Original Article

Epidemiology of traumatic spinal fracture caused by falls in patients referred to Vali-asr Hospital in Markazi Province

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KEY WORDS

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Abstract:

Background: Traumatic spinal fractures is a serious condition with significant morbidity and mortality, commonly caused by falls. However, data on patient characteristics and epidemiological patterns are limited. This study aims to describe the epidemiological features of fall-related traumatic spinal injuries in Markazi Province, in center of Iran.

Methods: A retrospective cohort study was conducted on 337 hospitalized trauma patients diagnosed with spinal injuries due to falls during 2022-2023. The patients' information including demographic and clinical characteristics were gathered. Mechanism of fall was considered low (less than 3 meters) and high height (more than 3 meters). Data analysis was done with SPSS24 software.

Results: The mean (SD) age of the patients was 48.59 (SD = 17.73) years, with a range from 1 to 94 years. Among the patients, 240 (71.2%) were male, and 246 (73%) sustained injuries from falls at a low height. The variables of age, sex, length of stay, number of injured vertebrae, ICU hospitalization, surgery, level of injury, presence of spinal cord injury, and occupation all showed a significant relationship with the mechanism of the fall (p less than 0.05). Additionally, the level of injury was associated with age, ICU hospitalization, presence of spinal cord injury, in-hospital mortality, length of stay in ICU, and ASIA classification (p less than 0.05).

Conclusions: Our study identifies distinct patterns in fall-related spinal fractures by age and demographics, with high-energy falls linked to greater severity and low-height falls more common in older adults and women. Findings underscore the need for targeted prevention in occupational and domestic settings and suggest that clinical and demographic factors can aid in early identification of high-energy mechanisms.

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Introduction

Trauma from falls occurs when an individual lands after slipping, tripping, colliding with an object, or falling from elevated surfaces such as furniture, ladders, scaffolding, buildings, or other high locations.[1,2] Falls are a widespread and serious issue that impose significant healthcare costs on families and society.[3] Notably,

unintentional falls from heights can result in increased rates of disability and mortality.[4] Spinal injuries frequently prompt individuals to seek treatment at healthcare facilities following falls, and these injuries can result in permanent disability, functional impairment, and total paralysis.[5, 6] This type of injury is one of the leading causes of disability worldwide.[7, 8]

The worldwide incidence of traumatic spinal injury (TSI) is roughly 10.5 cases per 100,000 people, with variations depending on the region. This rate is significantly higher in low- and middle-income countries, which report 13.69 cases per 100,000, compared to 8.72 cases per 100,000 in high-income countries.[7] In developed regions, the incidence of TSI is estimated at about 39 per million, with Australia documenting 16 cases per million and Eastern Europe reporting 15 cases per million.[9,10] In Iran, the incidence is estimated to be 318.45 per million.[11] Furthermore, spinal injuries occur more frequently in men than in women. Most research indicates that traffic accidents and falls are the leading causes of spinal injuries, influenced by various demographic, socio-economic, and geographic factors affecting trauma patients.[12-14]

Falling from a low height accounts for 58% of traumas in the elderly, and trauma due to falling from a low height increases with age.[15-16] Fifty-eight percent of spine fractures are due to fall and slipping.[17] Falls alone accounts for half of spine fractures in people over 50 years old.[18] Also, among spine trauma patients due to falls, the frequency of cervical injuries increases in people over 70 years old.[19-20]

Thus, given that the characteristics of trauma patients with spinal injuries from falls may differ from those with injuries caused by other factors, and to our knowledge, no study has yet explored the epidemiological features of traumatic spinal fracture due to falls in Iran. It should be noted that the present study is geographically limited to the central region of Iran. Therefore, while we aim to provide insights into the epidemiological features of traumatic spinal fracture due to falls, the findings may not be fully representative of the entire country. Future studies with broader recruitment sites across different regions of Iran are needed to provide a more comprehensive national perspective.

Materials and Methods

This article is part of project with the specific Ethics ID code IR.ARAKMU.REC.1403.006. The present cross-sectional analytical study was conducted on 337 patients with spinal cord injuries due to falls hospitalized in Valiasr Hospital in Markazi province during 2022-2023.

Demographic, clinical, and outcome-related data were collected from medical records or prospectively during hospitalization. The following variables were extracted and categorized as described: Age (categorized as 0–20, 21–40, 41–60, and >60 years), Gender (classified as male or female), ICU admission (categorized as Yes or No), Occupation or Job (categorized as: private sector, retired, laborer, driver, staff, farmer, student, housewife, or unknown), Marital status (classified as: married, single, or other (including divorced, widowed) cohabiting, dead wife), Education level (grouped as illiterate, elementary school, middle school, high school, diploma (post-secondary non-degree or vocational training), and college and more (including undergraduate, postgraduate degrees, and PHd), Glasgow Coma Scale (GCS) scores (categorized as: 3–8 (severe impairment), 9–12 (moderate impairment), and 13–15 (mild impairment or normal), Spinal cord injury (recorded as: Yes or No), Transportation to hospital (classified as: ambulance (including emergency medical services) or non-ambulance (e.g., private vehicle, walk-in, or transfer by family)), In-hospital mortality (categorized as: survived or death). Surgical intervention (categorized as: Yes or No), American Spinal Injury Association (ASIA) Impairment Scale (categorized as: A (complete injury), C (motor incomplete, with most key muscles below the neurological level having strength <3/5), D (motor incomplete, with at least half of key muscles below the neurological level having strength ≥3/5), or E (normal sensory and motor function), Neurological level of injury (classified anatomically as: cervical, thoracic, lumbar, or multiple), Length of stay (LOS) was recorded in days. The results were presented according to the level of injury (multiple-lumbar-thoracic-cervical) and mechanism of fall (defined as falls from a height greater than 3 meters (vs. low-height falls ≤3 meters)). Data analysis was done using chi-square, ANOVA, Kruskal-Wallis, and Mann-Whitney tests by SPSS24 software. The significant level of tests was considered to be 5%.

Findings

In this study, a total of 337 patients with spinal injuries were evaluated. The mean (SD) age of the patients was 48.59 (SD = 17.73) years, with a range from 1 to 94 years, and the mean length of hospitalization was 6.2 days (SD = 7.9). Among the participants, 240 were male, accounting for 71.2% of the total. Among the participants included in this study, 506 had injured vertebrae and had undergone surgery(mean(SD): 1.5(2.06)).

There were 5 fatalities, representing 1.5% of the patients. Notably, over 53.1% of the injuries were lumbar in nature. Approximately 75% of the patients had education levels below a diploma. The highest incidence of injuries occurred among workers and housewives. Additionally, 39.8% of the patients underwent surgery, while 4.5% experienced spinal cord injuries. Table 1 presents the demographic and clinical characteristics of the traumatic spinal injury patients based on the level of injury.

The mean age of patients with thoracic injury was higher than at other injury sites. The length of hospitalization of patients with lumbar injury was longer. The highest frequency of cervical and multiple injuries was in 21-40 years old, and thoracic and lumbar in 41-60 years old. Fifty-seven point six percent of women had lumbar injuries. Forty-nine point six of the operated vertebrae were in the lumbar vertebrae. The level of injury was significantly related to age, hospitalization in ICU, having spinal cord injury, death in hospital, length of hospitalization in ICU, and ASIA ($P<0.05$). The frequency distribution of the cause of falls according to the level of injury is presented in Table 2.

Table 2 shows falls from the building or structures were the most common (22.8%), followed by falls from a ladder (16.9%), falls on the same level (slipping, tripping) (15.7%), falls from stairs and steps (13.9%). We investigated the relationship between the spinal injury level and causes of falls and found a significant association ($p=0.006$).

In the following, the distribution of the demographic and clinical attributes of the patients according to the fall mechanism is presented in Table 3.

In this study, 73% of the victims suffered spinal injuries due to falling from low height. The mean age of patients falling from a low height was 50.2 and there was a significant difference between the ages of patients in the two fall mechanisms ($p<0.01$). Sixty percent of those injured from low height were over 60 years old. Falling from a high level was observed in 17.6% of women. Furthermore, based on the results of Table 3, age, sex, length of stay, number of injured vertebrae, hospitalization in ICU, surgery, levels of injury, having spinal cord injury and job were statistically significantly related to the fall mechanism ($p<0.05$).

The logistic regression analysis identified factors associated with high-energy falls, defined as falls from a height greater than 3 meters (vs. low-height falls ≤3 meters). In univariable analysis, a higher number of vertebrae injured, longer length of stay (LOS), ICU admission, female gender, age >60 years, non-ambulance transport, spinal cord injury, surgery, retired or housewife occupation, unknown job, lower education levels (elementary to diploma), ASIA C impairment, and multiple-level spinal injury were significantly associated with increased odds of high-energy falls. However, in the multivariable model adjusting for potential confounders, only the number of vertebrae injured, LOS, ICU admission, multiple-level spinal injury, age >60 years, non-ambulance transport, and unknown occupation remained independently significant. Specifically, each additional vertebra injured was associated with a 32% increase in odds (aOR = 1.32, p = 0.012), and each additional day of hospital stay increased the odds by 4% (aOR = 1.04, p = 0.031). ICU admission was linked to more than double the odds of a high-energy fall (aOR = 2.35, p = 0.002), and patients with multiple-level spinal injuries had 86% higher odds (aOR = 1.86, p = 0.029). In contrast, patients aged >60 years had 78% lower odds compared to those aged ≤20 years (aOR = 0.22, p = 0.021), non-ambulance transport was associated with 36% lower odds (aOR = 0.64, p = 0.013), and individuals with unknown occupation had 76% lower odds compared to those in the private sector (aOR = 0.24, p = 0.030). These findings are summarized in Table 4.

Moreover, in this study, 480 injured vertebrae were operated. Figure 1 shows the distribution of the frequency of operated vertebrae by fall mechanism

Figure 1 shows that most of the injured vertebrae required surgery are thoracic (220 vertebrae) and lumbar (192 vertebrae) in both injury mechanisms, so that the most operated vertebrae were L2, T12, L1, T11, and L3 in low height, respectively. In the fall from high height L1, L2, L3, T11, and T12 were the most operated vertebrae, respectively.

In the following, Figure 2 presents the level of injury by age group.

Figure 2 shows that with increasing age, the frequency of thoracic increased, but the frequency of multiples decreased. At ages over 20 years, more than 50% of injuries were in lumbar.

Figure 3 shows the distribution level of injury by mechanism of fall. According to Fig. 3, in both mechanisms, the lumbar spine was the most frequent. In the fall from a high height, the frequency of multiples was more than that of Thoracic Alone, but in the fall from a low height, the frequency of Thoracic fracture was higher

Figure 4 illustrates that the frequency of falling from a low and high height increases up to the age of 60, but in injured patients over 60 years old, the frequency of falling from a high height was three times more than falling from a low height.

Table 1: Demographic and clinical characteristics of traumatic spinal injury patients by level of injury

Variable	level	Level of injury				total	p.value
		cervical	thoracic	lumbar	Multiple		
Age		44.5(23.1)	52.8(18.3)	48.8(16.9)	44(16.7)	48.59(17.73)	0.03[a]
LOS in ICU		2.5(5.9)	0.76(3.3)	0.21(1.3)	2.1(4.7)	0.8(3.1)	0.001[b]
LOS total		5.6(5.5)	5.7(6.6)	6.1(8.7)	7.9(7.6)	6.3(7.9)	0.78[b]
Age (year)	0-20	3(15)	3(4.1)	7(3.8)	5(8.5)	18(5.3)	0.048
	21-40	7(35)	16(21.9)	53(28.6)	23(39)	99(29.4)	
	41-60	4(20)	28(38.4)	80(43.2)	18(30.5)	130(38.6)	
	>60	6(30)	26(35.6)	45(24.3)	13(22)	90(26.7)	
Gender	female	5(25)	23(31.5)	58(31.4)	11(18.6)	97(28.8)	0.46
	male	15(75)	50(68.5)	127(68.6)	48(81.4)	240(71.2)	
ICU admission	No	15(75)	67(91.8)	178(96.2)	45(76.3)	305(90.5)	0.001
	Yes	5(25)	6(8.2)	7(3.8)	14(23.7)	32(9.5)	
Job	private sector	3(15)	7(9.6)	19(10.3)	9(15.3)	38(11.3)	0.29[c]
	retired	2(10)	8(11)	10(5.4)	3(5.1)	23(6.8)	
	laborer	3(15)	19(26)	53(28.6)	22(37.3)	97(28.8)	
	driver	2(10)	3(4.1)	2(1.1)	2(3.4)	9(2.7)	
	staff	0(0)	1(1.4)	8(4.3)	0(0)	9(2.7)	
	farmer	2(10)	6(8.2)	16(8.6)	6(10.2)	30(8.9)	
	student	3(15)	2(2.7)	5(2.7)	4(6.8)	14(4.2)	
	house wife	3(15)	16(21.9)	44(23.8)	8(13.6)	71(21.1)	
	unkown	2(10)	11(15.1)	28(15.1)	5(8.5)	46(13.6)	
Marital status	married	15(75)	61(83.6)	151(81.6)	46(78)	273(81)	0.36
	single	5(25)	7(9.6)	25(13.5)	12(20.3)	49(14.5)	
	other	0(0)	5(6.8)	9(4.9)	1(1.7)	15(4.5)	
education	illiterate	8(40)	23(31.5)	48(25.9)	10(16.9)	89(26.4)	0.66
	Elementary school	4(20)	19(26)	38(20.5)	15(25.4)	76(22.6)	
	Middle school	1(5)	12(16.4)	29(15.7)	10(16.9)	52(15.4)	
	High school	2(10)	5(6.8)	23(12.4)	6(10.2)	36(10.7)	
	diploma	4(20)	12(16.4)	35(18.9)	16(27.1)	67(19.9)	
	college and more	1(5)	2(2.7)	12(6.5)	2(3.4)	17(5)	
GCS	3-8	1(5)	1(1.4)	1(0.5)	1(1.7)	4(1.2)	0.41[c]
	9-12	1(5)	0(0)	3(1.6)	1(1.7)	5(1.5)	
	13-15	18(90)	72(98.6)	181(97.8)	57(96.6)	328(97.3)	
Cord injury	No	18(90)	72(98.6)	180(97.3)	52(88.1)	322(95.5)	0.007
	Yes	2(10)	1(1.4)	5(2.7)	7(11.9)	15(4.5)	
Transportation services	Ambulance	17(85)	49(67.1)	130(70.3)	40(67.8)	236(70)	0.46
	Non-ambulance	3(15)	24(32.9)	55(29.7)	19(32.2)	101(30)	
In hospital mortality	Survived	18(90)	73(100)	184(99.5)	57(96.6)	332(98.5)	0.003[c]
	death	2(10)	0(0)	1(0.5)	2(3.4)	5(1.5)	
surgery	No	12(60)	41(56.2)	113(61.1)	28(47.5)	194(57.6)	0.32
	Yes	8(40)	32(43.8)	72(38.9)	31(52.5)	143(42.4)	
ASIA IMPAIRMENT SCALE	A	1(5)	1(1.4)	0(0)	6(10.2)	8(2.4)	0.004[c]
	C	1(5)	1(1.4)	3(1.6)	0(0)	5(1.5)	
	D	1(5)	4(5.5)	6(3.2)	2(3.4)	13(3.9)	
	E	17(85)	67(91.8)	176(95.1)	51(86.4)	311(92.3)	

a: ANOVA test; b: Kruskal-Wallis test; c: Fisher-exact test; the other p-value from chi-square test

Table 2: causes of falls by level of injury

Cause	cervical	thoracic	lumbar	Multiple	total
Fall from building or structure	4(21.1)	11(15.3)	38(20.7)	24(38.7)	77(22.8)
Fall from ladder	1(5.3)	11(15.3)	40(21.7)	5(8.1)	57(16.9)
Fall on same level (slipping, tripping)	4(21.1)	14(19.4)	31(16.8)	4(6.5)	53(15.7)
Fall from stairs and steps	4(21.1)	12(16.7)	29(15.8)	2(3.2)	47(13.9)
Fall from tree	1(5.3)	6(8.3)	16(8.7)	7(11.3)	30(8.9)
Fall from scaffolding	2(10.5)	4(5.6)	16(8.7)	5(8.1)	27(8)
falling objects	2(10.5)	4(5.6)	8(4.3)	5(8.1)	19(5.6)
other	2(10.5)	11(15.3)	7(3.8)	7(11.3)	27(8)

Table 3: Demographic and clinical characteristics of spinal trauma patients by mechanism of fall

variable	level	low fall(<=3 m)	high fall(>3 m)	Total	p.value
age		52.1(18.3)	40.97(13.7)	48.59(17.73)	0.001[a]
LOS		4.95(6.6)	9.28(9.6)	6.3(7.9)	0.001[b]
Number of injured vertebrae		1.02(1.7)	2.57(2.4)	1.5(2.06)	0.001[b]
Age (year)	<=20	9(3.9)	9(8.6)	18(5.3)	0.001
	21-40	57(24.6)	42(40)	99(29.4)	
	41-60	86(37.1)	44(41.9)	130(38.6)	
	>60	80(34.5)	10(9.5)	90(26.7)	
ICU	no	221(95.3)	84(80)	305(90.5)	0.001
	yes	11(4.7)	21(20)	32(9.5)	
Job	private sector	22(9.5)	16(15.2)	38(11.3)	0.001
	retired	21(9.1)	2(1.9)	23(6.8)	
	laborer	49(21.1)	48(45.7)	97(28.8)	
	driver	8(3.4)	1(1)	9(2.7)	
	staff	7(3)	2(1.9)	9(2.7)	
	farmer	19(8.2)	11(10.5)	30(8.9)	
	student	8(3.4)	6(5.7)	14(4.2)	
	house wife	56(24.1)	15(14.3)	71(21.1)	
	unkown	42(18.1)	4(3.8)	46(13.6)	
Gender	Female	77(33.2)	20(19)	97(28.8)	0.008
	Male	155(66.8)	85(81)	240(71.2)	
Marital status	married	192(82.8)	81(77.1)	273(81)	0.07
	single	26(11.2)	23(21.9)	49(14.5)	
	Other*	14(6)	1(1)	15(4.5)	

Table 3 (cont.): Demographic and clinical characteristics of spinal trauma patients by mechanism of fall

variable	level	low fall(<=3 m)	high fall(>3 m)	Total	p.value
education	illetrate	74(31.9)	15(14.3)	89(26.4)	0.13
	Elementary school	53(22.8)	23(21.9)	76(22.6)	
	Middle school	30(12.9)	22(21)	52(15.4)	
	High school	21(9.1)	15(14.3)	36(10.7)	
	diploma	42(18.1)	25(23.8)	67(19.9)	
	college and more	12(5.2)	5(4.8)	17(5)	
GCS	3-8	2(0.9)	2(1.9)	4(1.2)	0.62[c]
	9-12	4(1.7)	1(1)	5(1.5)	
	13-15	226(97.4)	102(97.1)	328(97.3)	
Level of injury	cervical	16(6.9)	4(3.8)	20(5.9)	0.001
	thoracic	55(23.7)	18(17.1)	73(21.7)	
	lumbar	134(57.8)	51(48.6)	185(54.9)	
	Multiple	27(11.6)	32(30.5)	59(17.5)	
Transportation services	Ambulance	151(65.1)	85(81)	236(70)	0.003
	Non-ambulance	81(34.9)	20(19)	101(30)	
In hospital mortality	Survived	230(99.1)	102(97.1)	332(98.5)	0.16[c]
	death	2(0.9)	3(2.9)	5(1.5)	
surgery	No	154(66.4)	40(38.1)	194(57.6)	0.001
	yes	78(33.6)	65(61.9)	143(42.4)	
Cord injury	No	226(97.4)	96(91.4)	322(95.5)	0.02
	yes	6(2.6)	9(8.6)	15(4.5)	
ASIA IMPAIRMENT SCALE	A	2(0.9)	6(5.7)	8(2.4)	0.07
	C	3(1.3)	2(1.9)	5(1.5)	
	D	9(3.9)	4(3.8)	13(3.9)	
	E	218(94)	93(88.6)	311(92.3)	

*divorce, widowed, dead wife, a: ANOVA test; b: Kruskal-Wallis test; c: Fisher-exact test; the other p-value from chi-square test

Table 4. Factors Associated with High-Energy Falls (>3 Meters): Results from Univariable and Multivariable Logistic Regression

Variable	Subgroup	unadjusted HR (95% CI)	p.value	adjusted HR (95% CI)	p.value
Number of vertebrae		1.44(1.28, 1.62)	<0.001	1.32(1.09, 1.85)	0.012
LOS		1.07(1.04, 1.11)	<0.001	1.04(1.01, 1.08)	0.031
ICU admission	no	1		1	
	yes	5.02(2.32, 10.86)	<0.001	2.35(1.29, 6.96)	0.002
gender	Male	1		1	
	Female	0.47(0.27, 0.83)	0.009	0.51(0.13, 2.01)	0.323
Marital status	married	1		1	
	single	1.02(0.65, 1.59)	0,913	1.43(0.55, 3.77)	0.470
age	<=20			1	
	21-40	0.74(0.27, 2.02)	0.552	0.51(0.05, 5.21)	0.559
	41-60	0.51(0.19, 1.38)	0.186	0.49(0.05, 5.34)	0.562
	> 60	0.13(0.04, 0.39)	<0.001	0.22(0.02, 0.64)	0.021
GCS	3-8	1		1	
	9-12	0.25(0.01, 4.73)	0.355	0.13(0.12, 20.81)	0.440
	13-15	0.45(0.06, 3.25)	0.430	1.22(0.04, 41.95)	0.920
Cord injury	no	1		1	
	yes	3.53(1.22, 10.19)	0.02	0.21(0.01, 3.09)	0.262
Transportation services	Ambulance	1		1	
	Non-ambulance	0.44(0.25, 0.77)	0.004	0.64(0.31, 0.88)	0.013
In hospital mortality	Survived			1	
	death	3.38(0.56, 20.55)	0.192	0.59(0.03, 11.69)	0.761
Job	private sector	1		1	
	retired	0.13(0.03, 0.64)	0.012	0.53(0.08, 3.43)	0.509
	laborer	1.35(0.63, 2.87)	0.441	2.11(0.79, 5.02)	0.141
	driver	0.17(0.02, 1.51)	0.113	0.23(0.02, 2.47)	0.225
	staff	0.39(0.07, 2.15)	0.281	0.46(0.06, 3.55)	0.457
	farmer	0.84(0.32, 2.13)	0.649	1.89(0.58, 6.12)	0.290
	student	1.03(0.33, 3.56)	0.961	0.41(0.03, 5.78)	0.512
	house wife	0.37(0.16, 0.87)	0.023	0.45(0.09, 2.33)	0.344
	unknown	0.13(0.04, 0.44)	0.001	0.24(0.05, 0.86)	0.030
surgery	No	1		1	
	Yes	3.21(1.99, 5.18)	<0.001	0.82(0.2, 3.24)	0.75
ASIA IMPAIRMENT SCALE	A	1		1	
	C	7.03(1.39, 35.49)	0.018	0.22(0.01, 5.53)	0.358
	D	1.56(0.26, 9.51)	0.628	0.12(0.01, 2.12)	0.141
	E	1.04(0.31, 3.47)	0.947	0.08(0.02, 2.29)	0.139
education	illiterate	1		1	
	Elementary school	2.14(1.02, 4.49)	0.044	0.69(0.26, 1.85)	0.461
	Middle school	3.62(1.66, 7.92)	0.001	1.11(0.37, 3.35)	0.852
	High school	3.52(1.48, 8.36)	0.004	1.02(0.32, 3.38)	0.998
	diploma	2.94(1.45, 6.18)	0.005	0.85(0.26, 2.73)	0.783
	college and more	2.06(0.63, 6.74)	0.232	2.15(0.42, 11.7)	0.376
Level of injury	cervical	1		1	
	thoracic	1.31(0.39, 4.43)	0.665	2.11(0.51, 8.83)	0.425
	lumbar	1.52(0.49, 4.77)	0.471	5.29(1.19, 23.57)	0.305
	Multiple	4.72(1.41, 15.89)	0.012	1.86(1.24, 8.56)	0.029

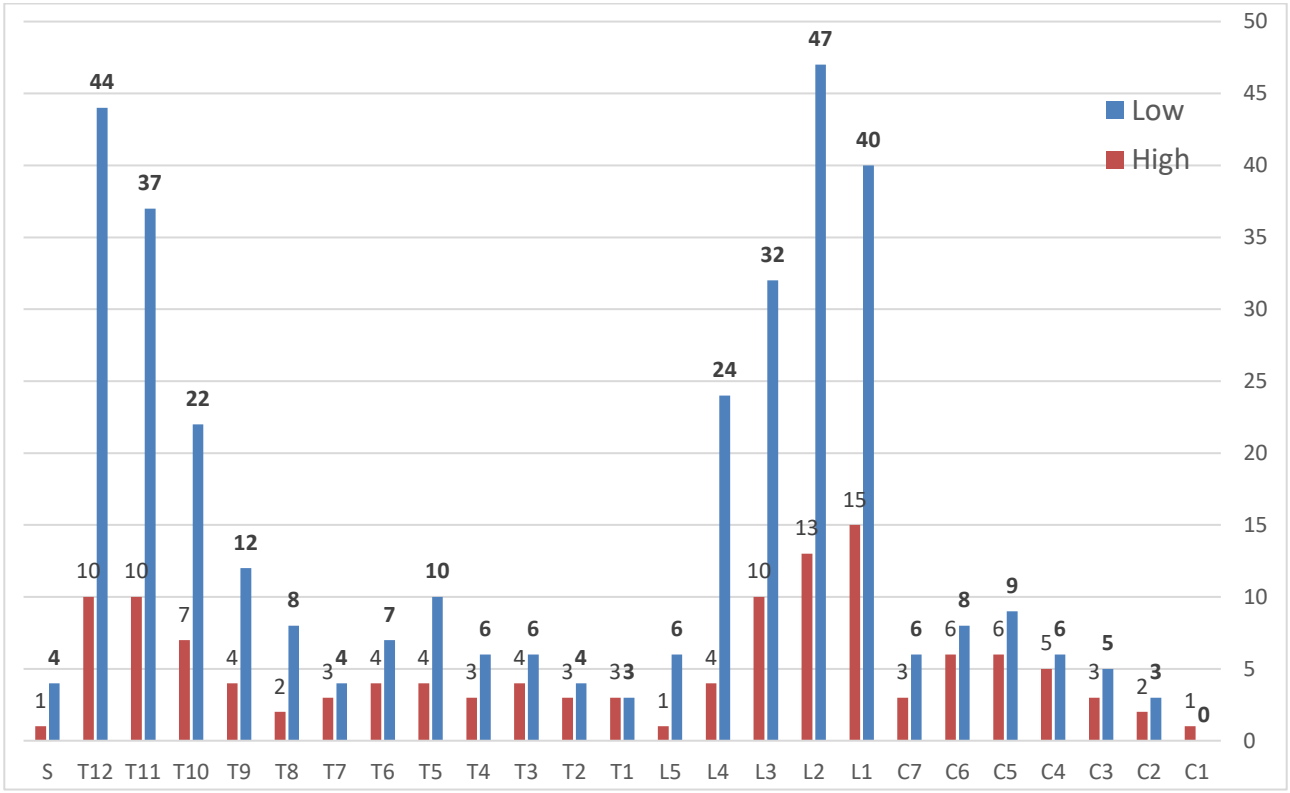


Figure 1: Frequency distribution of operated vertebrae according to fall mechanism

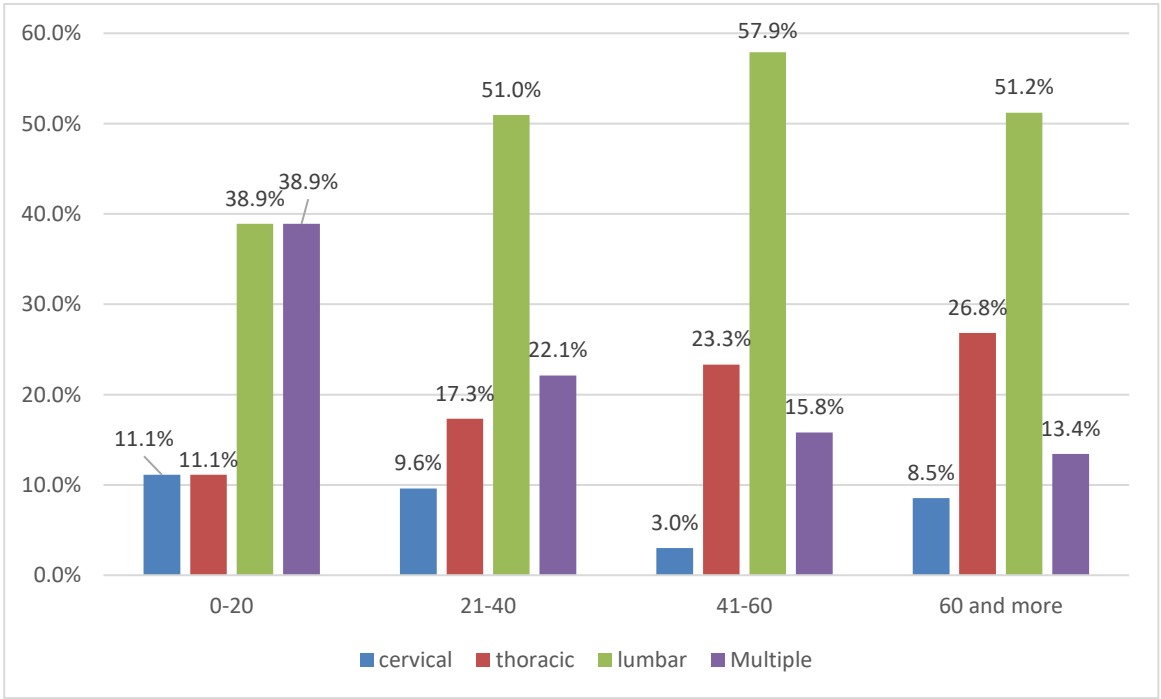


Figure 2: Distribution of level of injury by age groups

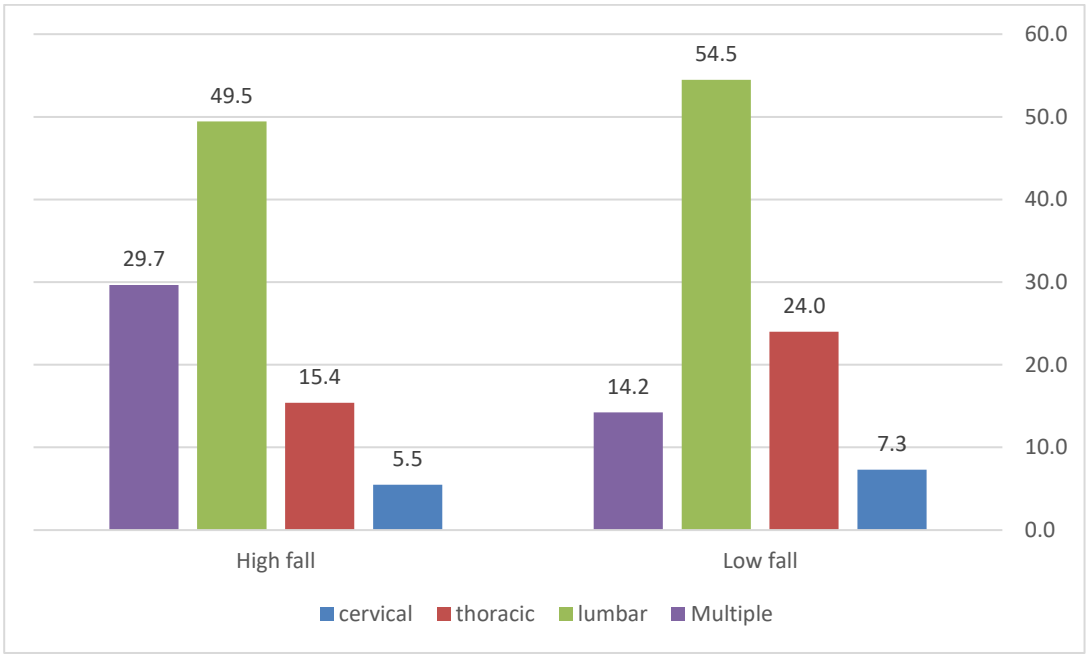


Figure 3: distribution of level of injury in level of falls

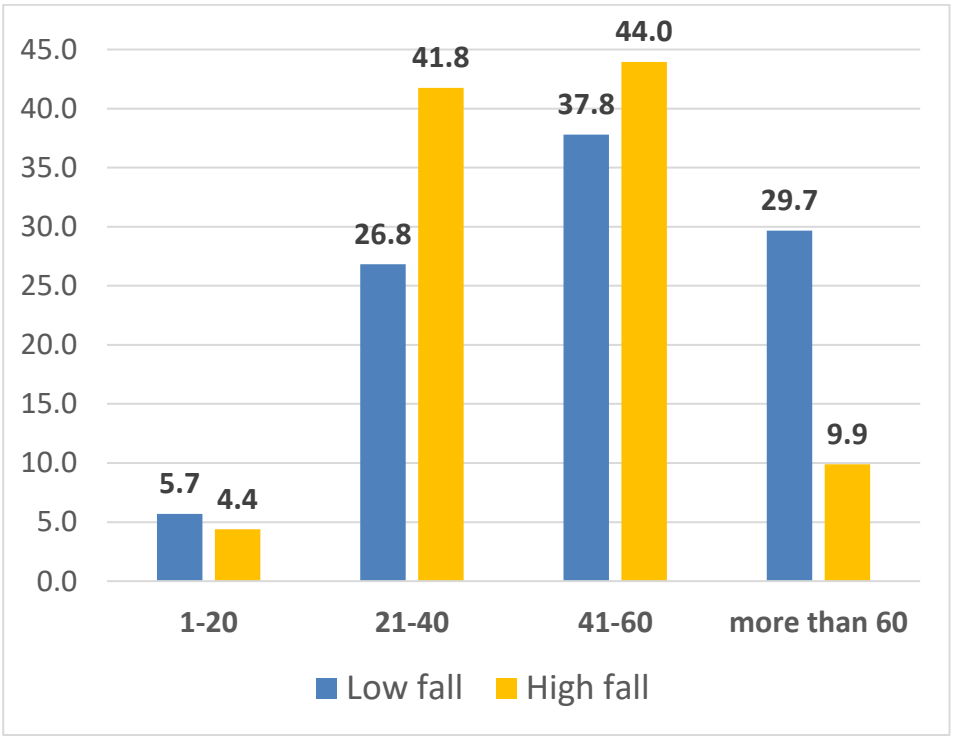


Figure 4: Frequency distribution of falls mechanism by age group

Discussion

Considering that traffic accidents and falls are the leading causes of trauma, and that the number of trauma patients resulting from falls has been rising in recent years, this study was conducted to examine the characteristics of trauma patients with spinal injuries from falls. It also aims to explore the relationship between the level of injury and the mechanism of the fall in relation to demographic and clinical characteristics.

Consistent with several studies, the current data show that older adults are disproportionately affected by low-height falls. For example, Bhattacharya et al. reported that 78.4% of fall-related trauma patients were aged 65 or older[21] substantially higher than the 25.3% in the current study. This discrepancy may reflect differences in population demographics or the inclusion of only Level 1 trauma centers in Bhattacharya's study, which may capture more severe, age-related injuries. The mean age in the current study (48.59 years) falls within the range reported in the literature. It is comparable to studies by Taçyıldız et al. (54.4 years)[22], Brotherton et al. (51.6 years),[23] and Chen et al. (52.9 years),[24] suggesting similarities in the overall age distribution of fall-related trauma patients across diverse settings. However, the current findings contrast with studies reporting younger populations, such as Bensch et al. (mean 42 years)[25] and Althobaiti et al.[26] in Saudi Arabia (37.34 years). The younger mean age in Althobaiti et al.[26] may reflect a higher incidence of occupational or high-energy falls among younger, working-age males in that region. Studies focusing on specific injury types or mechanisms show more variation. Hall et al. in England reported a much higher mean age (76.6 years) for spinal fracture patients,[27] likely because their cohort was restricted to elderly patients with osteoporotic fractures from minor falls. In contrast, Zhang et al. in China found only 8.5% of fall patients were over 60, with low-height falls being more common in older individuals (25.5%) than high-height falls (2.1%), which supports the current study's observation of age-related patterns in fall height.[1] Notably, Yang et al.[28] and Khudor et al. in China reported lower mean ages for high- height falls (42 and 33.8 years, respectively), reinforcing the global pattern that high- height falls tend to occur in younger, more risk-prone individuals, often in occupational or recreational contexts, while low-height falls predominate in older adults.[29] In the study by Lomaz et al. in Brazil, fall was the most frequent mechanism of trauma, accounting for 33.2% of cases. Individuals aged 40–59 years constituted 54.7% of the study population, and falls occurred in 36.6% of male patients.[30]

The current findings align with existing research in showing a bimodal pattern in fall-related trauma: older adults are more prone to low-height falls, while younger individuals are at greater risk of high- height falls. Differences in mean age across studies reflect variations in study design, population, location, and fall mechanisms. These variations highlight the influence of context on age trends and emphasize the need for age-specific prevention strategies, such as fall prevention programs for the elderly and safety measures for young workers in high-risk occupations.

In the present study, 71.7% of fall-related trauma patients were male, with men accounting for 68.8% of low-height falls and 81% of high-height falls. This gender distribution is consistent with global trends, though the proportion of male patients varies across studies. In several countries, both developed and developing, male prevalence was higher: Turkey (73.5%),[22] USA (79.4%),[24] Finland (78%),[25] and China (82.2%),[1] with similar male predominance in both low- and high-height falls. However, other studies reported lower male representation, such as in the USA (38.2% and 69%),[21, 23] Saudi Arabia (62.8%),[26] China (64.2%),[28] and England (41.5%).[29] The higher proportion of male patients in this study likely reflects greater male exposure to risky activities, especially in occupational or recreational settings. In contrast, women particularly those over 65, may experience higher injury severity due to osteoporosis and postmenopausal bone fragility, leading to more spinal injuries. This underscores the need for prevention strategies tailored to sex and age, addressing both behavioral risks in men and biological vulnerabilities in older women.

In the present study, lumbar spine injuries were the most prevalent, accounting for over 55% of cases. The incidence of thoracic and lumbar injuries increased with age, particularly up to 60 years, while cervical and multiple-level injuries were less frequent in older individuals. A significant association was observed between the level of spinal injury and several clinical factors, including age, ICU admission, spinal cord injury, in-hospital mortality, ICU length of stay, and ASIA impairment scale. These findings align with previous studies highlighting the evolving epidemiology of spinal trauma. While some international studies report cervical injuries as the most common (Brotherton et al.: 47%;[23] Hall et al.: 49.5%;[27] Chen et al.: 66.3%,[24] lumbar injuries predominated in our cohort and in the Brazilian study by Lomaz et al., where falls accounted for 60–69% of lumbar and thoracolumbar fractures.[30] Notably, fall-related injuries are increasingly recognized as a major cause of spinal trauma, particularly among older

adults. Wilson et al. found that 70% of cervical injuries in individuals over 80 years were fallrelated.[31] Similarly, the Norwegian study reported that falls caused 56% of cervical injuries and constituted 56.7% of all injury mechanisms, with a strong association with advancing age.[32] In contrast, Taçyıldız et al. in Türkiye reported a lower lumbar injury rate (31%), underscoring geographic and demographic variations in injury patterns.[22] Overall, our results and supporting literature suggest a shift toward fall-related, age-dependent spinal trauma, with lumbar and thoracolumbar regions disproportionately affected in middle-aged and older populations. Taking into account that the frequency of injuries among spine trauma patients varies based on the mechanism of falls (low versus high altitude), it was observed that high falls were more often work-related and typically resulted in injuries to the waist area (thoracic and lumbar). In contrast, low falls were more frequently linked to cervical fractures. In this study, since the majority of falls occurred from low heights, most of the injuries were concentrated in the waist area.

In this study, 42.4% of the injured people underwent surgery and the mean number of operated vertebrae was 1.4, and 1.6% of the injured died by the end of the study. In Hall et al.'s study, the mean number of injured vertebrae was 1.2 and 24.5% underwent surgical intervention and 18.7% died and mortality increased significantly with increasing age.[27] In Bensch et al.'s study, the mean number of vertebral fractures was 1.6, and 56% of the fractured vertebrae underwent surgery.[25] In the case of fractures that involve the nerve, surgery is usually performed, and for conservative treatments, the use of medical equipment, physical therapy, and occupational therapy is more common.[33] Considering that early surgery is recommended for neurological recovery and reduction of complications, therefore, immediate measures in early decompression of patients with improvement of paraclinical support lead to a reduction of hospitalization and thromboembolic duration and reduction of spinal cord lesions and death in the injured.

In this study, 73% of the patients experienced falls from a low height, with 82.6% of women and 69.4% of men falling from this level. The mean ages of patients who fell from low and high heights were 50.2 and 41.7 years, respectively as indicated in the results presented in Table 3. Following adjustment for potential confounders, multivariable analysis in our study identified the number of affected vertebrae, length of hospital stay (LOS), ICU admission, multi-level spinal injury, age >60 years, absence of ambulance transport, and unknown occupation as the only variables independently associated with the mechanism of fall (Table 4). In the study by Zhang et al., 25.5% of patients who fell from a low height were over 60 years old, whereas only 2.1% of those who fell from a high height suffered injuries to the waist area. Additionally, the proportion of men who fell from low and high heights was 78.8% and 83.5%, respectively. Also their study also found found significant associations between fall mechanism and age, injury level, severity (ASIA score), surgery, and length of stay.[1] Chen et al. reported that high-height falls were linked to younger age, male sex, and more severe spinal injuries.[24] Taçyıldız et al. identified fall height as a predictor of injury severity and surgical need in tree-fall injuries.[22] Bensch et al. noted that working-age males dominated high-energy fall cases, with more complex fractures.[25]

Furthermore, advanced age (≥80 years), comorbidities, polypharmacy, cognitive impairment, and sensory deficits (e.g., hearing and vision loss) are consistently recognized as major risk factors for falls across various studies [34-35].

This discrepancy may be attributed to differences in how falls were classified and variations in the severity of spinal cord injuries among patients in the two studies. However, multiple studies have evaluated the relationship between fall mechanism and variables such as age, sex, injury severity, spinal level, need for surgery, and outcomes. our study aligns with this body of evidence by identifying similar significant associations. The differences observed may reflect regional, methodological, or population-specific factors such as classification criteria for fall height or differences in trauma systems but overall support the importance of mechanism-based analysis in trauma research and prevention planning.

limitations of the current study

Several limitations should be considered when interpreting the findings of this study. First, the retrospective study design restricts the ability to establish causal relationships and relies on the accuracy and completeness of existing medical records, which may introduce information bias. Second, the relatively small sample size may limit the statistical power of the analysis and reduce the generalizability of the results, particularly when examining subgroup differences or less common outcomes. Third, there is a potential for selection bias, as the study included only patients referred to and treated at our teaching hospitals. This may lead to an overrepresentation of more severe or complex cases, as these centers often serve as tertiary referral hubs, thereby limiting the applicability of the findings to broader or community-based populations.

Future prospective studies with larger samples are needed to confirm and extend these results.

Inclusion and Exclusion criteria:

Patients were included if they had a confirmed spinal fracture, a documented fall mechanism (from any height), and a fall from a known or reliably estimated height. Exclusion criteria included pathological fractures (e.g., due to malignancy or osteoporosis without significant trauma), incomplete medical records, non-traumatic spinal fracture, and falls occurring during motor vehicle collisions or other high-impact mechanisms (e.g., crush injuries).

Conclusion

Spinal injuries from falls are common across all age groups, with distinct patterns based on fall height and patient demographics. High-energy falls are associated with greater injury severity, including multi-level vertebral involvement, ICU admission, and prolonged hospitalization. In contrast, older age, absence of ambulance transport, and unknown occupation were linked to less severe presentations, suggesting lower-energy mechanisms in these cases. In our study, low-height falls were more frequent among individuals over 60 years and among women, while over 85% of high-height fall injuries occurred in adults aged 21–60. Notably, about half of the injured were workers or housewives, underscoring the need for targeted prevention programs in occupational and domestic settings. These findings emphasize the value of clinical and demographic patterns in identifying high-energy trauma mechanisms and guiding preventive strategies.

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Study conception: GR, SJ, MS
Data collection: SJ, YP, DB, SB, AM, AS
Analysis: GR, AH, MS, AA
Investigation: SJ, AH, GR, MS, AS, AM
Writing: MS, FG, GR
Critical review and revision: all authors
Final approval of the article: all authors

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