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Patellar Fracture Following Patellofemoral Arthroplasty

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ABSTRACT

This study aims to report the incidence of patellar fracture after patellofemoral arthroplasty (PFA) and to determine associated factors as well as outcomes of patients with and without this complication. 77 knees in 59 patients with minimum two-year follow-up were included. Seven (9.1%) patients experienced a patellar fracture at a mean of 34 (range 16–64) months postoperatively. All were treated nonoperatively. Lower BMI ($P = 0.03$), change in patellar thickness ($P < 0.001$), amount of bone resected ($P = 0.001$), and larger trochlear component size ($P = 0.01$) were associated with a greater incidence of fracture. Fewer fractures occurred when the postoperative patellar height exceeded the preoperatively measured height. No statistically significant differences were found in outcome scores between groups at mean four-year follow-up.

Patellofemoral arthroplasty (PFA) is routinely used as treatment for advanced isolated patellofemoral arthritis. Several previous studies have stressed the importance of patient selection, while others have argued that intraoperative decisions are the leading factor for favorable outcomes [1,2]. Although recent changes in PFA component designs have led to better results, failures similar to those of other types of arthroplasty still exist [2–5]. Common sources of failure include progression of arthritis, stiffness, patellar instability, and patellar fracture [6].

In total knee arthroplasty, patellar resurfacing and lateral release techniques have been reported to contribute to increased risk of patellar fracture [7–11]. However, surgeons electing not to resurface the patella may see their patients return with greater anterior knee pain and require more revision operations [12]. Patient's demographic factors, as well as intraoperative decisions, such as over-resection of the patella, have all led to higher rates of patellar failure in total knee arthroplasty [12–14]. Greater patellar thickness following resurfacing has been associated with lateral subluxation of the patella and loss of flexion. However, reduced patella thickness following TKA has been associated with patella stress fractures and anteroposterior instability of the knee [15,16].

While much attention has focused on patellar fractures after total knee arthroplasty, there is currently a paucity of data regarding patellar fracture for patients undergoing patellofemoral arthroplasty. The goals of this study are to (1) determine demographic and surgical predictors of patellar fracture following PFA and to (2) compare the outcomes of patients with and without postoperative fracture.

Methods

After approval from our institutional review board, a retrospective review of all patients who underwent primary patellofemoral arthroplasty for osteoarthritis performed by a single surgeon (DLD) was conducted. Patients were excluded for postoperative follow-up of less than two years. The medical records, operative reports, and radiographic images of all patients meeting our inclusion/exclusion criteria were reviewed.

Patient-specific characteristics were noted, including gender, age, body mass index (BMI), injury mechanism, previous ipsilateral knee surgery (any non-arthroplasty surgery), initial or revision PFA, and Insall–Salvati ratio. Surgically-related factors, including preoperative patella and postoperative composite thickness, postoperative residual patella bone thickness, performance of a lateral retinacular release, patellar component size, and trochlear component size were also recorded. Patellar composite thickness, residual bone thickness, and component thickness measurements are visually displayed in Fig. 1[17]. Residual patellar bone thickness was calculated by subtracting the thickness of the patellar component from the intraoperatively measured composite patella thickness. This quantifies the amount of true patellar bone remaining after placement of the PFA components.

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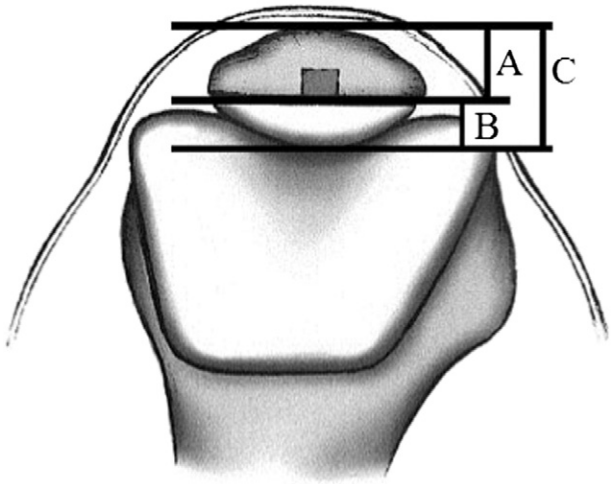


Fig. 1. Figure demonstrating various measurements for intraoperative patella measurements. Measurements of postoperative residual bone thickness (A), patella component thickness (B), and postoperative patella composite thickness (C). Figure modified from Pickering et al [17].

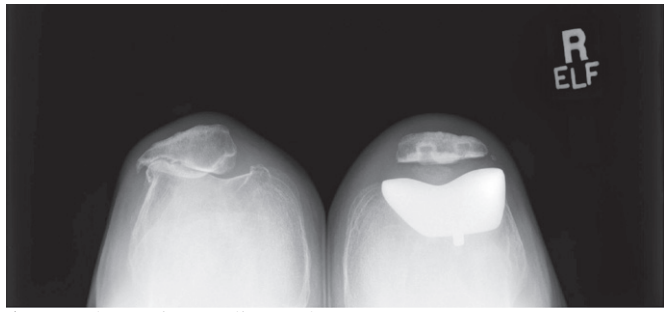
Preoperative and postoperative clinical function was documented using the Knee Society clinical rating system, UCLA Activity Score, and Tegner Activity Level Scale. Knee Society function, pain, and stair climbing scores were obtained via standardized questionnaires given to all patients prior to surgery and postoperatively at regular intervals, beginning at one year post-surgery. UCLA Activity Score and Tegner Activity Level scores were obtained retrospectively from the patients' medical records.

Radiographs of all patients were obtained preoperatively and postoperatively at regular intervals. Anterior-posterior (AP), lateral, merchant, and full-length standing hip–knee–ankle radiographs were reviewed for the degree of osteoarthritis preoperatively and for the presence of a patellar fracture postoperatively. Patellar height was determined using the Insall–Salvati ratio [18]. Patellar fractures were documented using a classification system developed by Ortiguera and Berry [13]. Fractures with a stable implant and an intact extensor mechanism were classified as type I, a disruption of the extensor mechanism as type II, and a loose patellar component with an intact extensor mechanism as type III. Fig. 2A (merchant) and Fig. 2B (lateral) show radiographs at 2 years status post PFA showing a mildly displaced type I distal pole patella fracture.

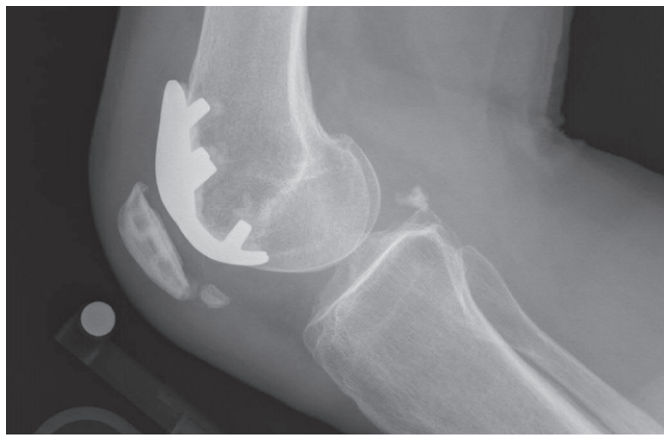
A single implant design (AVON Patello-Femoral Joint Replacement System, Stryker, Mahwah, New Jersey) by a single surgeon was used in all patients. Additionally, all patients underwent the same postoperative care regimen with progressive weightbearing beginning on their first postoperative day. Within 24 hours of surgery, active range of motion was initiated. By postoperative day two or three, patients were discharged after demonstrating safe ambulation with a walker, ascent of several stairs, and flexion of the knee to at least 90 degrees. In addition to immediate postoperative radiographs, follow-up visits were scheduled for examination and radiographs three months, one year, two years, and five years after surgery.

Patients were divided into two groups based on the presence or absence of a patellar fracture. Potential risk factors and clinical outcomes were compared between patients without any presence of patellar fracture versus patients with a radiographically documented patellar fracture. Risk factors included age, BMI, previous surgery, revision PFA, Insall–Salvati ratio, lateral release, preoperative patellar thickness, trochlear and patellar component sizes, postoperative patella composite thickness, and amount of patellar bone resected.

Risk factors were composed of continuous and categorical variables. Wilcoxon Chi-Square analysis was used to compare categorical risk factors to postoperative fracture. Logistic regression was used to compare continuous risk factors to postoperative fracture. A t-test was used to compare outcome measures of the patella fracture group to those without fracture. Significance was set at 0.05 for all tests.



A) Merchant view radiograph.



B) Lateral view radiograph.

Fig. 2. Merchant (A) and lateral (B) view radiographs 2 years status post PFA showing a mildly displaced type I distal pole patella fracture treated nonoperatively. (A) Merchant view radiograph. (B) Lateral view radiograph.

Results

77 knees in 59 patients met the inclusion criteria. Patients all underwent primary patellofemoral arthroplasty at a mean age of 56 (range 36–82) years with mean follow-up of 4 (range 2–9) years. Seven (9.1%) patellar fractures in six patients after PFA were radiographically documented at a mean of 34 (median 28, range 16–64) months postoperatively. Only two of the seven fractures were associated with a documented traumatic event. All were type I fractures (stable patellar component with intact extensor mechanism) with a mean displacement of 1.4 (range 0.9–2.1) mm and were treated nonoperatively.

Patients presenting with patellar fractures had a mean BMI of 25.4 (range 20–31) kg/m^2 and average age of 57.7 (range 45–65) years. For the 70 knees without an incidence of patellar fracture, the mean BMI was 29.8 (range 22–42) kg/m^2 with an average age of 56.1 (range 38–82) years. BMI proved to be significantly lower in patients who experienced a fracture ($P = 0.027$). An odds ratio of 0.78 (95% CI 0.62–0.96) showed that the risk of a patellar fracture decreased by 22% with each one-unit increase in BMI. Additionally, patients with a BMI < 31 had significantly more fractures than those patients with a BMI ≥ 31 ($P = 0.02$). All other patient demographic factors including age ($P = 0.48$), gender ($P = 0.24$), previous ipsilateral surgery ($P = 0.69$), and patellar position ($P = 0.28$) proved to be insignificant between the two groups.

Intraoperative data are displayed in Table 1. Comparing postoperative patellar thickness to preoperative thickness, our data showed a decrease (mean −0.5 mm, range −2.0 to 0.0) in composite patellar thickness for fracture cases and an increase (mean 1.05 mm, range −1.0 to 3.0) in thickness for nonfracture cases ($P = 0.0004$). Post-hoc

Table 1
Intraoperative Data for Fracture and Nonfracture Groups.

Intraoperative Risk Factor	Fracture Group	Nonfracture Group	*P*-Value
Preoperative patella thickness (mm)	22.3 (21–25)	21.1 (16–27)	0.19
Postoperative composite patella thickness (mm)	21.8 (20–25)	22.2 (18–26.5)	0.33
Change in thickness (mm)	−0.5 (−2.0 to 0.0)	1.05 (−1.0 to 3.0)	0.0004*
Bone resection (mm)	9.5 (9–11)	8.1 (6–10)	0.001*
Bone resection (%)	43% (36%–50%)	38% (29%–47%)	0.01*
Residual patella bone (mm)	12.8 (11–16)	13.1 (9–17)	0.39
Lateral release (%)	6/7 (86%)	55/70 (79%)	0.64

Values are expressed as averages, with ranges in parentheses. Statistically significant values are denoted with an asterisk (*) and include change in patella thickness, mm of bone resection, and percentage of the patella resected.

analysis revealed that patients with increased patellar thickness had significantly fewer patellar fractures ($P = 0.001$). By observing the amount of bone resected to fit the patellar component, we found that knees that did not fracture had a mean of 8.1 (range 6–10) mm of bone resected, while cases with a fracture underwent a mean 9.5 (range 9–11) mm of bone resection ($P = 0.001$). Accounting for patella thickness, the percentage of the patella that was resected also proved significantly different between the fracture (mean 43%, range 36%–50%) and nonfracture (mean 38%, range 29%–47%) groups ($P = 0.01$). Lateral release had no correlation with postoperative fracture. It was performed in 55 (79%) operations without a fracture and 6 (86%) patients who experienced a fracture ($P = 0.64$).

The component size distributions are displayed in Table 2. Larger trochlear components were associated with a greater risk of patellar fracture ($P = 0.01$). Patellar component size was not a significant risk factor ($P = 0.21$).

Preoperative and postoperative outcome scores are shown in Table 3. While no outcome was significantly different between the patients experiencing a fracture and those who did not, postoperative Knee Society Pain scores trended toward significance with fracture cases having decreased scores compared to non-fracture cases ($P = 0.09$).

Discussion

In this study, we present a single surgeon incidence of patellar fracture after PFA performed for treatment of isolated patellofemoral arthritis. To our knowledge, this is the only series reported in the literature. The purpose of this study was to determine demographic and surgical factors associated with patellar fracture following PFA and to compare the outcomes of patients with and without this postoperative complication.

Strengths of this study include the use of a single implant design by a single surgeon using a standardized technique. Additionally, extensive radiographic review and complete follow-up on all patients increase the reliability of this study. Our study has multiple limitations. First, this is a retrospective study. Retrospective studies can potentially underestimate the incidence of such events. To alleviate this possibility, only patients with routine two-year follow-up including radiographic images were included. A second limitation is that long term data are not yet available for this patient cohort. Lastly, a small sample size for the fracture group may have led to inconclusive statistical analysis for some factors.

Table 2
Component Size Distributions for the Fracture and Nonfracture Groups.

	Fracture Group		Nonfracture Group	
	Patellar	Trochlear	Patellar	Trochlear
Extra small	0	0	0	7 (10%)
Small	7 (100%)	0	55 (79%)	27 (39%)
Medium	0	7 (100%)	15 (21%)	34 (49%)
Large	0	0	0	2 (3%)

Patella thickness: small (9 mm), medium (9.5 mm), large (10 mm).

Our study found an overall incidence of patellar fracture after PFA of 9.1%. This is higher than data presented for total knee arthroplasty, where the reported incidence rate for patellar fracture ranges from 0.5% to 3.6% [19,20]. This increased rate in PFA is most likely due to the pathology of isolated patellofemoral arthritis, likely resulting in increased patellar wear and relatively thinner patellar bone stock when compared with standard total knee arthroplasty. The only significant difference found with respect to patient demographics was that patients who experienced a fracture had a lower BMI ($P = 0.03$). Intraoperatively, the amount of bone resected was significantly greater in patients who experienced a fracture ($P = 0.001$). When the postoperative patellar thickness exceeded preoperative thickness, fewer fractures occurred ($P = 0.001$). Lastly, larger trochlear component sizes also were linked to a greater risk of patellar fracture ($P = 0.01$). Standard outcome measurements for pain, function, and activity were not different preoperatively or postoperatively when comparing the fracture group against the non-fracture group.

While some studies have reported patient demographics alone as influential in patellar fractures, we found that both patient demographics and intraoperative surgical decisions were significant risk factors. Berry et al [21] noted several studies citing patient demographics to be inconsistent in predicting patellar fracture. Some studies cited males at higher risk [12,13], while others cited females at higher risk [19,22,23]. Additionally, age and body mass index have yet to be proven significant in patellar fracture in previous studies [13,21]. Several surgical factors have been reported to lead to an increased risk of patellar fracture in total knee arthroplasty. A study by Ortiguera et al [13] found patellar thickness to influence the risk, while others have found no correlation [12,22]. Ortiguera's results correlate with those of our current study, noting a high fracture rate when over 40% of the patella was resected [13]. Additionally, lateral retinacular release has been reported to be a factor [10,11,20]. Tria et al [20] found that a lateral release had been performed in all 18 of their cases of patellar fracture after total knee arthroplasty. Our study was unable to associate performance of a lateral release with a greater incidence of fracture. However, this may be a result of the high incidence of lateral release in our cohort.

We found that a comparison of preoperative and postoperative patellar thickness was an important predictor of patellar fracture. This is reported widely in the total knee arthroplasty literature [8,9,12,13,16]. If the patella is not restored to at least the preoperative height, there may be relatively little bone remaining after the resection is completed. This may weaken the patella and likely leads to a greater incidence of fracture. Additionally, larger trochlear component sizes were found to increase the rate of patellar fracture. The higher lateral ridge has been cited to effectively prevent patellar dislocation, however it may increase forces at the patella, which could predispose to patellar fractures or loosening [24,25]. This consequence is magnified if there is any medial displacement or internal rotation of the trochlear component [24]. These effects have been postulated in total knee arthroplasty and may also be a factor present in patellofemoral arthroplasty.

Table 3
Clinical and Functional Outcomes of Patients With and Without Patellar Fracture Following PFA.

Score Type	Nonfracture Preoperative	Fracture Preoperative	*P*-Value	Nonfracture Postoperative	Fracture Postoperative	*P*-Value
Knee Society function score, mean (SD)	56.8 (14.09)	55.7 (11.78)	0.85	79.7 (17.81)	79.3 (18.41)	0.95
Knee Society pain score, mean (SD)	57.0 (13.25)	60.7 (17.41)	0.49	91.3 (11.45)	83.1 (16.08)	0.09
Knee Society stair climbing score, mean (SD)	26.6 (8.93)	30.7 (7.76)	0.25	39.1 (9.52)	42.9 (8.81)	0.33
Tegner Activity Level, mean (SD)	2.2 (1.02)	2.14 (0.35)	0.89	3.9 (0.97)	3.9 (1.25)	0.92
UCLA Activity Score, mean (SD)	3.3 (0.80)	3.43 (0.73)	0.72	5.8 (1.52)	5.7 (1.83)	0.91

Clinically, there were no differences between the fracture and nonfracture groups when compared preoperatively or postoperatively in standard pain, function, and activity outcomes. As all fractures were type I and treated nonoperatively, these outcomes do not deviate from expected results. Nonoperative management of type I patellar fractures after PFA does not appear to negatively influence outcome. While many patellar fractures after PFA can be treated nonoperatively, as was the case in our study, it remains to be seen whether these fractures may increase the need for revision surgery over the long term [26].

Conclusion

Very little is reported on patellar fractures after patellofemoral arthroplasty and there is no consensus on causes of patellar fractures after total knee arthroplasty. Our data suggest that lower BMI, decreased patellar thickness, high amount of bone resection, and the use of larger trochlear component sizes all increase the risk of type I patellar fractures following PFA. Patients with this postoperative complication demonstrated no significant difference in clinical or functional outcomes at mid-term follow-up after nonoperative treatment.

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