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ORIGINAL ARTICLE

Predictors for nonunion, reoperation and infection after surgical fixation of patellar fracture

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Abstract
Introduction The most common major complications following surgical fixation of patellar fractures are infection, nonunion and reoperation. In this study, we sought to define the predisposing factors to the development of these complications.
Methods Open reduction and internal fixation surgeries for patellar fractures that were performed in a single institution between 2006 and 2011 were retrospectively reviewed. Patients' demographic data (age, gender, comorbidities), injury and fracture data (associated injuries, type of fracture, open or closed fracture), surgical data (type of surgery and interval between fracture occurrence and surgery) and major postoperative complications (infection, nonunion, symptomatic hardware and revision surgery) were collected from the medical records and verified by a telephone survey. Correlation analysis identified the major variables influencing the development of these complications.
Results The cohort of 188 patients had an average follow-up of 908 days. Thirteen (6.9 %) patients developed infection, 3 (1.6 %) had fracture nonunion and 42 (22.3 %) required a second operation. A history of cerebrovascular accident (CVA) correlated significantly with the development of infection (OR 6.18, CI 1.1–35.6, $p = 0.041$) and nonunion (OR 14.9, CI 1.2–188.1; $p = 0.037$). A history of diabetes significantly increased the risk of a second operation (OR 8.69, CI 95 % 1.8–41.9, $p = 0.007$). Open fracture did not increase the risk of any of these complications.
Conclusions A history of CVA and diabetes mellitus significantly increased the risk of complications following patellar fracture fixation. Patients with these comorbidities should be informed of their increased risk of these complications and be followed up more rigorously.

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Introduction

The patella is the largest sesamoid bone in the body, and its subcutaneous location makes it especially vulnerable to direct trauma and fractures, accounting for 1 % of all fractures [1]. Patellar fractures can be treated conservatively when they are nondisplaced and the knee extensor mechanism remains intact [2]. Displaced fracture and a disturbed extensor mechanism are the main surgical indications for patellar fixation. Infection, fracture nonunion and symptomatic hardware are the most frequent serious postoperative complications, with the reported rates of hardware removal ranging from 0 to 60 % [3]. Some authors claim that open patellar fractures increase the rates of these complications [4, 5].

The development of these complications is influenced by a variety of factors related to the patient, fracture and surgery. We sought to define the factors that influence the risk of experiencing one or more of the complications in a cohort of 188 patients with patellar fractures operated on in our institution between 2006 and 2011. We now report on what we believe to be the largest single-center cohort analyzed for these variables to date.

Methods

Patients and data collection

After obtaining institutional ethics board approval to conduct this study, we searched our hospital medical records for patients who were operated on for patellar fractures. A total of 211 patients were operated on between 2006 and 2011, and they comprised our initial study population. All patients' files were manually reviewed to collect information on the following three types of complications. The first was patient related, and those factors included age, gender, comorbidities [hypertension, diabetes mellitus, cardiac disorders, cerebrovascular accidents (CVAs), peripheral vascular disease and malignancy) and the American Society of Anesthesiologist (ASA) score [1–5]. The second was fracture related, and those factors included side and type, closed or open, and concomitant injuries (to the ipsilateral limb, contralateral limbs, spine, pelvis, head, chest or abdominal injuries). A descriptive classification of patellar fractures was used: nondisplaced, transverse, lower or upper pole, vertical, osteochondral, multi-fragmented nondisplaced or displaced [6]. Fracture-related data were verified by viewing the fracture via the hospital's picture archiving and communication system. The third was surgical-related, and those factors included time from fracture to surgery (days) and the surgical technique (anterior tension band, partial patellectomy, tension banding through cannulated screws, cerclage wiring and anchor suturing).

Postoperative complications

Infections, fracture nonunion and reoperations were defined as major complications, and information on their occurrence was retrieved manually from the patients' files. A telephone survey was carried out in order to complete and verify the findings on postoperative complications. One hundred eighty-eight patients (89 %) indicated whether they had sustained an infection or fracture nonunion or underwent re-operation. This group comprised our cohort.

Surgical technique

All the patients in our study were operated on by trauma surgeons from our orthopedic department, and all operations were performed through a central longitudinal incision. We employed the following fixation techniques:

1. Anterior tension banding—two Kirschner wires were inserted longitudinally followed by a stainless-steel wire looped around the patella through the mid-substance of the quadriceps and patellar tendons.
2. Tension banding through cannulated screws—a 3.5-mm cannulated screw was inserted similar to the Kirschner wire in the tension banding technique, and a 1.5-mm steel wire was passed through the screws and tied in a figure-eight shape.
3. Cerclage wiring (indicated for comminuted fractures)—the steel wire was placed in a circular fashion around the patella, through the quadriceps and patellar tendon and patellar retinaculum.
4. Partial patellectomy (indicated mainly for distal pole patellar fractures)—the fracture was explored and the bony fragments were removed. The remaining patellar tendon was sutured with Ethibond 5 to the patella through 2-mm bony tunnels.
5. Anchor suturing—a midline incision over the patella to the tibial tuberosity was performed, and the fracture was exposed and irrigated. Two types of suture anchors (Fastin and Panalok, Depuy, Warsaw, IN) were inserted in the main proximal patellar fragment, and ultra-braid sutures were tied up at the distal patellar pole [7].

The postoperative management was similar for all procedures. Straight knee immobilization in a brace or cylinder cast in extension was applied after surgery. Full weight bearing was allowed immediately, and gradual physical therapy was begun 6 weeks following surgery to regain knee range of motion. For cases in which stable fixation was achieved, range of motion exercises with a protective hinged knee brace were permitted as early as 3 weeks postoperatively. Open fractures were treated by debridement and irrigation with 9 l of saline followed by fracture fixation. Antibiotic treatment was delivered intravenously with the duration of administration determined according to the degree of contamination (cefazolin 1 g three times daily and gentamycin 240 mg once daily).

Statistics

All the data analyses were carried out by using SPSS, version 19. Descriptive statistics were evaluated by chi-square tests or Mann-Whitney tests, and the Kruskal-Wallis test with Bonferroni correction was applied for quantitative variables with asymmetric distribution. Spearman's rank correlation coefficient was used to test nonlinear associations between independent variables. Bivariate associations with a p value equal to or less than 0.15 were further tested in multivariate analyses. Multivariate logistic regression models were performed to identify the risk factors (age at operation, time from fracture to surgery, gender, ASA score, side of patella fracture, comorbidities and type of procedure) associated with each of the complications. Significant difference between groups was defined as less than 0.05.

Results

Patient demographics are presented in Table 1. The average follow-up for our study group was 908 days (SD 522). Their mean age at surgery was 56 years (range 13–94). Fourteen (7.4 %) patients had an open fracture, and the most common associated injuries were fractures of the ipsilateral limb ($n = 13$, 6.9 %) and other musculoskeletal injuries ($n = 14$, 7.4 %).

Fifty-one (27 %) patients suffered from hypertension, making it the most prevalent comorbidity, followed by diabetes ($n = 19$, 10.1 %), cardiac disorders ($n = 18$, 9.6 %), malignancy ($n = 11$, 5.9 %) and CVA ($n = 7$, 3.7 %). None of the patients had a history of peripheral vascular disease. Eighty-seven percent of the 100 patients who underwent ASA evaluation had scores that were either normal ($n = 29$) or indicative of mild systematic disease ($n = 58$). The standard tension band was the most frequent fixation procedure. All of the patients with a history of CVA had no neurologic deficits and received no anticoagulants except aspirin.

The most common recorded complications were infection in 13 patients (6.9 %) and nonunion in 3 patients (1.6 %). A second operation was required for 42 (22.3 %) of the participants. Associations between infections, nonunion or a second operation and independent characteristics of the participants are shown in Table 2. No association was found between any of the complications and the interval between fracture occurrence to surgery, ASA score, history of hypertension, heart disease or malignancy, open/closed fracture, type of fracture or type of surgery.

A multivariate logistic regression revealed that diabetes significantly increased the risk for a second operation by over eight-fold (CI 95 % 1.8–41.9, $p = 0.007$) and that a partial patellectomy procedure was significantly protective (OR 0.12; CI 95 % 0.02–0.7, $p = 0.014$) when adjusting for CVA and anchor suturing (model 1, Table 3). A history of CVA was significantly associated with infection and nonunion on multivariate logistic regression: a CVA increased the risk of postoperative infection by over 6-fold (OR 6.18, CI 1.1–35.6, $p = 0.041$, model 2, Table 3) and nonunion by over 14-fold (OR 14.9, CI 1.2–188.1; $p = 0.037$, model 3, Table 3).

Forty-two patients were re-operated: 27 (64 %) because of symptomatic hardware requiring its removal, 11 (26 %) because of infection who underwent either debriding (8/11) or hardware removal (3/11), 3 (7 %) because of hardware failure who were re-fixated on the second surgery and one because of nonunion (Fig. 1). The average time to the reoperation was 348 days (range 9–1509 days).

Table 1 General demographics, comorbidities, and fracture and surgical details of the study population ($n = 188$)

Demographics	
Male/female	111/77
Mean age (SD) years	55.9 (19.1)
Comorbidities	
Hypertension	51 (27 %)
Diabetes	19 (10.1 %)
Heart disease	18 (9.6 %)
CVA	7 (3.7 %)
History of malignancy	11 (5.8 %)
ASA score ($n = 100$)	
1	29 (29 %)
2	58 (58 %)
3	12 (12 %)
4	1 (1 %)
Fracture and injury details	
Open fracture	14 (7.4 %)
Side of fracture (right/left)	89/99
Type of fracture	
Undisplaced	9 (4.7 %)
Transverse	73 (38.8 %)
Upper or lower pole	65 (34.5 %)
Comminuted undisplaced	6 (3.1 %)
Comminuted displaced	27 (14.3 %)
Vertical fracture	4 (2.1 %)
Osteochondral fragment	4 (2.1 %)
Adjacent injuries	
Fracture ipsilateral limb	13 (6.9 %)
Other musculoskeletal injuries	14 (7.4 %)
Pelvis	3 (1.5 %)
Chest	3 (1.5 %)
Abdomen	2 (1 %)
Spine	4 (2.1 %)
Head	3 (1.5 %)
Surgery details	
Time from surgery to fracture, days (SD)	3.6 (9.2)
Surgical technique	
Anterior tension banding	69 (36.7 %)
Cerclage wiring	12 (6.3 %)
Cannulated screws	28 (14.8 %)
Suture anchors	31 (16.4 %)
Partial patellectomy	35 (18.6 %)
Others[a]	13 (6.9 %)

CVA cerebrovascular accident, *ASA* American Society of Anesthesiologists

[a] Arthroscopy with Biofix screw insertion, a tension band through the tibial tuberosity and a single screw

Table 2 Associations between selected background characteristics of the study cohort and infection, nonunion and reoperation following patella fracture surgery

	Yes	No	*p* value
Infection			
Mean age at operation, years (SD)	59.0 (15.6)	55.6 (19.3)	0.631
Gender: female, *n* (%)	9 (8.1)	102 (91.9)	0.564
Open fracture, *n* (%)	1 (7.1)	13 (92.9)	1.000
Mean time to surgery, days (SD)	5 (5.1)	3.5 (9.5)	0.15
Diabetes, *n* (%)	3 (15.8)	16 (84.2)	0.130
CVA, *n* (%)	2 (28.6)	5 (71.4)	0.076
Procedure, *n* (%)			
Standard tension band	3 (4.3)	66 (95.7)	
Cerclage	0	12 (100)	
Cannulated screws	5 (17.9)	23 (82.1)	
Anchors	3 (9.7)	28 (90.3)	
Partial patellectomy	2 (5.7)	33 (94.3)	
Others	0	13 (6.9)	
Reoperation			
Mean age at operation, years (SD)	53.5 (20.5)	56.5 (18.7)	0.500
Gender: female, *n* (%)	22 (19.8)	89 (80.2)	0.319
Open fracture, *n* (%)	5 (35.7)	9 (64.3)	0.31
Mean time to surgery, days (SD)	3.7 (4.6)	3.5 (10.2)	0.29
Diabetes, *n* (%)	7 (36.8)	12 (63.2)	0.109
CVA, *n* (%)	2 (28.6)	5 (71.4)	0.654
Procedure, *n* (%)			
Standard tension band	21 (30.4)	48 (69.6)	
Cerclage	3 (25.0)	9 (75.0)	
Cannulated screws	7 (25.0)	21 (75.0)	0.036
Anchors	4 (12.9)	27 (87.1)	
Partial patellectomy	2 (5.7)	33 (94.3)	
Others	5 (38.5)	8 (61.5)	
Nonunion			
Mean age at operation, years (SD)	58.3 (21.5)	55.8 (19.1)	0.979
Gender: female, *n* (%)	2 (1.8)	109 (98.2)	1.000
Open fracture, *n* (%)	0	14 (100)	1.000
Mean time to surgery, days (SD)	1.3 (0.6)	3.6 (9.3)	0.366
Diabetes, *n* (%)	0	19 (100)	1.000
CVA, *n* (%)	1 (14.3)	6 (85.7)	0.108
Procedure, *n* (%)			
Standard tension band	1 (1.4)	68 (98.6)	
Cerclage	0	12 (100)	
Cannulated screws	0	28 (100)	
Anchors	1 (3.2)	30 (96.8)	
Partial patellectomy	1 (2.9)	34 (97.1)	
Others	0	13 (100)	

CVA cerebrovascular accident

There were 13 cases of infection: 2 had deep infection requiring total patellectomy, 6 had deep infection requiring wound debridement with or without partial patellectomy, 3 were treated by hardware removal and intravenous antibiotics, and 2 were treated by intravenous antibiotics alone (Fig. 2).

Table 3 Logistic regression models for infection, nonunion and reoperation

Model	*B*	*p* value	OR	95 % CI
Model 1: second operation, $n = 119$				
Diabetes	2.16	0.007	8.69	1.80–41.91
Anchors	−0.10	0.130	0.37	0.10–1.34
Partial patellectomy	−2.10	0.014	0.12	0.02–0.66
CVA	1.41	0.164	4.10	0.56–29.97
Model 2: infection, $n = 188$				
CVA	1.82	0.041	6.18	(1.07–35.56)
Model 3: nonunion, $n = 188$				
CVA	2.70	0.037	14.92	1.18–188.11

CVA cerebrovascular accident

Discussion

The three main early complications when surgically treating patellar fractures are infection, nonunion and symptomatic hardware, and they usually require reoperation. Dy et al.'s [8] meta-analysis reported that the rate of re-operation was 33.6 % and that the frequency of infections and nonunions was 3.2 and 1.3 %, respectively. Additionally, they found that age, gender and operative method were not factors that influenced the development of those complications. Their report was based on a heterogeneous collection of studies on patients with patellar fractures, the largest of which included 93 patients. We examined the complication rate in a cohort of 188 patients who were treated in a single institution and assessed for the predictors for developing those complications. Our prediction models took into account a large variety of patients, injuries and surgery-related variables (the latter consisting of age, gender, comorbidities and ASA score, adjacent injury, open/closed fracture, fracture type, time to surgery and surgical technique).

The rate of hardware removal from all causes in our study population was 22.3 %, the rate of infection was 6.9 %, and the rate of nonunion was 1.6 %. Hardware failure was rare ($n = 3$, 1.6 %). The results of this study revealed a significant association between a history of CVA and the occurrence of infection and nonunion, while diabetes significantly increased the risk of requiring a second operation from all causes. An operation technique with no prominent hardware (anchorage sutures) or no hardware at all (partial patellectomy) was associated with fewer reoperations.

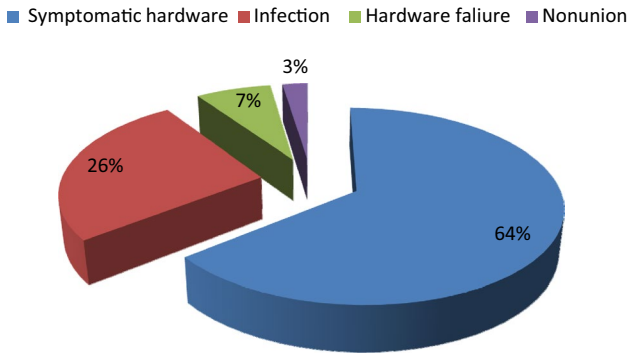

Fig. 1 Causes of reoperation after patellar fixation surgery

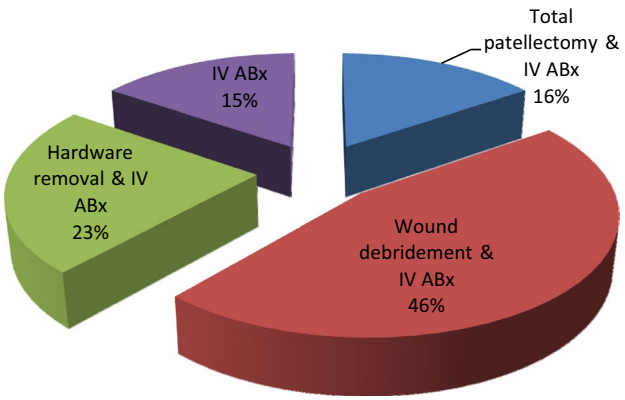

Fig. 2 Management of surgical site infection after patellar fixation surgery. IV ABx, intravenous antibiotics

The incidence of infection in our cohort was 6.9 %, which is high, but within the range of the 3–10 % postoperative infection rate reported by others [9–12]. We consider that this high infection rate may be partially attributed to the relatively older average age of the patients in our cohort (56 years) [13] and a high proportion of patients with associated comorbidities (56 %).

A correlation between CVA and contracting infection postoperatively has never before been demonstrated for patellar fractures. We are unable to provide any evidence-based rationale for this finding. Our hypothesis is, however, that a history of cerebrovascular accident is indicative of vasculopathy, and the patients may have developed atherosclerosis in the lower extremities as well. Atherosclerosis and poor blood flow can result in increased infection and non-union rates. Although none of the patients had a history of PVD, we did not examine the patients for this, so could not rule out milder cases of atherosclerosis. Patients should be informed of the higher risk for this complication, and the treating physicians should follow-up this subgroup more frequently and closely in an effort to reduce the risk of deep infections.

Diabetes' influence on complications of patellar fracture fixation was not studied extensively. However, several studies have found a correlation between diabetes and postoperative complications in fixation of other lower extremity fractures. Ricci et al. [14] reported that diabetes was an independent risk factor for deep infection and reoperations following distal femoral fracture fixation with lateral locked plates. SooHoo et al. [15] studied postoperative complications in 57,183 ankle fractures. Diabetes was associated with an increased risk of infection in the short term and an increased risk of re-operation in the long-term follow-up.

Open fractures were reported to increase the complication rate by some authors. The nonunion rate may reach as high as 7 % [2, 16] and the infection rate up to 11 % [4]. There was no significant association between open fractures and any complication in our experience. These data are in agreement with Dy et al.'s [8] meta-analysis of 737 patients and suggest that modern treatment of open fractures, including prompt irrigation and IV antibiotics, abolishes the risks of complications associated with them. Hoshino et al. [17] have recently reported an increased risk of infection for anterior tension bands over cannulated screws (OR 3.92), a trend that was not evident in our group. Fracture pattern and comminution were also not associated with the risk for infection as reported by Torchia and Lewallen [4].

Forty-two of our patients required reoperation from all causes, most (64 %) because of painful symptomatic hardware. Both of the comorbidities identified as being major ones in the current study, diabetes mellitus and CVA, were positively correlated with the risk of a second operation. A surgical technique without the use of prominent hardware, i.e., partial patellectomy and anchorage sutures, was a determinant in there being a lower rate of second operations. Recently published data on 448 patients with patellar fractures demonstrated significantly higher reoperation rates in patients undergoing fixation with Kirschner wires over cannulated screws [17]. We believe that our findings complete this clinical picture: the less prominent the hardware, the less risk of reoperation.

Our nonunion rate was 1.5 %, which was within the range described by other studies [8]. Our hardware failure rate of 1.5 % was lower than the 3.5–7 % recently published by Hoshino et al. [17].

Our study has several limitations. First, there might have been an information bias since our patients were followed up over the telephone and not evaluated by a physical examination of actual knee function. This also meant that we could not assess some of the more common complications associated with patellar fracture fixation, such as knee outcome. Our follow-up time of 31.5 months limits our ability to assess knee arthritis, which is the most common

complication over time [1, 18]. Although ours is one of the largest cohorts reported to date, we included many fixation groups, thus lowering the statistical power to delineate specific differences between groups.

Conclusion

Patellar fracture surgical fixation is associated with a high rate of three major complications, reoperation (24 %), infection (6.9 %) and nonunion (1.5 %). There was a significant correlation between postoperative infection and fracture nonunion and a history of CVA in our single-center cohort of 188 patients who underwent fixation surgery. CVA and diabetes mellitus were also associated with a higher risk of reoperation from all causes. We recommend that patients with these comorbidities be informed of their increased risk of complications and that they be followed up more rigorously. Less prominent hardware, such as anchor suturing and partial patellectomy, lowers the risk of reoperation and should be the preferred approach when possible.

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Conflict of interest The authors declare that they have no conflict of interest.

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