

Changes in patellar fracture characteristics: A multicenter retrospective analysis of 1596 patellar fracture cases between 2003 and 2017

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ABSTRACT

Purpose: This study aimed to investigate the characteristics of patellar fracture and the changes in these characteristics over time in Korea.

Methods: A total of 1596 patients with patellar fractures who visited 5 university hospitals from 2003 to 2017 were included in the analysis. The demographic characteristics of the patients, including age, sex, body mass index, and fracture characteristics, including the fracture classification, injury mechanism, fixation method, and postoperative complication rate, were analyzed through a review of the medical records and plain radiographs.

Results: There were 988 (61.9%) male patients and 608 (38.1%) female patients. The mean age was 51.3 (range, 3–97) years for the study group, 47.6 (range, 8–94) years for male patients, and 57.3 (range, 3–97) years for female patients. Increasing trends in the proportion of patients aged ≥ 60 years and in the proportion of female patients were observed during the study period ($p = 0.002$ and $p < 0.001$, respectively). The fixation method also changed significantly during the study period, with decrease of the tension band wiring and increase of the combined method ($p < 0.001$). The incidence of high-energy injuries and more complex types of fracture was higher in male patients than in female patients ($p < 0.001$ and $p < 0.001$, respectively). Patients aged ≥ 60 years with patellar fractures showed a higher percentage of low-energy injuries and higher postoperative complication rates than younger patients ($p < 0.001$ and $p = 0.002$, respectively).

Conclusions: Patellar fractures in the female and elderly populations are increasing. Moreover, elderly patients with patellar fractures had a higher postoperative complication rate and also a higher percentage of low-energy injury than younger patients. Therefore, patellar fractures in the elderly population should be considered fragility fractures, and further studies are warranted to suggest a specific treatment plan for fragility patellar fractures.

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Introduction

The patella is the largest sesamoid bone in the human body and plays an important role in the extensor mechanism. The posterior aspect of the patella constitutes a patellofemoral joint with the trochlea of the distal femur, and three-quarters of the posterior as-

pect of the patella is covered by articular cartilage. Therefore, most patellar fractures are intra-articular fractures that require anatomic reduction to restore joint congruency and rigid fixation to facilitate early mobilization.

Previous studies have reported an increasing incidence of patellar fractures in females and in the elderly population and suggested that patellar fractures in elderly female patients should be considered fragility fractures [1,2]. Fragility fractures require a specific treatment strategy, as mechanical complications occur more frequently in these types of fractures owing to poor bone quality [3,4]. In Korea, fractures in elderly patients, including fragility hip

Abbreviations: AO/OTA, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association.

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fractures, are increasing with the aging of society [5,6], and patellar fractures are also expected to show a similar increasing trend.

However, previous studies on patellar fracture in Korean patients showed that >80% were male patients, with the highest incidence in those aged 20–50 years and that >60% of patellar fractures resulted from high-energy trauma [7–10]. These previous reports cannot reflect the current characteristics of patellar fracture in Korea, as these studies were small case series conducted between the 1970s and early 1990s.

Therefore, the purpose of the current study was to investigate the characteristics of patellar fracture and to identify the changes in these characteristics over time in Korea.

Materials and methods

A total of 1604 patients with patellar fractures who visited 5 university hospitals from January 2003 to June 2017 were included in the analysis. Patients with incomplete medical records (8 patients) were excluded. Therefore, 1596 patellar fractures were included in the final analysis.

The change in age distribution over time and patient characteristics according to age group were analyzed. For these analyses, patients were divided into 3 groups according to age as follows: <30, 30–59, and ≥60 years. To assess changes over time in the patient age, proportion of female patients, and fixation method, the study period was divided into 5 subperiods each comprising 3 years: 2003–2005, 2006–2008, 2009–2011, 2012–2014, and 2015–2017.

Age, sex, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification, injury mechanism, associated injury, number of open fractures, number of operated cases, postoperative complications, and fixation method were analyzed through a review of medical records and plain radiographs.

The injury mechanism was defined as ground-level fall, fall from a height (>1.5 m), motor vehicle accident, direct blow or

sport injury, and others. To facilitate comparison between sex and age groups, the injury was also defined as either a low-energy or high-energy injury. The differences in patient characteristics according to age group were analyzed.

The fixation method was classified as tension-band wiring, cerclage wiring, pins or screws, fixation through multiple combined methods, or others (patellectomy, separate vertical wiring, or plating).

Statistical analysis

Student's *t*-test was used to compare continuous variables, including age and body mass index, between the sexes.

For categorical variables, a comparative analysis was performed using the χ^2 test or Fisher's exact test when ≥1 of the cells had an expected frequency of ≤5. The AO/OTA classification, injury mechanism, fixation method, number of open fractures, associated injury, and operative treatment were compared between the genders. The AO/OTA classification, injury mechanism, and postoperative complications were compared between the 3 age groups (<30, 30–59, and ≥60 years). The patient age, proportion of female patients, and fixation method were compared among the 5 subperiods (2003–2005, 2006–2008, 2009–2011, 2012–2014, and 2015–2017).

Values of *p* < 0.05 were considered statistically significant. SPSS version 24.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses.

Results

Of 1596 patients with patellar fractures, there were 988 (61.9%) male patients and 608 (38.1%) female patients. The mean age of the patients was 51.3 (range, 3–97) years, whereas the mean age was 47.6 (range, 8–94) years for male patients and 57.3 (3–97) years for female patients (*p* < 0.001). The patient demographics are shown in Table 1.

Table 1
Characteristics of patients with patellar fractures between 2003 and 2017.

	Total N = 1596	Male n = 988	Female n = 608	<i>p</i> -Value
Age (years)	51.3 ± 18.0	47.6 ± 17.6	57.4 ± 17.0	<0.001
BMI (kg/m ²)	23.4 ± 3.2	23.4 ± 3.1	23.3 ± 3.5	0.533
AO/OTA classification				<0.001
A	270 (16.9%)	164 (16.6%)	106 (17.4%)	
A1	247 (15.5%)	149 (15.1%)	98 (16.1%)	
A2	23 (1.4%)	15 (1.5%)	8 (1.3%)	
B	303 (19.0%)	205 (20.8%)	98 (16.1%)	
B1	201 (12.6%)	131 (13.3%)	70 (11.5%)	
B2	102 (6.4%)	74 (7.5%)	28 (4.6%)	
C	1021 (64.0%)	618 (62.6%)	403 (66.3%)	
C1	427 (26.8%)	225 (22.8%)	202 (32.2%)	
C2	176 (11.0%)	102 (10.3%)	74 (12.2%)	
C3	418 (26.1%)	291 (29.5%)	127 (21.0%)	
Unclassified	2 (0.1%)	1 (0.1%)	1 (0.2%)	
Injury mechanism				<0.001
High-energy injury	698 (43.7%)	575 (58.2%)	123 (20.2%)	
Low-energy injury	898 (56.3%)	413 (41.8%)	485 (79.8%)	
Specific injury mechanism				<0.001
Ground-level fall	707 (44.1%)	292 (29.4%)	415 (67.9%)	
Fall from a height	172 (10.8%)	139 (14.0%)	33 (5.4%)	
Motor vehicle accident	526 (32.9%)	436 (44.0%)	90 (14.7%)	
Direct blow/sports	135 (8.6%)	86 (8.9%)	49 (8.0%)	
Others	56 (3.8%)	35 (3.6%)	21 (3.9%)	
Open fracture	193 (12.1%)	152 (15.4%)	41 (6.7%)	<0.001
Associated injury	577 (36.2%)	444 (44.9%)	133 (21.9%)	<0.001
Surgery	1095 (68.6%)	701 (71.0%)	394 (64.8%)	0.010
Postoperative complications	74 (6.8%)	51 (7.3%)	23 (5.8%)	0.363

BMI, body mass index; AO/OTA, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association.

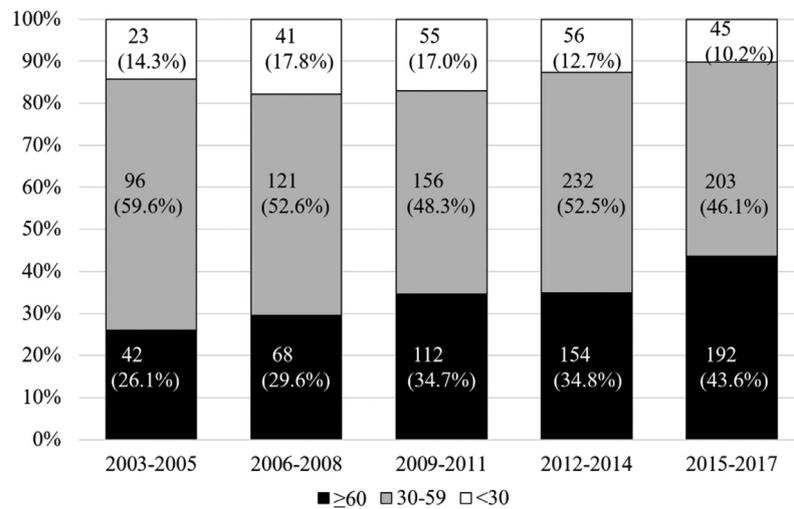


Fig. 1. Age distribution of patients with patellar fractures during the study period. Black color indicates the proportion of patients aged ≥ 60 years. Gray color indicates the proportion of patients aged 30–59 years. White color indicates the proportion of patients aged < 30 years. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

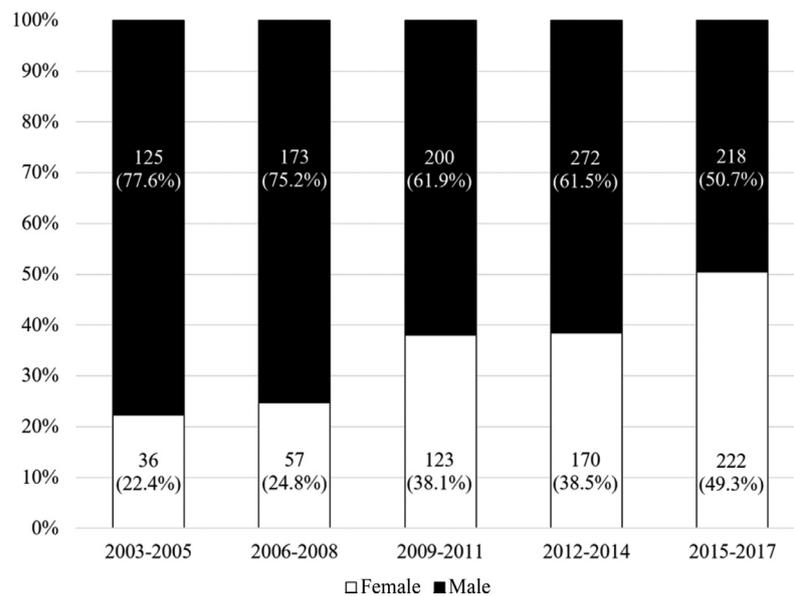


Fig. 2. Gender distribution of patients with patellar fractures during the study period. Black color indicates the proportion of male patients. White color indicates the proportion of female patients. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The proportion of patients aged ≥ 60 years showed an increasing tendency from 26.1% in 2003–2005 to 43.6% in 2015–2017, and the difference was statistically significant ($p = 0.002$, Fig. 1). An increase in the proportion of patients aged ≥ 60 years was found only in the male group, increasing from 16% in 2003–2005 to 33% in 2015–2017. In the female group, the proportion of patients aged ≥ 60 years was consistently high at $> 45\%$.

An increasing tendency was also observed in the number and percentage of female patients with patellar fractures over time. The percentage of female patients with patellar fractures increased from 22.4% in 2003–2005 to 50.5% in 2015–2017 ($p < 0.001$, Fig. 2).

According to the AO/OTA classification, type C1 was the most common type, with 427 (26.8%) cases, followed by type C3, with 418 (26.2%) cases (Table 1). In male patients, type C3 was the most common, with 291 (29.5%) cases, whereas in female patients, type C1 was the most common type, with 202 (33.2%) cases. The difference in the AO/OTA classification between the sexes was statistically significant ($p < 0.001$).

The number of patellar fractures that resulted from low- and high-energy injuries was 898 (56.3%) and 698 (43.7%), respectively. High-energy injuries occurred in 58.2% (575 cases) of male patients and 20.2% (123 cases) of female patients ($p < 0.001$, Table 1). The percentage of low-energy injuries increased with age, from 37.7% in patients aged < 30 years to 70.2% in patients aged ≥ 60 years. A statistically significant difference in the ratio of high-/low-energy injuries according to age group was found overall and in male and female patients ($p < 0.001$, $p < 0.001$, and $p = 0.025$, respectively; Table 2). The proportions of A, B, and C types of AO/OTA classification did not significantly change during the study period.

With respect to the specific injury mechanism, ground-level falls were the most common in 707 (44.3%) cases, followed by motor vehicle accidents in 526 (33.0%) cases (Table 1). In male patients, motor vehicle accidents were the most common injury mechanism in 436 (44.1%) cases. In female patients, ground-level falls were the most common injury mechanism in 415 (68.3%) cases. The composition of the injury mechanism was statistically significantly different between the sexes ($p < 0.001$).

Table 2
Injury mechanism, open fracture, surgery, and postoperative complications of patellar fracture according to age group.

	Total N = 1596	Age <30 years n = 220	Age 30–59 years n = 808	Age ≥60 years n = 568	p-value
Injury mechanism					
Low-energy injury					
Overall	898	83	416	399	<0.001
Male	413	52	218	143	<0.001
Female	485	31	198	256	0.025
High-energy injury					
Overall	698	137	392	169	<0.001
Male	575	124	331	120	<0.001
Female	123	13	61	49	0.025
Open fracture					
Overall	193	53	117	23	<0.001
Male	152	47	93	12	<0.001
Female	41	6	24	11	0.004
Surgery					
Overall	1095	148	573	374	0.123
Male	701	120	405	176	0.013
Female	394	28	168	198	0.999
Postoperative complications					
Overall	74	6	28	40	0.001
Male	51	6	22	23	0.003
Female	23	0	6	17	0.049

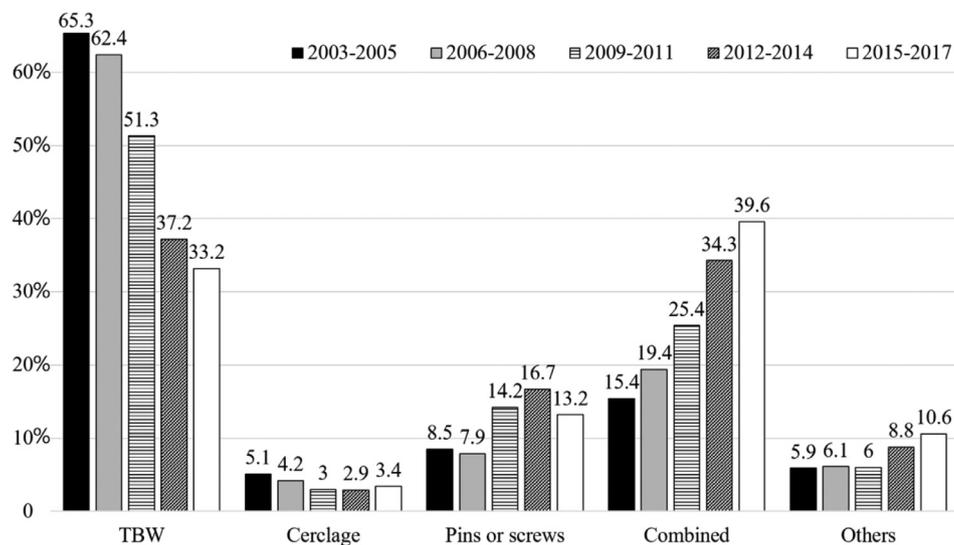


Fig. 3. Changes in the fixation method for patellar fractures. TBW, tension-band wiring.

The proportion of open fractures was about 20% in 2003–2005, 2006–2008 and it decreased to about 9% in 2009–2011, 2012–2014, and 2015–2017. Female patients had significantly fewer open fractures than male patients ($p < 0.001$, Table 1). Patients aged ≥ 60 years had significantly fewer open fractures than younger patients ($p < 0.001$, Table 2).

Among 1596 patients, operative treatment was performed in 1095 (68.6%) patients, including 701 male patients and 394 female patients. Among these patients, complications were found in 74 (6.8%) patients, including 51 (7.3%) in male patients and 23 (5.8%) in female patients (Table 1). Nonunion, including fixation failure, was the most common complication, accounting for 35.1% of all complications. The complication rate was the highest in patients aged ≥ 60 years, and the difference among age groups was statistically significant ($p = 0.001$, Table 2).

The fixation method used was significantly different among periods. The percentage of tension-band wiring procedures performed decreased from 65.5% in 2003–2005 to 35.3% in 2015–2017 ($p < 0.001$, Fig. 3). The combined method was used with increasing frequency in 14.9% of cases in 2003–2005 to 40.3% of cases in 2015–2017 ($p < 0.001$, Fig. 3).

Discussion

The current study found an increasing trend in patellar fractures in female and elderly patients between 2003 and 2017. Furthermore, patellar fractures in female and elderly patients were more likely to have resulted from low-energy injuries than those in male and younger patients. Elderly patients with patellar fractures had a higher postoperative complication rate than younger patients. With respect to the change in fixation method, tension-band wiring was less frequently used and a combined fixation method was more frequently used between 2003 and 2017.

The percentage of female patients with patellar fractures consistently increased from 22.4% to 50.5% during the study period. Previous reports have also noted a large increase in the proportion of female patients with patellar fractures [1,2,11]. Bengner et al. [1] reported that female patients with patellar fractures increased by 141% between 1950 and 1955 and 1980–1983, whereas only an 8% increase was found for male patients with patellar fractures. Court-Brown et al. [11] also reported a 40% increase in the overall incidence of patellar fractures and a 128% increase in the incidence of patellar fractures in female patients after comparing the

incidence in 1954–1958 and 2010–2011 in Scotland. Larsen et al. [2] reported a higher incidence of patellar fractures in women than in men.

The percentage of patellar fractures in the elderly population increased from 26.1% to 43.6% during the study period. The main reason for this finding was assumed to be the increase in the elderly population caused by fast aging in Korea [12]. Other fragility fractures, such as osteoporotic hip fractures, have also been increasing in Korea [5,6].

Notably, among female patients with patellar fractures, more than half were elderly patients, and this proportion was consistently high during the study period at >45%. In male patients with patellar fractures, the proportion of elderly patients was 26.6%; however, this proportion increased from 16% to 33% between 2003–2005 and 2015–2017.

Previous studies have also reported an increased incidence of patellar fractures in the elderly population. Bengnér et al. [1] showed that the proportion of patients aged ≥ 65 years increased from 21.6% in 1950–1955 to 43.2% in 1980–1983. Larsen et al. [2] showed that the incidence of patellar fractures increased with increasing age. In interpreting these results, Bengnér et al. [1] and Larsen et al. [2] suggested that patellar fractures in elderly patients, especially in female patients, should be considered fragility fractures. The finding of this study that patellar fractures in elderly and female patients were more likely to have resulted from low-energy trauma, such as a ground-level fall, supports their hypothesis.

In the current study, the proportion of male patients was higher than that of female patients. In contrast, in previous studies on patellar fracture conducted since 2000, the proportion of female patients with patellar fractures was higher than that of male patients [2,11]. This discrepancy may be attributed to the fact that the patients included in the current study were more likely to have sustained high-energy injuries, as this study analyzed patients who visited university hospitals.

According to the AO/OTA classification, C1 and C3 types were the most common type of fractures, accounting for nearly the same proportions of fracture types of approximately 26.8% and 26.2%, respectively. Larsen et al. [2] also reported a similar result, with 23.2% for C1 type fractures and 25% for C3 type fractures. Analysis of the AO classification according to sex showed that C3 was the most common type in male patients, and C1 was the most common type in female patients. The larger percentage of high-energy injuries in male patients may be a reason for the complex type of fractures in these patients.

In the current study, 68.6% of the patellar fractures were treated using an operative method. This high rate of operative treatment may be because the current study was conducted at university hospitals; therefore, patients with relatively severe injuries were included.

Elderly patients with patellar fractures showed a higher postoperative complication rate than younger patients. The higher prevalence of osteoporosis and the relatively higher number of comorbidities in elderly patients than in younger patients may have caused these results. Notably, the most common postoperative complication was nonunion, including fixation failure, which is a common complication in other fragility fractures [3,4].

Regarding fixation method, the percentage of tension-band wiring procedures performed decreased and that of fixation procedures performed with multiple combined methods and other methods, including plating, increased during the study period. We attributed these trends to the need for more stable fixation owing to the increase in the incidence of fragility fractures.

This study has some notable limitations. First, although a relatively large sample size was included, the patients analyzed in this

study were enrolled in only 5 institutions in Korea. Therefore, the incidence of patellar fracture in Korea or in a specific region in Korea cannot be identified based on the current study. Second, because this study was conducted at 5 university hospitals and had a retrospective design, there may have been selection bias. Third, because of the retrospective analysis of patellar fractures, the follow-up period varied for different patients. Therefore, the frequency of postoperative complications may have been underestimated.

Despite these limitations, this study has clinical relevance in terms of demonstrating the increasing trend in the number of patellar fractures in female patients and in the elderly population and in showing that the complication rate was higher in elderly patients than in younger patients with patellar fractures.

Conclusion

Patellar fractures in the female and elderly populations are increasing. Moreover, elderly patients with patellar fractures had a higher postoperative complication rate and percentage of low-energy injury than younger patients. Therefore, patellar fractures in the elderly population should be considered fragility fractures, and further studies are warranted to suggest a specific treatment plan for fragility patellar fractures.

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Declaration of Competing Interest

Author Seong-Eun Byun, Author Jae-Ang Sim, Author Yong Bum Joo, Author Ji Wan Kim, Author Wonchul Choi, Author Young Gon Na, and Author Oo-jin Shon declare that they have no conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.injury.2019.10.016](https://doi.org/10.1016/j.injury.2019.10.016).

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