prospective studies evaluating the value of mFI for the prediction of postoperative complications and mortality following orthopedic surgery, as all such studies to date have a retrospective study design. The prospective nature of our study can be considered one of its strengths, while the main limitations are the small sample size and the coincidence of the study period with the COVID-19 pandemic, which led to misleadingly higher mortality rates than in previous studies.

Conclusions

mFI was found to be a strong predictor of postoperative complications and mortality, and can be considered an easy, reliable, and simple tool for the evaluation of frailty during the preoperative period. We believe that the routine use of mFI for the preoperative evaluation of cases undergoing major surgery, such as orthopedic procedures, could facilitate decision-making during patient selection, aid in risk classification, help in the identification of appropriate preventive measures to optimize potential modifiable factors, could minimize complications. There is a need, however, for further prospective studies investigating the value of mFI for predicting postoperative complications and mortality involving larger samples.

Conflict of Interest
The authors declare that they have no conflict of interests.

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Ethics Approval
The study has been performed in accordance with the Helsinki Declaration and the permission has been obtained from the Ankara University Ethics Committee (approval number: İ2-59-19, date: 18.07.2019).

Informed Consent
Written informed consent was obtained from the patients.

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