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Patellar fractures in elderly patients: a multicenter computed tomography-based analysis

Jae-Ang Sim[1] · Yong Bum Joo[2] · Wonchul Choi[3] · Seong-Eun Byun[3] · Young Gon Na[6] · Oog-Jin Shon[4] · Ji Wan Kim[5]

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Abstract

Introduction This study aimed to demonstrate the characteristics of patellar fractures and evaluate clinical outcomes in elderly patients.

Patients and methods Medical records of patients aged ≥ 60 years who presented with patellar fractures were retrospectively reviewed from an institutionally approved multicenter (five institutions) orthopedic database. Patient characteristics and fracture patterns were identified, and the clinical outcomes were investigated. We compared differences according to the injury mechanism (low- vs. high-energy).

Results A total of 202 patients [mean age, 69.4 years (range, 60–88 years); male, 89, female, 113] were included in this study. The mean follow-up period was 14.8 months (range 6–58 months), and 75% of the fractures were from low-energy injuries. According to the AO /OTA classification, the most common type was type C (136 cases, 67.3%; 33 cases, C1; 23, C2; and 80, C3), followed by type A (39 cases), type B (26 cases), and unclassified (1 case). The unclassified case was an intra-articular marginal impaction without cortical breakage. Computed tomography (CT) revealed that of the cases, 66.8% had an inferior pole involvement; 80.7%, a comminuted fragment; and 10.4%, an impacted fracture. A total of 166 fractures (82.2%) were treated surgically. The mean union time and range of motion were 13.1 weeks and 123.8° (range 30–150°), respectively. The Lysholm score was 82.1 ± 12.0, with 65.7% of the cases having excellent or good function. The complication rate was 12.4% (24 cases), including ten, four, two, and five cases of infection, fixation failure, nonunion, malunion, and pin migration, respectively. The reoperation rate was 26.4%.

Conclusion Patellar fractures in the elderly were mostly from low-energy injuries, and types C3 and A1 were the most common. CT images demonstrated high rates of an inferior pole involvement and comminution. The complication and reoperation rates were relatively high.

Keywords Patella · Fracture · Fragility fracture · CT · Outcome

✉ Ji Wan Kim
bakpaker@hanmail.net

1 Department of Orthopaedic Surgery, Gil Medical Center, Gachon University College of Medicine, Incheon, Republic of Korea

2 Department of Orthopaedic Surgery, Chungnam National University Hospital, Chungnam National University School of Medicine, Daejeon, Republic of Korea

3 Department of Orthopaedic Surgery, CHA Bundang Medical Center, CHA University, Seongnam, Republic of Korea

4 Department of Orthopaedic Surgery, Yeungnam University Medical Center, Daegu, Republic of Korea

5 Department of Orthopaedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, 88, Olympic-ro 43 gil, Songpa-gu, Seoul 05505, Republic of Korea

6 Department of Orthopaedic Surgery, CM Hospital, Seoul, Republic of Korea

Introduction

Patellar fractures account for approximately 1% of all skeletal fractures and can disrupt extensor function and damage the articular surface of the patellofemoral joint [1]. Falling on the knee is a more common cause in the elderly or patients with osteoporosis, whereas a direct blow on the dashboard during a motor vehicle collision occurs more frequently in the younger population [2]. The incidence of patellar fracture in the female and elderly populations has been increasing; however, the incidence is twice as high in males [2]. Patellar fractures in elderly female patients might be fragility fractures and require careful treatment, as mechanical complications have been more frequent owing to poor bone quality. However, there is a paucity of literature on patellar fractures in the elderly. Therefore, we aimed to conduct a retrospective study to demonstrate the characteristics of patellar fractures in the elderly based on computed tomography (CT) findings.

Materials and methods

This study was a multicenter (five university hospitals) retrospective study approved by our institutional review board. We searched our database from March 2003 to September 2017 for patients with patellar fractures. The inclusion criteria were as follows: (1) age ≥ 60 years, (2) patients with patellar fractures, and (3) patients with CT data. The exclusion criteria were as follows: (1) periprosthetic fractures, *(2) knee deformity, (3) incomplete medical records, and (4) follow-up for < 6 months. A total of 2865 patients were screened, and 202 patients were included in the final analysis (Fig. 1).

Age, sex, body mass index (BMI), comorbidity, injury mechanism, associated injury, open fractures, and treatment methods (surgical vs. conservative) were reviewed. Comorbidity was assessed using the Charlson comorbidity index (CCI) [3] and American Society of Anesthesiologists (ASA) physical status classification [4]. Radiographic findings and CT images were evaluated by an experienced orthopedic surgeon. The radiological parameters included the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification, inferior pole involvement, displacement, comminution, and impaction. The clinical outcomes included postoperative displacement of the fracture, union time; functional outcomes, including the range of motion (ROM) and Lysholm score at postoperative 1 year; and complications, including delayed union, malunion, infection, and secondary intervention.

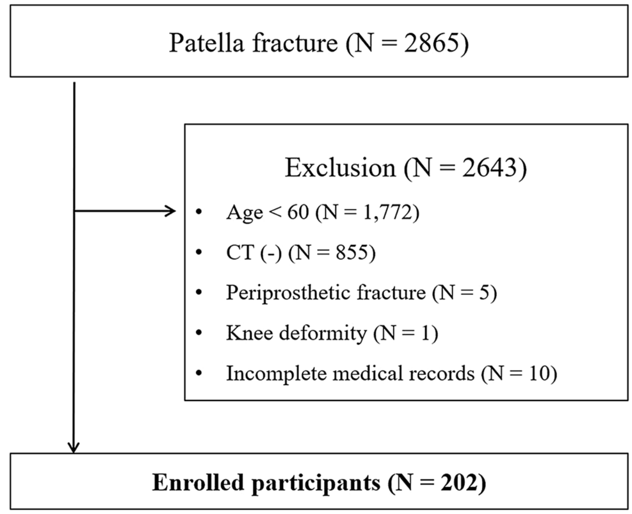


Fig. 1 Flowchart of the enrolled participants

The primary measure was to analyze the fracture pattern based on the CT image and evaluate clinical outcomes of the patellar fractures in the elderly. The secondary outcome was to compare differences according to the injury mechanism (low- vs. high-energy). The injury mechanism was defined as ground-level fall, fall from a height, motor vehicle accident, direct blow or sports injury, and others. Low-energy injury is defined as low-energy falls from heights of ≥ 1 m [5].

Statistical analyses

The Student t test was used to compare continuous variables between the two injury mechanisms. For categorical variables, a comparative analysis was performed using the Chi square test or Fisher exact test when ≥ 1 of the cells had an expected frequency of ≤ 5. Values of $p < 0.05$ were considered statistically significant. SPSS version 21.0 (IBM Corp., Armonk, NY, USA) was used for the statistical analyses.

Results

The mean age of the patients was 69.4 years (range 60–88 years). Of the patients, 89 were male and 113 were female (55.9%). The mean BMI was 23.7 kg/m^2 (range 16.9–33.7 kg/m^2), and the mean follow-up period was 14.8 months (range 6–58 months). Of the fractures, 75% and 25% were from low- and high-energy injuries, respectively. Fifteen patients (7.4%) had open fractures, and 44 patients (21.8%) had associated fractures. The mean CCI was 4.3 (range 3–11), and the ASA physical status score was 2.2.

According to the AO/OTA classification, the most common type was type C (136 cases, 67.3%), followed by type A

Table 1 Fracture classification

AO/OTA classification	Total $n=202$ (%)	Low-energy $n=152$ (%)	High-energy $n=50$ (%)	p value
A	39 (19.3)	29 (19.1)	10 (20.0)	0.524
A1	37 (18.3)	29 (19.1)	8 (16.0)	
A2	2 (1.0)	0 (0)	2 (4.0)	
B	26 (12.9)	17 (11.2)	9 (18.0)	0.458
B1	24 (11.9)	17 (11.2)	7 (14.0)	
B2	2 (1.0)	0 (0)	2 (4.0)	
C	136 (67.3)	105 (69.1)	31 (62.0)	**< 0.001**
C1	33 (16.3)	32 (21.1)	1 (2.0)	
C2	23 (11.4)	20 (13.2)	3 (6.0)	
C3	80 (39.6)	53 (34.9)	27 (54.0)	
Unclassified	1 (0.5)	1 (0.7)	0 (0)	

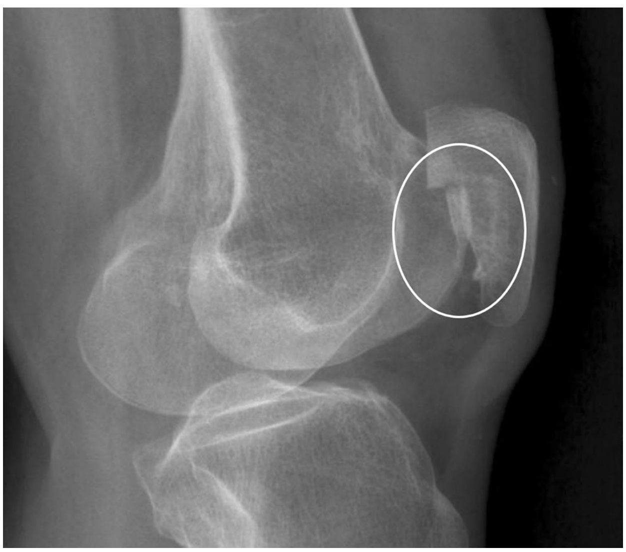


Fig. 2 Unclassified type of patellar fracture with intra-articular impaction (white circle) without cortical disruption

(39 cases), type B (26 cases), and unclassified case (1 case; Table 1). The unclassified case was an intra-articular marginal impaction without cortical breakage (Fig. 2). The CT analysis revealed that of the cases, 135 (66.8%) had an inferior pole involvement (Fig. 3); 163 (80.7%), a comminuted fragment; and 21 (10.4%), an impacted fracture (Fig. 4).

The low-energy injury group had older patients, a higher female ratio, a higher CCI, and a lower rate of open fracture than the high-energy injury group (Table 2). Type C3 was the most common in the low-energy injury group, while the prevalence of type C1 was significantly higher in the low-energy injury group than in the high-energy injury group ($p<0.001$; Table 1). The fracture morphology in terms of inferior pole involvement, comminution, or impaction was not different between the two groups.

One hundred sixty-six fractures (82.2%) were treated surgically as follows: tension band wiring (TBW), 80 cases; TBW with cerclage wiring, 42; TBW with a screw, 16; vertical wiring, three; screw fixation, 18; and plating, seven. The mean union time was 13.1 weeks. Functional outcomes were evaluated in 172 patients. The mean extension lag was 5.1° (range 0–35°) with a mean flexion angle of 128.1° (range 30–150°), and the mean ROM was 123.8° (range 30–150°). The mean Lysholm score was 82.1 ± 12.0 (range 32–100), indicating excellent function in 37 patients (21.5%), good function in 76 (44.2%), average function in 51 (25.2%), and poor function in 4 (4.7%). The complication rate was 11.9% (24 cases), with ten cases of infection, four cases of fixation failure, three cases of nonunion, two cases of malunion, and five cases of pin migration (Fig. 5). Fifty-two patients (25.7%) underwent a secondary surgery because of the following causes: infection in nine, wire or pin breakage in four, reduction loss in two, nonunion in one, pin migration in three, and implant removal in 33.

Discussion

The present study found that 75% of the patellar fractures in the elderly were from low-energy injuries, most of which occurred in women. The female ratio was significantly higher in the low-energy group than in the high-energy group. Danish national registry indicated that the incidence of patellar fractures among patients aged ≥ 50 years was higher in women than in men, increasing to 36.0/100,000 persons/year in 60–80-year-old women [2]. A large cohort study also showed increasing trends of the incidence of patellar fracture in patients aged ≥ 60 years and female patients [6]. In the present study, the cases of low-energy patellar fracture in the elderly were characterized by older age, higher percentage of females, and a higher CCI; these

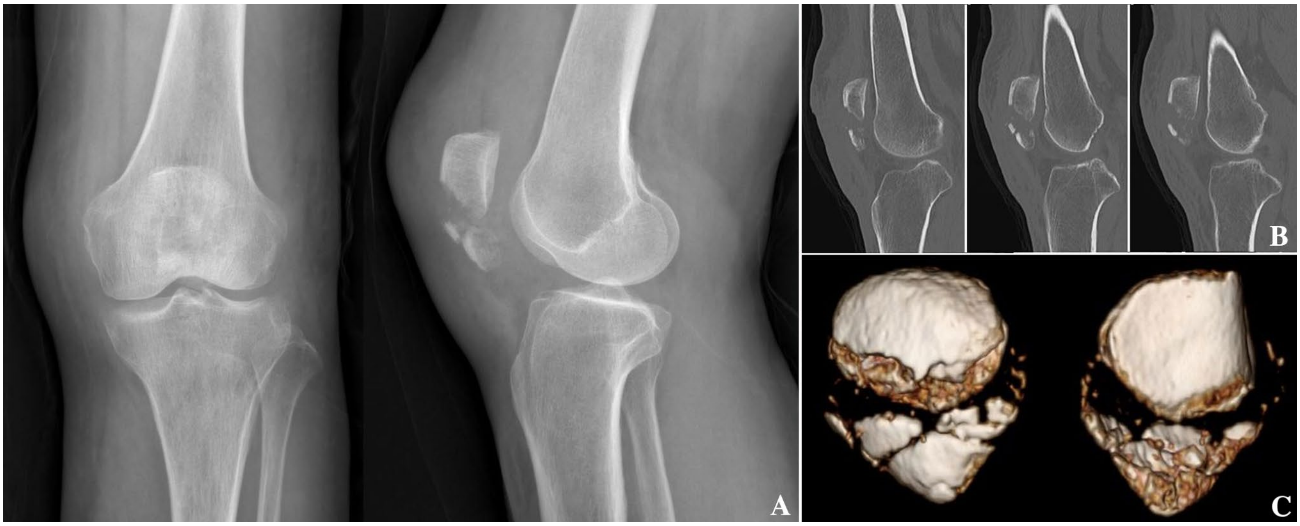


Fig. 3 Comminuted inferior pole fracture. **a** Plain radiographs. **b** Sagittal reconstruction computed tomography images. **c** Three-dimensional reconstruction images (front and back)

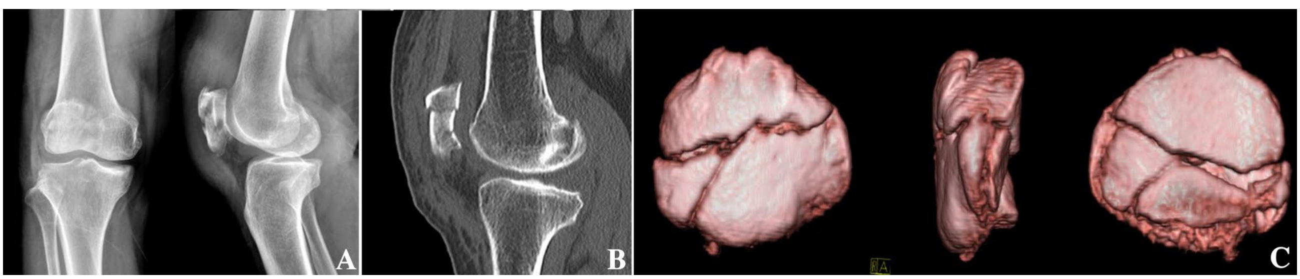


Fig. 4 Complex fracture with an intra-articular impacted fracture. **a** Plain radiographs. **b** Sagittal reconstruction computed tomography images. C. Three-dimensional reconstruction images

Table 2 Comparison of fracture characteristics according to injury mechanism

Parameters	Low-energy (n = 152)	High-energy (n = 50)	p value
Age (years)	70.1 ± 7.5	67.5 ± 5.9	**0.014**
Female ratio	98 (64.5%)	15 (30%)	**< 0.001**
Body mass index (kg/m^2)	23.8 ± 3.1	23.4 ± 3.2	0.367
Charlson comorbidity index	4.5 ± 1.4	4.0 ± 1.3	0.049
ASA score	2.2 ± 0.6	2.1 ± 0.6	0.442
Open fracture	2 (1.3%)	13 (26%)	**< 0.001**
Displacement (mm)	8.8 ± 8.4	7.4 ± 6.5	0.283
Inferior pole involvement	105 (69.1%)	30 (60%)	0.237
Comminution	121 (79.6%)	42 (84%)	0.495
Impaction	33 (21.7%)	16 (32%)	0.148
Surgical treatment	129 (84.9%)	38 (76%)	0.133
Union time (weeks)	12.4 ± 6.6	15.3 ± 9.2	0.058
Nonunion	1 (0.7%)	2 (4%)	0.644
Infection	8 (5.3%)	2 (4%)	0.701
Secondary surgery	44 (28.9%)	8 (16%)	0.068

ASA American Society of Anesthesiologists physical status

Fig. 5 Complications and reoperation

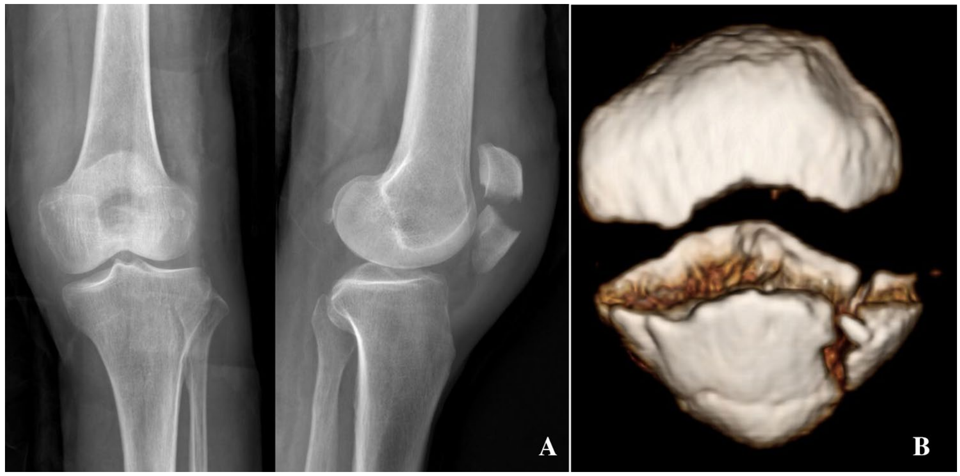
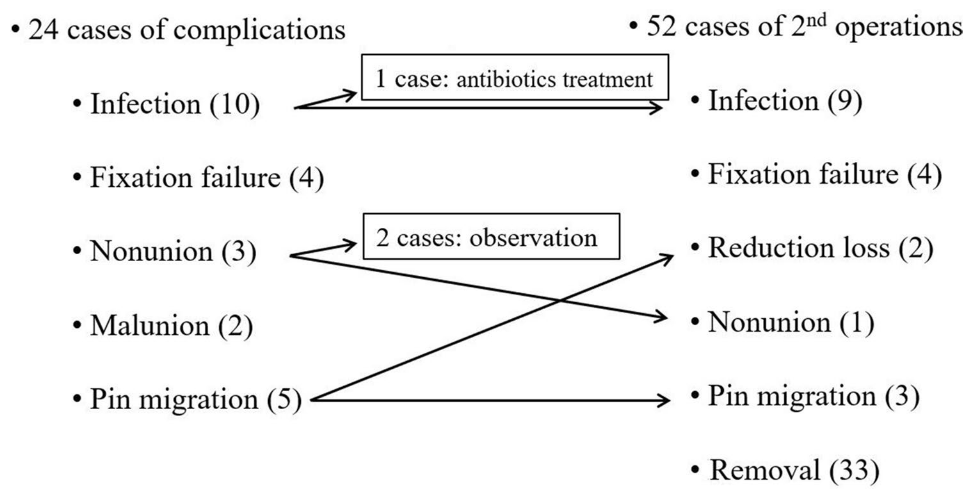


Fig. 6 Transverse patellar fracture with an inferior pole involvement and additional vertical split. **a** Plain radiograph. **b** Three-dimensional reconstruction image



characteristics are all consistent with the risk factors associated with fragility fractures [7].

The strength of the present study is the analysis of CT-based radiographic findings as follows: inferior pole involvement in 66.8% of cases; comminution in 80.7%; and impaction in 10.4%, which were specific characteristics of osteoporosis [8]. The CT images revealed higher rates of inferior pole involvement and comminution than the expected rates, and this would be because CT is better than the conventional plain radiography for identifying intra-articular step-offs and gaps [9, 10]. Type C was the most common fracture, but a more complex fracture pattern was shown in the CT images. Figure 6 illustrates a case in which plain radiography revealed type C1 (simple transverse), but CT images revealed an additional fracture in the inferior pole and a vertical split with surrounding comminuted fragment. This fracture pattern was commonly found in the elderly, although whether this kind of fracture should be classified as type C1 or not is controversial because the comminuted fragment and inferior pole are extra-articular components. In this pattern, the conventional TBW method could lead to early fixation failure because the wire may pierce through the vertical fracture line. In the most common type, C3, the two important radiological findings were anterior cortex comminution and impacted fragment. An intact cortical buttress is one of the fundamental prerequisites for TBW, but the comminuted anterior cortex cannot withstand the tensile forces of TBW [5], which also may lead to fixation failure. The impacted fragment in patellar fracture has not been well described yet except impaction associated with patellar dislocation [11]. Intra-articular impaction is challenging to restore, and the remaining step-off would result in patellofemoral arthritis. Therefore, we should propose the reduction and fixation technique of the impacted fragment in the future. These two radiological findings, comminution and impaction, can be poor prognosis factors, which explains the higher failure rate in the patellar fractures in the elderly [12, 13].

Isolated avulsion fractures of the inferior pole (type A1) were the second most common, and most of the avulsion fragments were comminuted. The separate vertical wiring technique for this kind of fracture has been proved to achieve successful outcomes [14, 15]. However, the achieving stability of these comminuted fragments in osteoporotic elderly patients is difficult because a cutting through of the fracture line of the wire and loss of reduction may occur [10, 16]. Recently, several techniques have been introduced to overcome the stability issue and revealed satisfactory outcomes, including hook plating [17] and basket plate and rim plate augmentation [16, 18]. Currently, we have adopted a new surgical technique to overcome the high failure rate; however, improvement of outcome needs to be validated with a large-scale study.

Our results show a relatively high rate (11.9%) of complications, and the main causes were infection (5.0%) and nonunion, including mechanical failure (3.5%). A recent meta-analysis estimated that the incidence rates of infection and nonunion after surgical treatment of patellar fractures were 3.2% and 1.9%, respectively [19]. Kadar et al. [20] reported infection, nonunion, and reoperation rates of 6.9%, 1.6%, and 22.3%, respectively. In addition, they found that a history of cerebrovascular accident (CVA) correlated significantly with the development of infection and nonunion. Miller et al. found that age and comminution were a strong predictor of failure [12]. Our study showed a higher complication rate than that of a previous meta-analysis [19]. In our study, most of the patellar fractures in the elderly were comminuted, and this may have influenced a higher complication rate. In addition, a higher comorbidity index was indirectly associated with the CVA history of the patients.

This study has several limitations. First, the number of patients was relatively small. However, to the best of our knowledge, it was the largest cohort study that focused on elderly patients. Second, this study did not represent the national general population, and the number of participants was too small to reach a definitive conclusion, although we did collect data from five institutions in various regions. Third, potential bias might be present because the surgeries were performed in different centers. Although evaluating the treatment outcomes were beyond the scope of our main investigation, we tried to minimize the potential bias using a standard surgical procedure based on basic fracture principles.

Despite these limitations, this study is clinically relevant because it demonstrates, using a CT-based analysis, that patellar fractures in an elderly population may exhibit characteristics of fragility fractures.

Conclusion

The patellar fractures in the elderly were mostly from low-energy injuries, and CT image demonstrated high rates of inferior pole involvement and comminution. The complication and reoperation rates were relatively high. Therefore, low-energy patellar fractures in the elderly population should be considered fragility fractures, and special attention is needed for the treatment of fragility patellar fractures.

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Compliance with ethical standards

Conflict of interest All authors (Jae-Ang Sim, Yong Bum Joo, Wonchul Choi, Seong-Eun Byun, Oog-Jin Shon, and Ji Wan Kim) declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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