


## CLINICAL ARTICLE

# Epidemiological Study of Tibial Plateau Fractures Combined with Intercondylar Eminence Fractures

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**Objective:** To investigate the epidemiological characteristics of tibial plateau fractures combined with intercondylar eminence fractures and identify the risk factors.

**Methods:** This retrospective study enrolled patients with tibial plateau fractures who were treated in the third hospital of Hebei Medical University from January 2015 to December 2018; 1020 patients (693 [68%] men and 327 [32%] women) meeting the inclusion and exclusion criteria had a mean age of  $45.2 \pm 13.8$  years. In total, 506 (50%) cases were left injuries, 495 (48%) were right injuries, and 19 (2%) were bilateral injuries. Among them, 458 (44.9%) with a mean age of  $47.0 \pm 13.9$  years had intercondylar eminence fractures, including 324 men and 134 women. A total of 562 (55.1%) patients were identified without intercondylar eminence fractures, including 369 (65.7%) men and 193 (34.3%) women with an average age of  $43.8 \pm 13.6$  years. The distribution characteristics of tibial plateau fractures with intercondylar eminence involved were identified. The potential associations among fractures and various other factors, such as age, gender, occupation, and mechanism of injury, were explored.

**Results:** The highest proportion age group of tibial plateau fractures included the ages 35–54 years, with more men than women for both age groups. For males, the highest proportion age group was 35–44 years, and for females, it was 55–64 years ( $\chi^2 = 71.336$ ,  $P < 0.01$ ). According to Schatzker classification, type IV tibial plateau fractures had the highest risk of intercondylar eminence being involved (70.6%) without significance with type V (69.5%) and VI (68.2%) but with greater significance with types I (11.9%), II (39.2%), and III (9.4%,  $\chi^2 = 280.187$ ,  $P < 0.01$ ). Multiple analysis showed that simple fractures, including types I, II, and III (OR 0.108, 95% CI: 0.080–0.145), were less likely to involve intercondylar eminence fractures than complex fractures, including types IV, V, and VI. Patients aged >74 years were more likely to have intercondylar eminence fractures compared with other age groups. Retired patients (OR 4.332, 95% CI: 1.147–16.362) were more likely to have fractured intercondylar eminence.

**Conclusion:** The current study revealed the characteristics of tibial plateau fractures, especially those involving intercondylar eminence fractures, as well as their proportion, distribution, and risk factors, which can be used as reference data for clinical assessment and surgical protocol selection.

**Key words:** classification; intercondylar eminence; risk factors; tibial plateau fracture

## Introduction

Fractures of tibial intercondylar eminence are common knee injuries, with an incidence of 3/100 000<sup>1,2</sup>. An isolated fracture of intercondylar eminence is an avulsion injury fracture, caused by traction of the anterior cruciate ligament at the tibial insertion, commonly seen in sports injuries. Among them, 2/3 of the fractures occur in teenagers and

children<sup>3,4</sup>. Intercondylar eminence fractures can also be seen in tibial plateau fractures, which means that intercondylar eminence fractures are tibial plateau fractures. According to the OTA/AO classification of proximal tibial fractures, intercondylar eminence fractures can be seen in 28.6% of type B tibial plateau fractures and 89.4% of type C fractures<sup>5</sup>. Schatzker classification is the most common system used to

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Received 6 February 2020; accepted 19 February 2020

assess the severity of the injury, which categorizes tibial plateau fractures into six types, based on the injury site and displacement on the X-ray films<sup>6</sup>. Tibial intercondylar eminence is often involved in tibial plateau fractures<sup>7-11</sup>. The combined injury of tibial plateau fractures with intercondylar eminence fractures implies a high risk of potential soft-tissue injuries around the knee joint, especially anterior cruciate ligament (ACL) disruption, which should be taken into consideration when operative plans are discussed<sup>12</sup>. In some cases of tibial plateau fractures with displaced intercondylar eminence fractures, fixation of the intercondylar eminence may be required in addition to the internal fixation of tibial plateau fractures, with the aim of restoring the ACL stability and reducing the risk of future traumatic arthritis<sup>13,14</sup>. Therefore, it is important to investigate the epidemiological characteristics of tibial plateau fractures combined with intercondylar eminence fractures. Nevertheless, there is a paucity of literature regarding the injury characteristics of tibial plateau fractures accompanied by intercondylar eminence fractures, as well as the risk factors for the association of tibial plateau involvement with intercondylar eminence fractures.

Therefore, we conducted this epidemiological study on tibial plateau fractures combined with intercondylar eminence fractures. The purpose of this study was: (i) to investigate the injury features of tibial plateau fractures combined with intercondylar eminence fractures; (ii) to clarify the relationship between tibial plateau fractures of different types of Schatzker classification and intercondylar eminence fractures; and (iii) to introduce a predictive model for the risk of these combined injuries based on multiple factor analysis.

## Patients and Methods

### *Inclusion Criteria and Exclusion Criteria*

The inclusion criteria were as follows: (i) definite diagnosis of tibial plateau fractures; and (ii) standard lateral and frontal position of knee joint film. The exclusion criteria of this study were: (i) multiple injuries; (ii) pathologic fractures; (iii) patients with a history of ipsilateral tibial fracture; (iv) meniscal injuries; (v) collateral or cruciate ligament injuries; and (vi) patients with history of arthropathy or operation on the affected knees.

A total of 1698 patients with tibial plateau fractures, who were treated in our hospital from January 2015 to December 2018, were included in this study. Among them, 678 patients were excluded, including 521 patients with multiple injuries, meniscal injuries, collateral or cruciate ligament injuries, 29 patients with pathologic fractures, 13 patients with a history of ipsilateral tibial fracture, and 115 patients with unqualified lateral and frontal position of knee joint film. Finally, 1020 patients were included for final analysis (Figs 1,2).

### *Demographic Information and Fracture Pattern*

The medical records of enrolled patients were retrieved using the medical record inquiry system. The demographic characteristics of patients and detailed information on tibial plateau fractures were recorded. The preoperative radiographs, CT, and MRI of the affected knees were collected with the use of the picture archiving and communication system. The X-ray films, CT, and MRI scans of tibial plateau fractures were reviewed by two orthopaedic surgeons with more than 10 years of experience. Schatzker classification was used to assess the pattern of tibial plateau fractures. Whether there were intercondylar eminence fractures was recorded. If there was any disagreement in the classification of tibial plateau fractures and the diagnosis of intercondylar eminence fractures, a final decision would be made through discussion, with consensus achieved by the two surgeons. The indicators measured in the present study are summarized in Table 1.

### *Age Groups*

There were eight age groups in this study: 0-14 years, 15-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, and > 74 years. Participants were classified into four major groups by age: children ( $\leq 14$  years), young adults (15-44 years), middle-aged adults (45-64 years), and the elderly (65 years and over).

### *Treatment Methods*

Two management algorithms were divided into conservative treatment and operative treatment. Operative treatments include internal fixation (open reduction, internal fixation, and minimally invasive surgery) and external fixation. The internal fixator, plate or intramedullary nail, was recorded.

The Institutional Review Board of the third hospital of Hebei Medical University approved the study protocol. This study has been registered with the Chinese Clinical Trial Registry (number ChiCTR1900021306).

### *Indicators/Outcome Measures*

#### *Marital Status*

Three statuses were classified: single, married, and divorce or widowed.

#### *Residential Category*

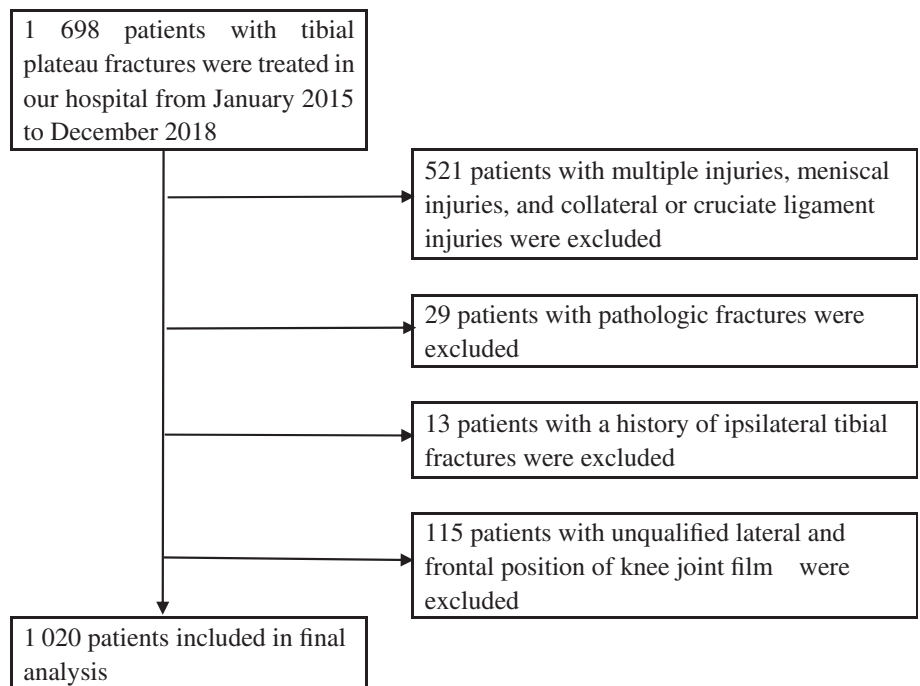
Residents were classified into two areas: urban and rural.

#### *Occupation*

There were six occupational categories: office worker, farmer, manual worker, retired, students, and other occupations.

#### *Season*

The season when fractures occurred was recorded: spring, summer, autumn, and winter.



**Fig. 1** Flowchart of the selection of tibial plateau fractures, 2015–2018.



**Fig. 2** Six representative images of tibial plateau fractures combined with intercondylar eminence fractures. (A) This patient is a 65-year-old woman, with an intercondylar eminence fracture, involved with a type I tibial plateau fracture. (B) This patient is a 52-year-old man, with an intercondylar eminence fracture, involved with a type II tibial plateau fracture. (C) This patient is a 50-year-old man, with an intercondylar eminence fracture, involved with a type III tibial plateau fracture. (D) This patient is a 45-year-old man, with an intercondylar eminence fracture, involved with a type IV tibial plateau fracture. (E) This patient is a 45-year-old man, with intercondylar eminence fracture, involved with a type V tibial plateau fracture. (F) This patient is a 60-year-old woman, with intercondylar eminence fracture, involved with a type VI tibial plateau fracture.

### ***Injury Mechanisms***

The injury mechanisms of traumatic fractures included traffic accidents, falls from height, slips, trips or falls, crushing injury, and others. This classification is commonly used in the field of traumatology and orthopaedics.

### ***Medical Payment Models***

Four modes of payment were applied: province/city medical insurance, new rural cooperative medical insurance, self-

funded, and others (commercial insurance and occupational injury insurance).

### ***Preoperative Complications***

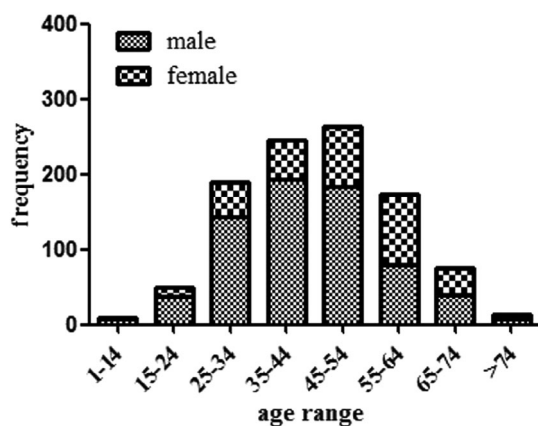
Patients were classified as “none” or “yes” (including diabetes, hypertension, cardiovascular and cerebrovascular system disease, respiratory system disease, liver and kidney system disease, venous thrombosis of lower extremity, and others).

**TABLE 1** The assignment and description of indicators observed in the study

Indicator	Assignment and description
Sex	Male = 1, Female = 2
Age	0–14 = 1, 15–24 = 2, 25–34 = 3, 35–44 = 4, 45–54 = 5, 55–64 = 6, 65–74 = 7, >74 = 8
Occupation	Office worker = 1, Farmer = 2, Manual worker = 3, Retired = 4, Students = 5, Others = 6
Marital status	Single = 1, Married = 2, Divorce or widowed = 3
Urbanization	Rural area = 1, Urban area = 2
Medical payment method	Province/city medical Insurance = 1, New rural cooperative medical insurance = 2, Self-funded = 3, Others = 4
Season	Spring = 1, Summer = 2, Autumn = 3, Winter = 4
Mechanism of injury	Traffic accidents = 1, Fall from height = 2, Slips, trips or falls = 3, Crushing injury = 4, Others = 5
Preoperative complications	Yes = 1, No = 2
Fracture types	Simple fracture including types I, II, and III of Schatzker classification = 1, Complicated fracture including types IV, V, and VI of Schatzker classification = 2

### Fracture Pattern

Schatzker classification is the most commonly used system for tibial plateau fracture classification, which is based on the location and the extent of the fracture and associated depression of the bone. Schatzker classification includes six types<sup>12</sup>: type I, split fracture of the lateral tibial plateau without articular depression; type II, split fracture of the lateral tibial plateau with articular depression; type III, isolated depression of the lateral plateau; type IV, fracture of the medial plateau with associated intercondylar eminence avulsion; type V, split bicondylar fracture; and type VI, split bicondylar fracture with diaphyseal, metaphyseal dissociation. The simple fracture included types I, II, and III, and the complex fracture included types IV, V, and VI.



**Fig. 3** Frequency distribution of age range for 1020 patients (3-year interval).

### Statistical Analysis

Statistical analyses were performed with the use of SPSS 21.0 (IBM, USA). A  $P$ -value of  $<0.05$  was considered significant. Differences in the constituent ratios of different types of tibial plateau fractures according to Schatzker classification with intercondylar eminence fractures were tested using the Rao–Scott  $\chi^2$ -test. The constituent ratios were also assessed among children ( $\leq 14$  years), young adults (between 15 and 44 years), middle-aged adults (between 45 and 64 years), and older individuals (65 years and over). Differences among different age groups of patients with tibial plateau fractures accompanied with intercondylar eminence fractures were tested using the linear-by-linear  $\chi^2$ -test. The Kolmogorov–Smirnov test was used to check whether results were in accordance with the normal distribution. The Wilcoxon rank sum test was used to compare the hospitalization times that were not in accordance with the normal distribution, which was expressed by the  $M(Q_R)$ .

The potential correlations between the combined injury of tibial plateau fracture and intercondylar eminence fracture and various other factors, such as age, sex, residence, occupation, marital status, preoperative complications, injury mechanism, and seasonality were analyzed. Factors with a  $P < 0.2$  in a single-factor analysis were all included in a multiple factor analysis. The logistic regression models were constructed to identify the potential risk factors for tibial plateau fractures combined with intercondylar eminence fractures. The odds ratio (OR) was also calculated.

### Result

#### Demographic Information and Fracture Pattern

Over the 4-year period, 1020 patients were identified with tibial plateau fractures. There were 693 (67.9%) men and 327 (32.1%) women, with an average age of  $45.2 \pm 13.8$  years. A total of 506 (50%) cases were left injuries, 495 (48%) cases were right injuries, and 19 (2%) case were bilateral injuries. Among them, 458 (44.9%) patients had intercondylar eminence fractures; there were 324 men (70.7%) and 134 women (29.3%), with an average age of  $47.0 \pm 13.9$  years. A total of 562 (55.1%) patients were identified without intercondylar eminence fractures, including 369 (65.7%) men and 193 (34.3%) women, with an average age of  $43.8 \pm 13.6$  years.

#### Distribution of Patients by Age Group

The highest proportion age group of tibial plateau fractures included the ages of 45–54 years, with more men than women for both age groups. For males, the highest proportion age group was 35–44 years, and for females, it was 55–64 years ( $\chi^2 = 71.336$ ,  $P < 0.01$ , Fig. 3).

Among patients with tibial plateau fractures combined with intercondylar eminence fractures, the elderly group had the highest proportion (51/90, 56.7%), which was higher than that of the middle-aged group (252/529, 47.6%) and the young adult group (152/391, 38.9%). Children had the lowest proportion (3/10, 30.0%), with a significant difference when



**Fig. 4** A total of 1020 tibial plateau fractures, combined with intercondylar eminence fractures in different age groups.

compared with the other three groups ( $\chi^2 = 13.274$ ,  $P = 0.004$ , Fig. 4).

#### **Distribution of Patients by Treatment Methods**

A total of 121 (11.9%) cases underwent conservative treatment and 899 (88.1%) underwent surgical treatment. A total of 891 (99.1%) patients underwent internal fixation, and 8 (0.9%) patients underwent an external fixation surgical procedure. There were 755 (84.7%) open reduction and internal fixation operations, and 136 (15.3%) closed reduction and internal fixation operations. A total of 678 (76.1%) patients underwent internal plate fixation and 213 (23.9%) patients underwent a screw placement. The mean hospitalization time was 16 days<sup>13</sup>. The hospitalization time of patients with intercondylar eminence fractures (15<sup>11</sup>) was significantly shorter than that of patients without intercondylar eminence fractures (17<sup>13</sup>,  $Z = 5.821$ ,  $P < 0.01$ ).

#### **Distribution of Patients by Marital Status**

A total of 59 single patients sustained tibial plateau fractures; 955 patients were married and 6 were divorced or widowed. A total of 24 single, 431 married, and 3 divorced or widowed individuals suffered from tibial plateau fractures combined with intercondylar eminence fractures, and other patients were identified without intercondylar eminence fractures (35 single, 524 married and 3 divorced or widowed).

#### **Distribution of Patients by Residential Category**

A total of 342 patients who sustained tibial plateau fractures lived in urban areas and 678 in rural areas. Among them, 154 urban patients and 304 rural patients suffered from tibial plateau fractures combined with intercondylar eminence fractures, and other patients were identified without intercondylar eminence fractures (188 urban patients and 374 rural patients).

#### **Distribution of Patients by Occupation**

There were 95 office workers, 396 farmers, 62 manual workers, 21 retirees, 26 students, and 420 with other occupations who sustained tibial plateau fractures. Among them,

40 office workers, 197 farmers, 27 manual workers, 16 retirees, 9 students, and 169 with other occupations suffered from tibial plateau fractures combined with intercondylar eminence fractures, and other patients were identified without intercondylar eminence fractures (55 office workers, 199 farmers, 35 manual workers, 5 retirees, 17 students, and 251 with other occupations).

#### **Distribution of Patients by Season**

A total of 201 patients sustained tibial plateau fractures in spring, 263 in summer, 262 in autumn, and 294 in winter. Among them, 88 patients suffered from tibial plateau fractures combined with intercondylar eminence fractures in spring, 116 in summer, 131 in autumn, and 123 in winter, and other patients were identified without intercondylar eminence fractures (113 patients in spring, 147 in summer, 131 in autumn, and 171 in winter).

#### **Distribution of Patients by Injury Mechanisms**

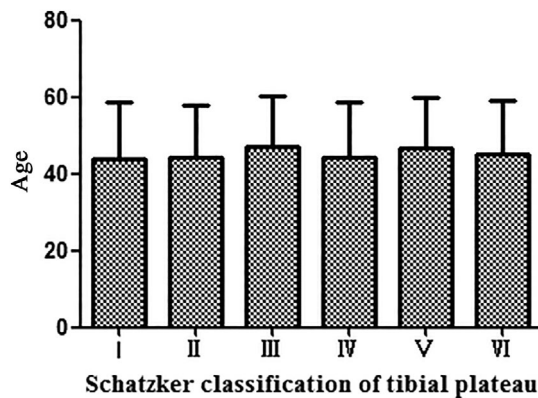
A total of 433 patients sustained tibial plateau fractures as a result of traffic accidents; there were 370 falls from height, 101 slips, trips or falls, and 116 others. Among them, 169 patients suffered from tibial plateau fractures combined with intercondylar eminence fractures as a result of traffic accidents, 189 had fallen from height, 47 had slipped, tripped or fallen, and there were 53 others; other patients were identified without intercondylar eminence fractures (264 traffic accidents, 181 falls from height, 54 slips, trips or falls, and 63 others).

#### **Distribution of Patients by Medical Payment Models**

A total of 78 patients who sustained tibial plateau fractures were covered by province/city medical insurance and 87 by new rural cooperative medical insurance; 589 were self-funded and there were 266 others. Among them, 34 patients who suffered from tibial plateau fractures combined with intercondylar eminence fractures were covered by province/city medical insurance and 46 by new rural cooperative medical insurance; 259 were self-funded and there were 119 others. Other patients were identified without intercondylar eminence fractures (44 with province/city medical insurance, 41 with new rural cooperative medical insurance, 330 self-funded, and 147 others).

#### **Distribution of Patients by Preoperative Complications**

There were 399 patients with tibial plateau fractures who had preoperative complications (31 with diabetes, 77 with hypertension, 62 with cardiovascular and cerebrovascular system disease, 19 with respiratory system disease, 31 with liver and kidney system disease, 173 with venous thrombosis of lower extremity, and 52 others) and 621 patients who had no preoperative complications. Among them, 171 patients suffered from tibial plateau fractures combined with intercondylar eminence fractures and 228 without intercondylar eminence fractures had preoperative complications; other patients had no preoperative complications (287 patients

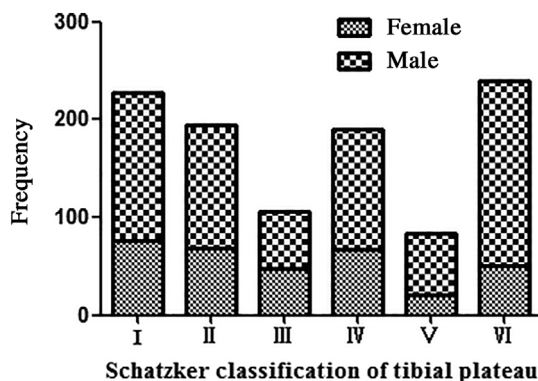


**Fig. 5** Frequency distribution of age in tibial plateau fractures of 1039 different Schatzker classifications.

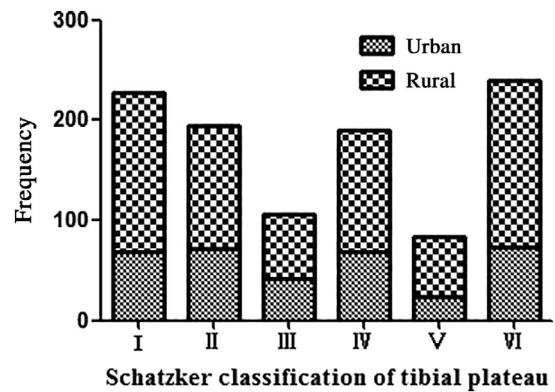
suffered from tibial plateau fractures combined with intercondylar eminence fractures and 334 without intercondylar eminence fractures).

#### Distribution of Patients by Fracture Pattern

According to Schatzker classification, 1039 patients with type V tibial plateau fractures had the highest average age ( $48.2 \pm 13.8$  years), followed by those with types III ( $47.2 \pm 13.1$  years) and VI ( $45.1 \pm 13.2$  years) fractures. However, there was no statistical significance ( $F = 1.727$ ,  $P = 0.126$ , Fig. 5). For each type of tibial plateau fracture, there were more men than women, with statistical significance ( $\chi^2 = 25.101$ ,  $P < 0.01$ ). The male to female ratio in patients with type V (3.0) and VI (3.7) fractures was  $>3$ , while it was  $<2$  in patients with type I (1.9), II (1.8), III (1.2), and IV (1.8) (Fig. 6). There were more patients in rural areas (693) than in urban areas (346), and the rural to urban area ratio for types I, II, III, IV, V, and VI fractures were 2.3, 1.7, 1.6, 1.8, 2.6, and 2.3, respectively. However, there was no statistical significance ( $F = 5.955$ ,  $P = 0.311$ , Fig. 7).



**Fig. 6** Frequency distribution of sex in 1039 tibial plateau fractures of different Schatzker classifications.



**Fig. 7** Frequency distribution of residence in 1039 tibial plateau fractures of different Schatzker classifications.

#### Constituent Rate of the Combined Injuries (Tibial Plateau Fracture Combined with Intercondylar Eminence Fracture) among All Tibial Plateau Fractures

There was a significant difference in the constituent ratios of the combined injuries among different types of tibial plateau fractures, according to Schatzker classification ( $\chi^2 = 280.005$ ,  $P < 0.01$ ). Type IV tibial plateau fractures had the largest proportion of combined intercondylar eminence fractures (70.6%), without a significant difference when compared with those of type V (69.5%) and VI tibial plateau fractures (68.2%). However, the proportion of type IV was significantly higher than those of types I (11.9%), II (39.2%), and III (9.4%) fractures, respectively (Table 2).

#### Multiple Analysis for the Combined Injuries

Table 3 summarizes the characteristics of tibial plateau patients accompanied by or without intercondylar eminence fractures; the proportion ratios of the combined injuries among all tibial plateau fractures were found to be statistically different in different age, occupation, mechanism of injury,

**TABLE 2** The constituent rate of tibial plateau fracture combined with intercondylar eminence fracture, n (%)

Schatzker classification of tibial plateau fracture	n (%)	Combined with tibial intercondylar eminence fracture
Type I	227 (21.8)	27 (11.9)*
Type II	194 (18.7)	76 (39.2)*
Type III	106 (10.2)	10 (9.4)*
Type IV	190 (18.3)	135 (70.6)
Type V	83 (8.0)	57 (69.5)
Type VI	239 (23.0)	163 (68.2)
$\chi^2$ -value	280.187	
P-value	$<0.01$	

\* Compared with type IV  $P < 0.05$ .

**TABLE 3** Characteristics of tibial plateau fracture patients with or without intercondylar eminence fracture, *n*(%)

Indicators	N		No		Yes		$\chi^2$ -value	P-value
Sex								
Male	707	(68.0)	376	(65.8)	331	(70.7)	2.814	0.093
Female	332	(32.0)	195	(34.2)	137	(29.3)		
Age (years)								
0–14	10	(1.0)	7	(1.2)	23	(0.6)	19.254	0.007*
15–24	51	(4.9)	32	(5.6)	19	(4.1)		
25–34	195	(18.8)	121	(21.2)	74	(15.8)		
35–44	248	(23.9)	140	(24.5)	108	(23.1)		
45–54	269	(25.9)	145	(25.4)	124	(26.5)		
55–64	175	(16.8)	87	(15.2)	88	(18.8)		
65–74	77	(7.4)	37	(6.5)	40	(8.5)		
>74	14	(1.4)	2	(0.4)	12	(2.6)		
Marital status								
Single	61	(5.9)	36	(6.3)	25	(5.3)	0.831	0.660
Married	971	(93.5)	532	(93.2)	439	(93.8)		
Divorce or widowed	7	(0.7)	3	(0.5)	4	(0.9)		
Urbanization								
Rural area	692	(66.7)	381	(66.7)	311	(66.5)	0.018	0.895
Urban area	346	(33.3)	189	(33.1)	157	(33.5)		
Occupation								
Office worker	95	(9.1)	55	(9.6)	40	(8.5)	13.668	0.018*
Farmer	399	(38.4)	201	(35.2)	198	(42.3)		
Manual worker	63	(6.1)	35	(6.1)	28	(6.0)		
Retired	21	(2.0)	5	(0.9)	16	(3.4)		
Students	27	(2.6)	17	(3.0)	10	(2.1)		
Others	434	(41.8)	258	(45.2)	176	(37.6)		
Season								
Spring	208	(20.0)	115	(20.1)	93	(19.9)	4.049	0.256
Summer	268	(25.8)	152	(26.6)	116	(24.8)		
Autumn	263	(25.3)	131	(22.9)	132	(28.2)		
Winter	300	(28.9)	173	(30.3)	127	(7.1)		
Mechanism of injury								
traffic accident	443	(42.6)	269	(47.1)	174	(37.2)	17.741	0.001*
Falls from heights	62	(6.0)	27	(4.7)	35	(7.5)		
slips, trips or falls	103	(9.9)	54	(9.5)	49	(10.5)		
crushing injury	377	(36.3)	185	(32.4)	192	(41.0)		
Others	54	(5.2)	36	(6.3)	18	(3.8)		
Medical payment method								
Province/city medical insurance	81	(8.4)	44	(7.7)	37	(7.9)	2.443	0.486
New rural cooperative medical insurance	87	(9.1)	41	(7.2)	46	(9.8)		
Self-funded	602	(58.2)	337	(59.0)	265	(56.6)		
Others	269	(24.4)	149	(26.1)	120	(25.6)		
Preoperative complications								
Yes	562	(55.1)	334	(57.1)	228	(53.8)	1.098	0.293
No	458	(44.9)	287	(42.9)	171	(46.2)		
Fracture types								
Simple fracture	527	(50.7)	414	(72.5)	113	(24.1)	240.643	<0.01*
Complicated fracture	512	(49.3)	157	(27.5)	355	(75.9)		

\*  $P < 0.05$ .

and fracture type groups ( $\chi^2 = 19.254$ ,  $P = 0.007$ ;  $\chi^2 = 13.668$ ,  $P = 0.018$ ;  $\chi^2 = 17.741$ ,  $P = 0.001$ ;  $\chi^2 = 240.643$ ,  $P < 0.01$ ).

Table 4 summarizes the risk factors for tibial plateau fractures combined with intercondylar eminence fractures. Compared with persons aged >74 years, those aged 0–14 years (odds ratio [OR] 0.046, 95% CI: 0.004–0.517), 15–24 years (OR 0.110, 95% CI: 0.019–0.629), 25–34 years (OR 0.103, 95% CI: 0.019–0.562), 35–44 years (OR 0.132, 95% CI: 0.024–0.717), 45–54 years (OR 0.132, 95% CI: 0.025–0.714),

55–64 years (OR 0.217, 95% CI: 0.040–1.183), and 65–74 years (OR 0.124, 95% CI: 0.022–0.702) were less likely to simultaneously sustain intercondylar eminence fractures. Compared with office workers, retirees were more likely to have combined intercondylar eminence fractures (OR 4.332, 95% CI: 1.147–16.362). Compared with complicated fractures, simple fractures were less likely to be accompanied by intercondylar eminence fractures (OR 0.108, 95% CI: 0.080–0.145).

**TABLE 4 Risk factors for tibial plateau fracture associated with intercondylar eminence fracture**

Indicators	B	S.E.	Wald	P-value	OR value	95% CI	
Age(years)			16.348	0.022			
0-14	-3.069	1.229	6.233	0.013*	0.046	0.004	- 0.517
15-24	-2.210	0.891	6.153	0.013*	0.110	0.019	- 0.629
25-34	-2.275	0.867	6.891	0.009*	0.103	0.019	- 0.562
35-44	-2.022	0.862	5.503	0.019*	0.132	0.024	- 0.717
45-54	-2.023	0.860	5.531	0.019*	0.132	0.025	- 0.714
55-64	-1.526	0.864	3.118	0.077*	0.217	0.040	- 1.183
65-74	-2.087	0.885	5.565	0.018*	0.124	0.022	- 0.702
Occupation			10.419	0.064			
Farmer	0.460	0.271	2.885	0.089	1.585	0.932	- 2.695
Manual worker	0.509	0.387	1.723	0.189	1.663	0.778	- 3.553
Retired	1.466	0.678	4.675	0.031*	4.332	1.147	- 16.362
Students	0.488	0.709	0.475	0.491	1.630	0.406	- 6.537
Other occupations	0.095	0.270	0.125	0.723	1.100	0.649	- 1.866
Fracture pattern	-2.227	0.152	213.627	<0.01*	0.108	0.080	- 0.145

\* P < 0.05.

## Discussion

The present study reports, for the first time, the epidemiological features and the risk factors of the combined injuries of tibial plateau fractures accompanied with intercondylar eminence fractures. It is a priority to recognize and appropriately manage these injuries, due to the possible detrimental functional outcomes, if left untreated in a displaced position<sup>15</sup>. Chan *et al.* found that type IV was likely to be accompanied by an intercondylar eminence fracture<sup>12</sup>. Our data revealed that type V and VI tibial plateau fractures tended to be accompanied by intercondylar eminence fractures, in addition to type IV fractures. The multiple analysis showed that Schatzker types IV, V, and VI were the independent risk factors for tibial plateau fractures likely to be accompanied by intercondylar eminence fractures. Therefore, intercondylar eminence fractures seem to be neglected as an involved type V and VI tibial plateau fracture in the current literature. Krause *et al.*<sup>5</sup> put forward “ten segment classification,” which classified the intercondylar eminence as the central area, and divided the eminence into the anterior and posterior subareas. Approximately 90% of all OTA/AO-type C fractures of the tibial plateau involve the intercondylar eminence. The incidence of intercondylar eminence fractures is commonly seen in tibial plateau fractures, which should be paid increasing attention by orthopaedic doctors. Orthopaedic surgeons should be aware of the high possibility of intercondylar eminence fracture involvement in complex tibial plateau fractures of Schatzker type IV, V, and VI fractures<sup>16</sup>.

In this study, male patients dominated those with tibial plateau fractures, especially in complex fractures (types V and VI); according to the studies of Albuquerque *et al.*<sup>17</sup>, Yuwen *et al.*<sup>18</sup>, and Biz C *et al.*<sup>19</sup>, male patients account for 70%, 69%, and 64% of all patients, respectively. However, this was contradictory to Elsoe's cohort study, which found

that females account for 53% of the reenrolled patients<sup>20</sup>. Another important finding of our investigation was that the highest proportional age group of tibial plateau fractures was 45–54 years: 35–44 years for males and 55–64 years for females, which is similar to the findings of Zheng *et al.* (2019)<sup>21</sup>. For young adult males, this is associated with an increasing risk of high-energy trauma, such as traffic accidents, falls from height, and serious crashes<sup>13,22–25</sup>, which, in turn, lead to serious tibial plateau fractures with a high risk of being accompanied by intercondylar eminence fractures. The phenomenon of peak age delay for females may be due to the high prevalence of osteoporosis among women, especially following menopause<sup>26–28</sup>. Osteoporosis causes bones to become brittle, which can often be accompanied by comminuted fractures, when compared with young adults with the same trauma. Comminuted tibial plateau fractures increase the risk of intercondylar eminence.

This study identified the risk factors for tibial plateau fractures combined with intercondylar eminence fractures, which included patients who were aged over 74 years and retired. The findings are consistent with other investigations<sup>29,30</sup>. Lee *et al.*<sup>31</sup> found that age over 65 years was a significant factor related to osteoporosis and osteoporotic fractures, which are more likely to become comminuted and involved with the intercondylar eminence.

There are some limitations in this retrospective study. This is a study in which inevitable recall bias may exist; CT and MRI scans were not available for all patients. The fracture assessment and classification were mainly based on the radiographs of knee joints; body mass density was not evaluated in most patients. Therefore, the role of osteoporosis in combined injuries was not assessed. Lotter Meyer's classification is commonly used to identify the avulsion fracture from the intercondylar eminence. No special classification has been proposed to assess the intercondylar eminence



fractures involved with tibial plateau fractures. In future research, we will analyze the imaging data of all patients who sustained this combined injury to develop a new system to identify the intercondylar eminence fractures that were involved with tibial plateau fractures.

### Acknowledgments

We thank the patients who took part in this study and the information provided by all of the authors.

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