



# Injury Mechanisms of Hip Fractures in India

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**Purpose:** Hip fractures are a major cause of morbidity and mortality in the elderly; however, the current literature on the injury patterns of hip fractures in India is lacking. Understanding the injury profile of these patients is important to develop targeted interventions to prevent hip fractures.

**Materials and Methods:** This was a prospective study of all hip fracture patients aged 50 years or older admitted from February 2019 to December 2019. Details about the injury were recorded by an in-person interview. Multivariate logistic regression analysis was used to identify the factors associated with any particular injury mechanism.

**Results:** Two hundred and eighty-three hip fractures were included. The mechanism of injury for the majority of patients was a fall from a standing height (n=217, 76.7%) while 60 patients (21.2%) were injured as the result of a road traffic accident (RTA). Slipping on a wet floor (n=49, 22.6%) and change in posture (n=35, 16.1%) were the most commonly reported reasons for falling. Pedestrian injuries were the most common form of RTA (n=29, 48.3%). Increasing age ( $P<0.001$ ) and female sex ( $P=0.001$ ) were associated with fall as the mode of injury while sustaining another fracture in addition to hip fracture ( $P=0.032$ ) was associated with RTA as the mode of injury.

**Conclusion:** A fall from standing height is the predominant mode of injury among elderly hip fractures especially among women. Environmental hazards and postural changes are responsible for the majority of falls while pedestrian accidents contribute to a majority of the RTAs.

**Key Words:** Hip fractures, Multiple trauma, Hip injuries, Osteoporotic fractures

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## INTRODUCTION

Hip fractures among the geriatric population are a major cause of morbidity and mortality, and the one-year mortality rate after hip fractures estimated to be as high as 30%<sup>1-4</sup>. The worldwide annual incidence of hip fractures is estimated to be about 1.6 million and is expected to increase to 2.6 million by the year 2025 and 4.5 million by 2050 due to the aging population<sup>5-7</sup>. Despite the morbidity associated with elderly hip fractures, few studies have evaluated the incidence and epidemiology of hip fractures in India<sup>8</sup>. As a result, the true figures on the incidence of hip fractures in India is lacking, though the annual incidence is estimated to be over 120 fractures per 100,000 persons over the age of 50, with higher rates in women<sup>8</sup>.

Considering that the population of India over 50 is close to 170 million according to the 2011 census, this translates to about 0.2 million hip fractures a year<sup>9</sup>.

Understanding the clinical and injury profile of these patients is important to develop targeted interventions to prevent hip fractures. Balance and mobility decline with age, predisposing older people to falls<sup>10</sup>. In addition, poor visual activity, underlying medical comorbidities, side effects of medications, etc. may make elderly individuals prone to various environmental hazards, ultimately resulting in injuries and fractures<sup>11</sup>. Although more than 90% of hip fractures are the result of falls, some studies have shown that road traffic accidents (RTAs) also contribute to a considerable number of hip fractures in developing countries<sup>12,13</sup>. Moreover, a large number of elderly people in developed countries stay in nursing homes, and most preventive programs are directed towards reducing falls in such settings<sup>14</sup>. However, these programs may not be applicable to settings in India where the vast majority of elderly patients remain at home, and the injury mechanisms for falls may differ. Currently, few studies have evaluated the injury mechanisms of hip fractures in India. Therefore, we conducted a prospective study of hip fractures at our institution to evaluate demographic and injury patterns. It was hypothesized that the vast majority of hip fractures were a result of fall, and demographics and fracture patterns were associated with injury mechanisms.

The objectives of this study were to 1) identify the self-reported modes of injury in patients suffering from hip fractures in India, and 2) assess the factors associated with the mode of injury.

## MATERIALS AND METHODS

This was a prospective observational study of all hip fracture patients admitted at a single tertiary level trauma center from February 2019 to December 2019. This study was approved by the ethical review board of this institution (IECPG-631/19.12.2018, RT-29/23.01.2019) and followed the Declaration of Helsinki (2013). All patients agreed to participate in the study and provided written informed consent. Data were collected by in-person interviews of patients and/or relatives during admission along with review of medical records.

All hip fractures (proximal femur fractures: neck, intertrochanteric, or subtrochanteric) in individuals 50 years or older were included in the study (age at the time of injury). During the study period, there were 377 hip frac-

ture admissions of which 93 were under the age of 50. One patient did not provide consent, leaving behind 283 patients who were finally included in the study. All patients presented to the emergency department (ED) and were attended by a senior resident from the orthopedic department. After diagnosis, patients were admitted to the orthopedic ward after routine investigations and preliminary medical examination by the ED physician. Surgery was planned for the earliest available slot pending anesthetic fitness. After surgery (fixation or replacement), patients were mobilized on day 1 and were discharged by day 2 or 3 if the wound was healthy.

Data regarding the nature of the injury, medical illness, ambulatory status, and history of prior fall in the preceding year were collected by interview of the patient and the relatives during admission. Additionally, medical records and ED notes were further reviewed to obtain and/or confirm details pertaining to injury, and to collect medical comorbidities, fracture patterns, and note the presence of any associated fracture other than the hip (concomitant fracture). The mode of injury was broadly classified into fall from standing height (or simply referred to as fall), RTA, or others (trivial injuries, fall from heights, etc.). The fracture pattern was classified using the new AO Foundation/Orthopaedic Trauma Association (AO/OTA) classification<sup>15</sup>. Isolated greater trochanteric fractures (31A1.1) and head fractures (31C) were not included in the study. As the AO classification does not include a separate term for subtrochanteric fractures, they were classified under either the reverse obliquity trochanteric fractures (31A3) or the proximal diaphysis fractures (32 with qualification 'a')<sup>16,17</sup>. The ambulatory status at baseline was recorded as community ambulatory (able to mobilize in the community with or without assistive devices) or home ambulatory (able to mobilize inside the home with or without assistive devices, minimal ambulation, wheelchair-bound or bedridden)<sup>18</sup>.

Descriptive statistics were used to assess the demographic and clinical features of hip fractures. Categorical variables were compared using a chi-squared or Fisher exact test. A Student's *t*-test was used to compare continuous variables. Univariate logistic regression was used to assess the factors associated with falls. To adjust for possible confounders, all factors were included in the multivariate regression model, and final variables were selected using stepwise backward elimination with  $P < 0.05$  set as the threshold for inclusion. The level of significance for the remaining analysis was also set at  $P < 0.05$ . Statistical analysis was completed using Stata statistical software (ver. 12; StataCorp., College Station,

**Table 1.** Baseline Features of Patients by Fracture Pattern

Variable	All patients (n=283)	Neck (n=77)	Trochanteric (n=206)	P-value
Age (yr)	70±12	67±12	71±12	0.030
Sex				0.369
Male	131 (46.3)	39 (50.6)	92 (44.7)	
Female	152 (53.7)	38 (49.4)	114 (55.3)	
Comorbidities				
Hypertension	127 (44.9)	33 (42.9)	94 (45.6)	0.676
Diabetes	66 (23.3)	16 (20.8)	50 (24.3)	0.536
Lung disease	37 (13.1)	15 (19.5)	22 (10.7)	0.051
Heart disease	26 (9.2)	9 (11.7)	17 (8.3)	0.373
Neurological disease	26 (9.2)	5 (6.5)	21 (10.2)	0.337
Renal disease	11 (3.9)	4 (5.2)	7 (3.4)	0.498
Thyroid disorder	14 (4.9)	4 (5.2)	10 (4.9)	>0.999
Dementia	10 (3.5)	3 (3.9)	7 (3.4)	>0.999
Malignancy	7 (2.5)	2 (2.6)	5 (2.4)	>0.999
Ambulatory status				0.030
Community	244 (86.2)	72 (93.5)	172 (83.5)	
Home	39 (13.8)	5 (6.5)	34 (16.5)	
Concomitant fracture	11 (3.9)	2 (2.6)	9 (4.4)	0.733
Prior fall	44 (15.5)	8 (10.4)	36 (17.5)	0.143

Values are presented as mean ± standard deviation or number (%).

TX, USA).

**RESULTS**

The mean age was 70±12 years. There were 152 females (53.7%). Pertrochanteric fractures were observed in 206 patients (72.8%) while neck-of-femur fractures were observed in 77 patients (27.0%). There was no significant difference in the baseline features among the different fracture types (Table 1). Based on the AO fracture classification, 31A2.2 (n=91, 32.2%) was most common followed by 31A1.3 (n=35, 12.4%) (Table 2). Hypertension was the most prevalent comorbidity (n=127, 44.9%) followed by diabetes (n=66, 23.3%), and chronic lung disease (n=37, 13.1%). The majority of the patients were community ambulators (n=244, 86.2%), and 44 patients (15.5%) had a history of fall in the preceding year. Eleven patients (3.9%) also suffered another fracture other than hip fracture from the injury.

The majority of patients reported fall as the mode of injury (n=217, 76.7%) while 60 patients (21.2%) had injuries as a result of a RTA (Table 3). Slipping over a wet floor (n=49, 22.6%) and change in posture (n=35, 16.1%) were the most commonly reported reasons for fall. Forty-eight patients (17.0%) reported that they had a loss of balance without any specific inciting event. Pedestrian injuries were the most common form of RTA (n=29, 48.3%) followed by

**Table 2.** AO Classification of Fracture (n=283)

Type of fracture	Number (%)
31A	202 (71.4)
31A1	67 (23.7)
31A1.2	32 (11.3)
31A1.3	35 (12.4)
31A2	102 (36.0)
31A2.2	91 (32.2)
31A2.3	11 (3.9)
31A3	33 (11.7)
31A3.1	7 (2.5)
31A3.2	3 (1.1)
31A3.3	23 (8.1)
31B	77 (27.2)
31B1	32 (11.3)
31B1.1	4 (1.4)
31B1.2	2 (0.7)
31B1.3	26 (9.2)
31B2	33 (11.7)
31B2.1	20 (7.1)
31B2.2	7 (2.5)
31B2.3	6 (2.1)
31B3	12 (4.2)
32	4 (1.4)
A1a	3 (1.1)
C1a	1 (0.4)

two-wheeler accidents (n=21, 35.0%). The injury mechanisms by age, sex, and fracture pattern are detailed in Table

4. Older patients, female sex, and subcapital and basicervical fractures had a higher proportion of falls (Table 4).

On univariate analysis, increasing age ( $P<0.001$ ), female sex ( $P<0.001$ ), home ambulators ( $P=0.016$ ), and those with a history of prior fall ( $P=0.014$ ) were likely to have fall as

the mode of injury (Table 5). On multivariate analysis, increasing age ( $P<0.001$ ) and female sex ( $P=0.001$ ) were significantly associated with fall being the mode of injury while patients sustaining another fracture in addition to hip fracture were less likely to have a fall ( $P=0.032$ ) (Fig. 1).

Among the 283 patients, 274 underwent surgery (total hip arthroplasty: 8, hemiarthroplasty: 49, fixation: 215; 2 patients elected to undergo surgery outside of our institution and the details were not available), 4 died prior to surgery, 2 refused surgery and left against medical advice, and the remaining 3 were managed conservatively due to poor health. The mean length of stay was  $7.4 \pm 4.6$  days, and 10 patients (3.5%) (died during the hospital stay).

**Table 3.** Mechanism of Injury (n=283)

Mechanism of injury	Number (%)
Fall from standing height	217 (76.7)
Wet floor	49 (17.3)
Change in posture	35 (12.4)
Stairs	32 (11.3)
Activity related	21 (7.4)
Trip and fall	16 (5.7)
Dizziness	15 (5.3)
Seizure	1 (0.4)
Unspecified loss of balance	48 (17.0)
Road traffic accident	60 (21.2)
Pedestrian	29 (10.2)
Two wheeler	21 (7.4)
Fall from moving vehicle	4 (1.4)
Three wheeler	4 (1.4)
Four wheeler	2 (0.7)
Others	6 (2.1)
Trivial	3 (1.1)
Fall of heavy object	2 (0.7)
Fall from height	1 (0.4)

## DISCUSSION

Hip fractures are common among elderly individuals and have morbid consequences. As the population of elderly people in India is rising, understanding the characteristics of hip fractures as well as the modes of injury is important. In this prospective study of hip fractures for individuals age 50 or older, there were roughly equal proportions of men and women, and intertrochanteric fracture was the most common type. The present study also found that fall from standing height was the predominant mode of injury, especially when the patient is an elderly woman with an iso-

**Table 4.** Injury Mechanism Based on Age, Sex, and Fracture Pattern

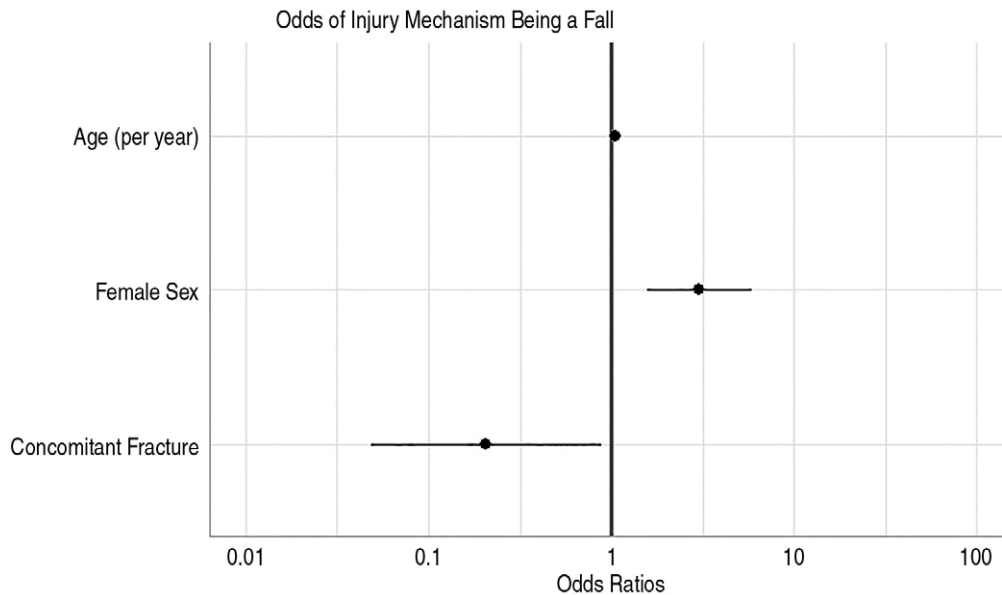
Variable	Total	Fall from standing height	Road traffic accident	Others
Age group				
50-59	61 (100)	37 (60.7)	23 (37.7)	1 (1.6)
60-69	72 (100)	52 (72.2)	19 (26.4)	1 (1.4)
70-79	78 (100)	63 (80.8)	14 (17.9)	1 (1.3)
80-89	59 (100)	52 (88.1)	4 (6.8)	3 (5.1)
$\geq 90$	13 (100)	13 (100)	0 (0)	0 (0)
Sex				
Male	131 (100)	87 (66.4)	43 (32.8)	1 (0.8)
Female	152 (100)	130 (85.5)	17 (11.2)	5 (3.3)
Fracture type				
Neck	77 (100)	58 (75.3)	18 (23.4)	1 (1.3)
Subcapital (31B1)	32 (100)	27 (84.4)	5 (15.6)	0 (0)
Transcervical (31B2)	33 (100)	21 (63.6)	11 (33.3)	1 (3.0)
Basicervical (31B3)	12 (100)	10 (83.3)	2 (16.7)	0 (0)
Trocchanteric	206 (100)	159 (77.2)	42 (20.4)	5 (2.4)
Stable pertrochanteric (31A1)	67 (100)	51 (76.1)	16 (23.9)	0 (0)
Unstable pertrochanteric (31A2)	102 (100)	79 (77.5)	21 (20.6)	2 (2.0)
Reverse intertrochanteric /subtrochanteric fracture (31A3, 32)	37 (100)	29 (78.4)	5 (13.5)	3 (8.1)

Values are presented as number (%).

**Table 5.** Factors Associated with the Injury Being a Fall

Factor	Univariate		Multivariate	
	Odds ratio	P-value	Odds ratio	P-value
Age	1.07 (1.04-1.10)	<0.001	1.06 (1.03-1.09)	<0.001
Sex				
Male	Ref.		Ref.	
Female	3.78 (2.03-7.05)	<0.001	3.03 (1.58-5.84)	0.001
Ambulatory status				
Community	Ref.		-	-
Home	11.7 (1.6-87.5)	0.016	-	-
Fracture type				
Neck	Ref.		-	-
Trochanteric	1.17 (0.63-2.20)	0.615	-	-
No. of comorbidities				
0	Ref.		-	-
1	1.44 (0.73-2.84)	0.291	-	-
≥2	1.86 (0.91-3.84)	0.089	-	-
Concomitant fracture	0.14 (0.04-0.50)	0.003	0.21 (0.05-0.88)	0.032
Prior fall	4.56 (1.36-15.30)	0.014	-	-

Ref.: reference.



**Fig. 1.** The coefficient plot of a multivariate logistic regression model showing the effect of different variables in predicting the mechanism of injury. The odds ratio along with the 95% confidence intervals are given for the significant predictors of fall as the mechanism of injury.

lated hip fracture. Additionally, our findings show that about one-fifth of hip fractures were a result of RTA, especially related to pedestrian accidents.

There are some limitations to the current study. The assessment of injury mechanisms was based on interviews with the patient and relatives. In cases where there was no witness of the incident, the mode of injury was obtained sole-

ly based on the recollection of the patient. The presence of comorbidities like dementia, the occurrence of dizziness or light-headedness preceding the injury, delirium during the hospital admission, etc. can affect an accurate description of the injury mechanism. Although these factors may have resulted in a recall bias, the prospective nature of the study and simultaneous interviews of both patients and relatives/

attendants would have minimized this bias. There are considerable variations among studies with respect to the definition of hip fractures in elderly populations. The present study included all patients 50 years or older, similar to other previous studies from India and other developing countries, which was chosen with the consideration that life expectancy in India is approximately 69 years<sup>12,19-24</sup>. However, it is possible that some younger patients in our study may not have had a true osteoporotic fracture. As bone mineral density measurements are not routinely performed at our institution, it was not possible to estimate the incidence of osteoporosis among these patients. Additionally, the current study was not able to assess the risk factors for falls as a control cohort of patients who did not experience a fall was not included in this study. Finally, the current study only included patients that presented to the ED of a major trauma hospital in a metropolitan city, and the findings may be less applicable to other parts of the country.

In the current study, roughly equal proportion of both males and females were seen. This is in contrast to many studies in the developed countries where women comprise well

over 70% of all hip fractures<sup>25,26</sup>. However, studies in Indian populations have found sex representation similar to our study<sup>8,13</sup>. In a prospective study by Dash et al.<sup>13</sup>, 60% of hip fractures studied in India were females, while Dhanwal et al.<sup>8</sup> reported a female prevalence of 58% among hip fractures in Rohtak. Similar findings were reported by other studies in developing countries<sup>25-27</sup>. The larger proportion of men in our cohort may be a reflection of the sex ratio of the country<sup>28</sup>. However, elderly women being neglected and not brought to hospitals may be an explanation to be explored in future studies<sup>29</sup>. The majority of fractures were intertrochanteric which was similar to other studies<sup>13,27</sup>. Hypertension and diabetes remained the two most common prevalent comorbidities followed by lung disease. Dhibar et al.<sup>27</sup> similarly found hypertension, diabetes, and lung disease as the most prevalent comorbidities in a prospective study from North India.

Although fall was the major reason for hip fractures in our study, the contribution of fall was slightly lower than that reported in studies from developed countries (Table 6)<sup>12,21,22,30-36</sup>. Many studies from developed countries report fall as the

**Table 6.** Injury Mechanisms of Hip Fracture in Different Parts of the World

Study	Country	No. of patients	Age group	Fracture mechanisms
Moayeri et al. <sup>30</sup> (2006)	Iran	555 (49% females)	>50	Falls, 81%; RTA, 19%
Mackey et al. <sup>31</sup> (2007)	USA	878 (92% females)	>65	Low energy, 96%; high energy, 4%
Kim et al. <sup>32</sup> (2010)	Korea	820 (78% females)	>50	Slip down, 84%; fall from a height, 10%; minor contact injury, 2%; unidentified, 5%
Onwukamuche et al. <sup>12</sup> (2013)	Nigeria	47 (gender wise numbers not available)	>50	Fall from standing height, 50%; high energy fall, 23%; RTA, 13%; miscellaneous, 4%
Wongtriratanachai et al. <sup>21</sup> (2013)	Thailand	690 (71% females)	>50	Simple fall, 79%; falling from heights, 11%; RTA, 5%
Hagino et al. <sup>33</sup> (2017)	Japan	488, 759 (78% females)	>35 (highest in 80-89 group)	Simple falling, 80%; RTA, 7%; fall on stairs, 5%; miscellaneous, 8%
Tsabasvi et al. <sup>22</sup> (2017)	Tanzania	222 (59% females)	>50	Fall from standing height, 76%; RTA, 14%; fall height, 9%; trivial, 1%
Mattisson et al. <sup>34</sup> (2018)	Sweden	10,548 (69% females)	>18 (mean age of 82 years with >95% over 50)	Fall at the same level, 83%; unspecified fall, 10%; fall from height, 4%; RTA, 2%; others, <1%
Chen et al. <sup>35</sup> (2019)	China	1,539 (74% females)	>65	Low-energy injuries, 93%
Vasiliadis et al. <sup>36</sup> (2019)	Greece	73 (69% females)	>60	Fall from same level, 97%; fall from height, 1%; high energy, 1%
Present study	India	283 (54% females)	>50	Falls, 77%; RTA, 21%; others, 2%



contributor for over 90% of fractures while only about three-quarters of fractures in our study were the result of falls<sup>37,38</sup>). However, studies in some developing countries have reported a high percentage of RTAs similar to our study<sup>12,13,39</sup>. Dash et al.<sup>13</sup> prospectively studied 1,031 hip fracture patients above 55 years of age in India and found that the most common mode of injury was fall (45%), followed by slipping while walking (36%). In the present study, slipping while walking was included under falls, and other mechanisms of falls were also explored. Environmental measures like anti-slip mats in bathrooms, avoiding stairs or level differences between rooms, adequate lighting of rooms, etc. might be implemented to protect from falls. As a change in posture was another major trigger for falls, education of elderly to avoid sudden changes in posture, and tailoring hypotensive medications are other possible means to prevent falls<sup>40-42</sup>.

The present study also found that falls were likely to be the major mode of injury in older women. Similar findings were also reported by Onwukamuche et al.<sup>12</sup> who found that 65% of the fractures in men were from RTA compared to 22% in women. This suggests that younger patients and males might have been more engaged in outdoor activities<sup>12</sup>. There was a high rate of pedestrian injuries in our cohort. Elderly pedestrians are more likely to succumb to injuries and have been shown to have higher mortality than their younger counterparts<sup>43,44</sup>. Increasing the signal times for pedestrian crossing, including voice and tactile signals, improved lighting, refuge islands, and behavioural changes are helpful measures, though their implementation in the Indian setting may prove challenging<sup>45,46</sup>. Additionally, in the current study, about 15% of the patients reported a fall in previous years though this was not significant in the multivariate analysis. Pierrie et al.<sup>47</sup> reported that about a quarter of hip fracture patients presented with falls in the preceding year, and very few received fall counseling. Therefore, even if prior falls did not cause injury, they should be considered as opportunities to assess fall risk and manage osteoporosis. As the results of the current study indicated elderly women were more likely to have suffered a fall, elderly women presenting for follow-up in the fragility fracture clinics are currently being routinely referred to a fall prevention program at our institution (SAve The Hip Initiative, SATHI) where their gait and balance are being assessed by physiotherapists, and appropriate training is given.

## CONCLUSION

In summary, the results of the present study show that a fall from a standing height is the predominant mode of injury among hip fractures in India. Female sex and increasing age were associated with fall as the mechanism of injury of hip fracture. The majority of falls resulted from a wet floor or postural changes suggesting that education on environmental safety measures and on postural changes should be included in fall counseling. Public behaviour changes and elderly pedestrian safety measures should also be a part of hip fracture prevention programmes. Using the information presented in this study, further research to plan and assess fall prevention initiatives is recommended.

## CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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