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Reoperation and Complication Rates Following Patellar Fracture Repair with Plates

A Retrospective Analysis with Patient-Reported Outcomes at More than 1 Year of Follow-up

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Background: Recent work has suggested good clinical and functional results with dorsal surface plating of patellar fractures. The primary outcome measurement of this study was reoperation rates for patellar fractures that had been treated with dorsal plating.

Methods: This work consists of a retrospective review of clinical and functional outcome data following repair of patellar fractures with dorsal plates. We obtained institutional review board approval for this study and conducted a review of 9 consecutive years of our group's trauma practice. We also contacted patients to assess patient-reported outcomes (PROs) after 12 months.

Results: Eighty-five patellar fractures were treated with open reduction and internal fixation (ORIF) via plating over 9 years. Eight (9.41%) of the patients required reoperation. Of the 72 patients with complete follow-up of ≥12 weeks, 3 (4.17%) had nonunion of the fracture site and 4 (5.56%) had loss of reduction of the fracture. The average Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score among our sample was 18.84 (slight symptoms); 72.41% of the patients in our sample had slight or no symptoms at ≥12 months postoperatively.

Conclusions: Our results indicated that plating of comminuted patellar fractures is a safe, viable treatment strategy. The PROs at ≥12 months of follow-up data were promising. Additionally, dorsal plating may allow for early return of function and less postoperative bracing.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Although patellar fractures represent only approximately 1% of skeletal injuries[1], their impact on quality of life may be profound due to the patella's critical role in the extensor mechanism of the knee. As a result, operative treatment is recommended[2] for displaced fractures and those with loss of the extensor mechanism. Obtaining an anatomic reduction and ensuring robust fixation of these fractures are critical to returning a patient back to his or her original activity level and function. However, the superficial location of the patella, combined with the high biomechanical load that is transmitted through it, creates a technical challenge for both obtaining and maintaining reduction in surgery and during the perioperative period[1,3].

The most common method of fixation for patellar fractures is the modified AO tension-band technique, with or without cannulated screws[4,5]. Tension-banding converts anterior tension forces to compressive forces at the articular surface, and independent screws provide compression across the fracture site[6]. Although these techniques are commonly performed, they are not without limitations. Tension-banding can result in implant migration due to the lack of connections between the Kirschner and tension-band wires[4]. Furthermore, the hardware can be prominent and a source of soft-tissue irritation. Both tension bands and independent screws are limited in their utility for simple fracture patterns and are contraindicated in the commonly seen comminuted patellar fracture because of the poor mechanical stability they provide. Unfortunately, secondary surgery for removal of tension-band constructs is not uncommon[7].

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A390).

Fig. 1

Fig. 2

Fig. 3

Fig. 1 Preoperative radiograph of a patellar fracture that was treated by our practice. **Fig. 2** Postoperative anteroposterior view of the ORIF with patellar plating. **Fig. 3** Postoperative lateral view of the ORIF with patellar plating.

Because of the limited treatment options for treating comminuted patellar fractures, several surgeons have advocated for other treatment options. Recently, plating of the patella has been reported to have good to excellent results[8]; however, because this method is still novel, the results are relatively sparse. Therefore, we sought to evaluate the utility of dorsal patellar fracture plating as the method for surgical treatment of patellar fractures. Our primary objective was to

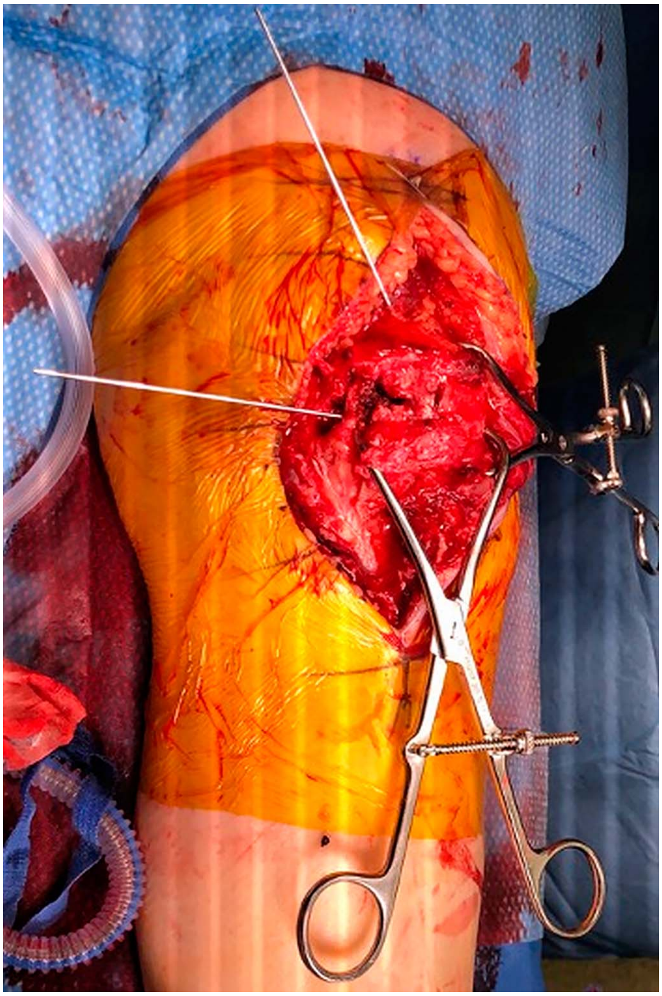

Fig. 4
Clinical photograph demonstrating the preliminary reduction efforts.

evaluate reoperation rates and the complications of plating of patellar fractures that require secondary surgery. Secondary outcomes included patient-reported outcome (PRO) data, as well as other negative outcomes.

Materials and Methods

Our study was approved by the St. Francis Health System and St. John Health System institutional review boards in Oklahoma. The patients were selected by searching the medical records of our trauma practice using the patellar repair Current Procedural Terminology (CPT) code (27524). All surgeries were performed between 2012 and April 2020 by surgeons within the same group. It should be noted that patellar plating is not the only way in which these surgeons treat patellar fractures; tension-band fixation was also used during this time period, when indicated, for simple transverse patellar fractures. Initially, our indications for patellar plating were primarily focused on comminuted fractures of the patella; however, over time, our indications for plating have widened to include all fracture types. No patients who had undergone open reduction and internal fixation (ORIF) of the patella with plates and screws were excluded from this analysis. Each patient's demographics, comorbidities, fracture pattern, and intra- and postoperative outcomes were extracted from his or her electronic health record. The extracted data were stored and evaluated in an Excel (Microsoft) spreadsheet. Each patient was reevaluated at standard follow-up visits by the treating surgeon, and standard postoperative radiographs and functional data were obtained. The primary outcome measurement of this study was the need for reoperation in patients with patellar fracture plating. Secondary outcomes included knee pain, infection, wound dehiscence, knee range of motion, loss of reduction, prominent and painful knee hardware, and knee outcome scores. Knee outcome scores were based on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) surveys. For secondary outcomes, follow-up of ≥12 weeks was required for inclusion in our analyses, and follow-up for ≥12 months was required for inclusion in our WOMAC survey analysis.

Surgical Technique

A standard surgical technique for exposure of the patella using a vertical dorsal incision was used for all fractures that were evaluated in this study. First, the superficial fascia was opened, and the fracture was exposed. Next, the hematoma was evacuated and the deep fascia and the periosteum over the patella were lifted off of the dorsal surface to expose the fracture edges and provide another layer of soft-tissue coverage over the plate. We then reduced the fracture using Kirschner wires as joysticks as well as point-to-point clamps. Additional Kirschner

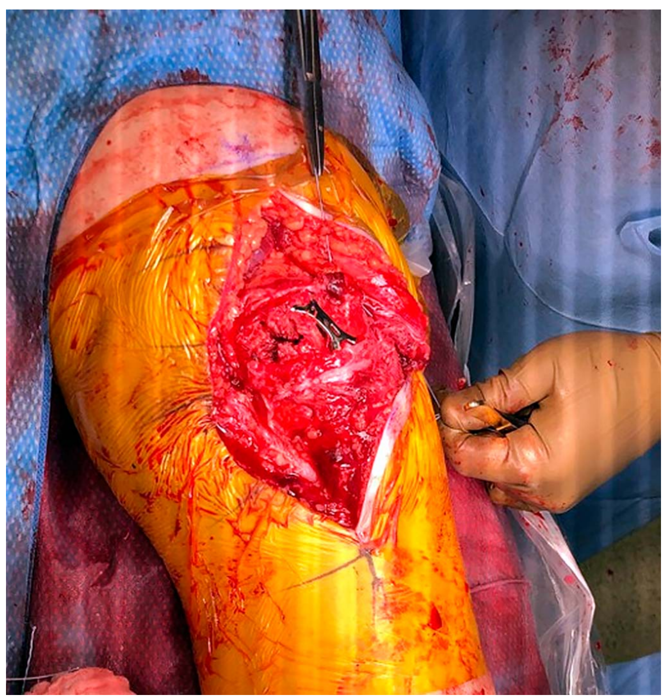

Fig. 5
Clinical photograph demonstrating the final intraoperative reduction with the patellar plate.

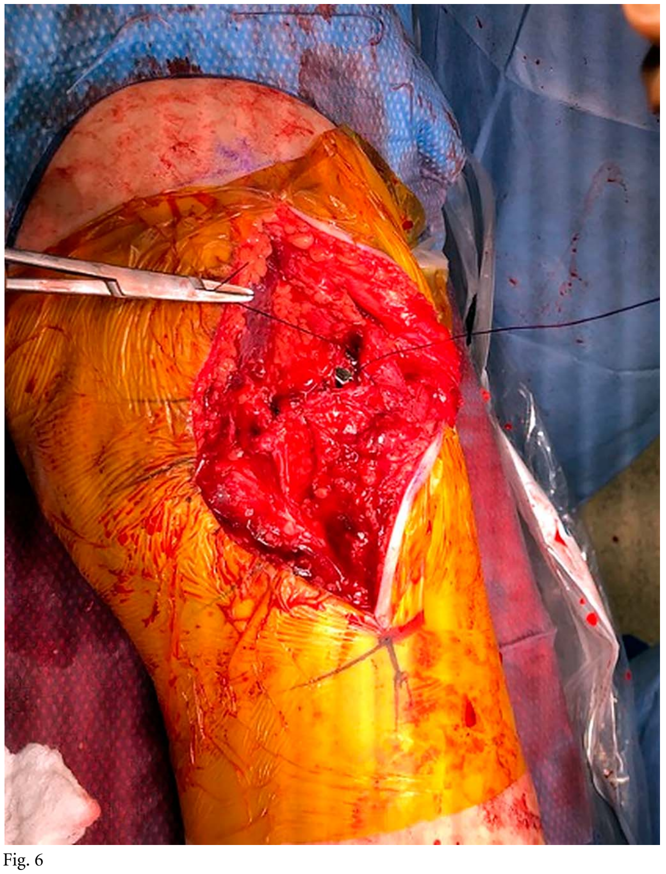

Fig. 6
Clinical photograph demonstrating closing of the fascia over the patellar plate.

wires were used in the patella to provisionally stabilize the fracture. Once the fracture had been reduced and stabilized, the joint was visualized via the retinacular tears and, in some cases, with extension of the retinacular tear via a lateral parapatellar extension. Occasionally, independent 2.4 and 2.7-mm lag screws were placed to hold the comminuted fragments. Then, an appropriately sized off-label plate (most frequently, a 2.0-mm cuboid foot plate [Synthes]) was placed dorsally and secured with up to 4 locking and nonlocking screws per plate. Next, we used direct visualization and a C-arm to confirm the adequacy of the reduction and screw placement. Any retinacular tears were then repaired with 2-0 polydioxanone (PDS; Ethicon) or other heavy suture. Following repair of any retinacular tears, the knee was placed through near-full range of motion to test the stability of the repair. The deep fascia was closed over the plate, followed by the superficial fascia and then a third layer consisting of the subcutaneous tissue and the skin (Figs. 1 through 6).

Postoperatively, the knees were placed in an immobilizer and the patients were allowed to bear full weight immediately while wearing the brace. The brace was removed at 2 weeks, and weight-bearing on level surfaces without the brace was allowed as tolerated. Patients were instructed to avoid stair climbing and rising from a chair with weight on the injured leg. Isometric quadriceps strengthening was encouraged, but no concentric or eccentric exercises were begun until a minimum of 6 weeks postoperatively.

Objective Outcome Measures

Patients were followed at multiple intervals from 4 to 52 weeks postoperatively. Demographic variables and comorbidities were extracted and measured for all patients. The fracture type and whether the injury was open or closed were recorded. We also evaluated variables such as the presence of osseous or functional union at 12 to 16 weeks for each patient. Complications, such as infection or wound complications, loss of reduction, and the need for secondary surgery, were also noted. Each knee was taken through a series of range-of-motion evaluations, and range of motion in flexion was measured for each patient at 4 to 8 and 12 to 16 weeks postoperatively. Statistical comparisons were analyzed using paired t tests and the Fisher exact test, with a prespecified significance threshold of $p = 0.05$.

PROs

PROs were included for all patients with ≥12 months of follow-up. PROs were recorded using the WOMAC score, which has previously been validated for use with issues other than osteoarthritis, including for femoral neck fractures[9]. We evaluated many PRO questionnaires and felt that the WOMAC provided the most relevant information regarding patient function and satisfaction, and could easily be applied to the treatment of patellar fractures with plating. The WOMAC score is a score with 3 dimensions: pain, stiffness, and functional mobility, with these factors scored as none (a score of 0), slight (1), moderate (2), severe (3), or extreme (4). The WOMAC score was determined by adding the aggregate scores for pain, stiffness, and function. In our evaluation, a total score of 96 meant maximal pain, stiffness, and difficulty with functional mobility, while a score of 0 represented no pain, stiffness, or difficulty with functional mobility. All of the patients were called and asked to complete the questionnaire over the telephone; if a patient could not be reached, questionnaires were mailed at various intervals. Statistical comparisons were analyzed using paired t tests and the Fisher exact test, with a prespecified significance threshold of $p = 0.05$.

Source of Funding

No funding was received for this study.

Results

We identified 85 patients who were treated with ORIF via plating over a 9-year period (from 2012 to 2020) (Fig. 7). The mean age of the patients was 52.66 years (range, 18 to 88 years). Fifty-two (61.18%) of the patients were women. Sixty-five patients (76.47%) in our population self-identified as White, 10 (11.76%) identified as American Indian, 7 (8.24%) did not specify their race, 2 (2.35%) identified as Hispanic, and 1 (1.18%) identified as African American. The average body mass index of our patient population was 27.81 kg/m^2 (range, 18.1 to 43.0 kg/m^2) (Table I). Of the fractures, 63 (74.12%) were classified as comminuted and 22 (25.88%) were classified as transverse or simple patterned.

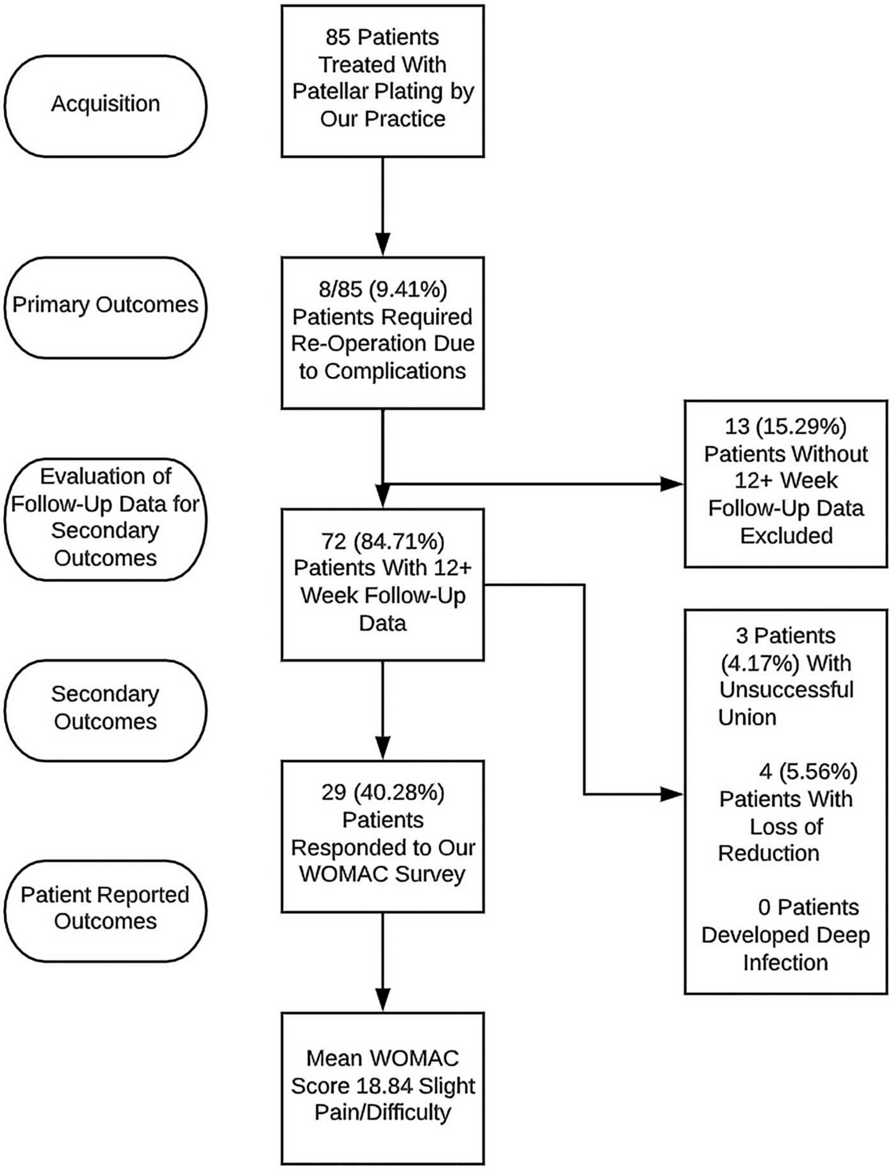

Fig. 7
Flowchart demonstrating patient acquisition and the outcomes process. WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

Reoperation was required in 8 (9.41%) of the patients in our sample. Of these secondary surgeries, 4 (4.71%) were needed due to wound dehiscence (2 because of noncompliance that resulted in falls, and 2 in patients who had substantial peripheral vascular disease, 1 of whom required an above-the-knee amputation). Additionally, 2 secondary surgeries (2.35%) were needed due to the patient reporting painful hardware. Lastly, 1 secondary surgery (1.18%) was required for loss of reduction, and 1 (1.18%) was necessary for posttraumatic contractures about the knee joint.

Of the patients who needed a secondary surgery, 5 of 8 (62.5%) had comorbid medical conditions or risk factors. In our patient sample, comorbidities such as diabetes, smoking, and illicit drug use were not associated with a significant increase in reoperation rates (Table II). However, diabetes and drug use were associated with an increased odds ratio (OR = 2.29 and 1.25, respectively) for reoperation (Table II).

Of the 85 patients in our sample, 72 (84.71%) had complete follow-up data at ≥12 weeks postoperatively (Fig. 7). Of these 72 patients, 3 (4.17%) had nonunion at the fracture site at 12 to 16 weeks postoperatively; however, these nonunions eventually healed, and reoperation for nonunion was not needed in these patients. Four of the 72 patients (5.56%) had loss of reduction or imperfect reduction of the fracture at 12 to 16 weeks postoperatively. No patients developed a deep infection or septic arthritis of the knee joint. On average, patients were able to flex their knee to 110° at the 12- to 16-week postoperative period.

TABLE I Characteristics of Study Population*

Age *(yr)*	
Mean and SD	52.66 ± 18.61
Range	18-88
Sex *(no. [%])*	
Men	33 (38.82)
Women	52 (61.18)
BMI *(kg/m²)*	
Mean and SD	27.82 ± 6.07
Range	18.10-43.00
Fracture type *(no. [%])*	
Open	9 (10.59)
Closed	76 (89.41)
Diabetes *(no. [%])*	
Yes	19 (22.35)
No	66 (77.65)
Smoker *(no. [%])*	
Yes	24 (28.24)
No	61 (71.76)
Illicit drug use *(no. [%])*	
Yes	3 (3.53)
No	82 (96.47)
Comminuted patellar fracture *(no. [%])*	
Yes	63 (74.12%)
No	22 (25.88%)

*No. of patients = 85. SD = standard deviation, and BMI = body mass index.

PROs at ≥12 Months of Follow-up

We received WOMAC survey responses for 29 (40.28%) of the 72 patients in our sample (Fig. 7). All 29 patients in our sample were ≥12 months out from their patellar ORIF with dorsal plating when the survey was performed. The mean follow-up for the WOMAC survey was 28.28 months (range, 12 to 103 months). The median follow-up was 21 months. Among our sample, the average WOMAC score was 18.84 (indicating slight symptoms overall). Our patients' highest scores (indicating the most symptoms) were found in the sections of the survey that described morning stiffness, difficulty bending to the floor, difficulty with ascending stairs, and difficulty with descending stairs. Five patients (17.24%) reported a score of 0, with no pain, stiffness, or difficulty with any activities. Seventeen patients (58.62%) reported a score from 1 to 24 (indicating slight symptoms), 4 patients (13.79%) reported a score from 25 to 49 (indicating moderate symptoms), 3 patients (10.34%) reported a score from 50 to 74 (indicating severe symptoms), and no patients (0%) reported a score from 75 to 96 (indicating extreme symptoms). These results indicated that 72.41% of the patients in our sample had slight or no symptoms at a mean of 28.28 months postoperatively. The longest follow-up was 103 months in 1 patient, and the WOMAC score, which was 11, indicated only slight symptoms at nearly 9 years postoperatively.

Discussion

In this study, we retrospectively analyzed the rate of reoperation as our primary outcome. Additionally, we analyzed the rate of loss of reduction and other complications associated with patellar plating. Finally, we evaluated PROs for patients with ≥12 months of follow-up.

In our sample of 85 patellar fractures, the overall reoperation rate was 9.41% (8 of 85). Two patients required reoperation due to wound dehiscence because of falls in the early postoperative period, and 2 required reoperation due to vascular deficiency. Only 2 patients (2.35%) required reoperation due to painful hardware, 1 required reoperation for the loss of fracture reduction, and 1 (1.18%) required reoperation due to posttraumatic contracture about the knee joint. Our analysis demonstrated an increased likelihood of reoperation following patellar plating in patients with diabetes (OR, 2.29), although this was not significant. Furthermore, almost all of our patients went on to achieve successful union of their fracture while also maintaining fracture reduction. In contrast to the results

TABLE II Characteristics of Complications*

Union at 16 weeks† *(no. [%])*	
Yes	69 (95.83)
No	3 (4.17)
Reduction maintained† *(no. [%])*	
Yes	68 (94.44)
No	4 (5.56)
Wound dehiscence† *(no. [%])*	
Yes	4 (5.56)
No	68 (94.44)
Reoperation‡ *(no. [%])*	
Yes	8 (9.41)
No	77 (90.59)
Diabetes (19 total) + reoperation *(no. [%])*	P = 0.29, OR: 2.29 (95% CI: 0.49-10.60)
Yes	3 (15.79)
No	16 (84.21)
Smoker (24 total) + reoperation *(no. [%])*	P = 0.83, OR: 0.83 (95% CI: 0.16-4.45)
Yes	2 (8.33)
No	22 (91.67)
Drug use (3 total) + reoperation *(no. [%])*	P = 0.89, OR: 1.25 (95% CI: 0.06-26.36)
Yes	0 (0.00)
No	3 (100.00)

*OR = odds ratio, and CI = confidence interval. †No. of patients = 72. ‡No. of patients = 85.

described above, studies evaluating other methods of patellar fracture fixation have indicated that reoperation rates can be much higher than those that were seen in our patient population. Furthermore, our population primarily had comminuted fractures, indicating a higher degree of case complexity. Egol et al. evaluated 36 patellar fractures in which 11 (30.6%) had to undergo subsequent reoperation due to hardware pain or failure[7]. Additionally, Shea et al. recently evaluated reoperation rates of 3 separate techniques[10]. Their sample consisted of 87 fractures, of which 34 (39.1%) underwent subsequent reoperation, primarily due to hardware pain or failure; however, there were also 2 cases in which reduction was lost. Hsu et al. similarly found a high rate of reoperation when utilizing nonplating techniques for treating patellar fractures; approximately half of the 170 patellar fractures in their sample required reoperation and implant removal due to painful and prominent hardware[11]. Lastly, Dy et al. performed a systematic review and meta-analysis of 24 studies with 737 patellar fractures, none of which were treated with dorsal plating. They found an overall reoperation rate of 33.6% among this very large sample[12].

There have been several recent studies examining reoperation rates of patellar fracture plating. Ellwein et al. evaluated reoperation rates in 19 patients with primary patellar fractures that were first treated with patellar plating using the StarPlate and ArrowPlate (Arthrex) systems[13]. In their sample, 4 (21.1%) underwent reoperation due to postoperative complications; 1 (5.3%) of these reoperations was due to anterior knee pain. Wurm et al. also evaluated the treatment of patellar fractures with the StarPlate and ArrowPlate systems; they found that 11 (18.6%) of their 59 patients who were first treated with patellar plating underwent subsequent reoperation for "various" reasons[14]. Lastly, Lorich et al. conducted a prospective study evaluating their method of plating for patellar fractures[8]. In their sample of 25 patients who were treated with patellar plating, none underwent reoperation due to loss of reduction, nonunion, or painful hardware.

The remarkably lower incidence of reoperations and complications that is seen with patellar plating when compared with other techniques indicates that this technique provides a health-care and economic advantage for our patients and the health-care system in general. The reoperation rates for other techniques range from approximately one-third to one-half of all cases[7,10-12]. Following reoperation, patients are subject to additional time off from work, further rehabilitation, a risk of infection, and added expense, not to mention surgical discomfort. Because plate constructs are biomechanically superior to tension-band and independent screw constructs[15,16], this alternative surgical procedure with a lower risk of negative consequences should be greeted with enthusiasm. Considering our findings, we advocate for a large prospective randomized trial evaluating patellar plating versus other fixation methods.

Finally, our prospective data collection with WOMAC functional knee outcome scores showed promising data that favor the plating of patellar fractures. With a 40.28% response rate at a mean of nearly 30 months following surgery, 75.86% of the patients in our sample had slight or no symptoms at ≥12 months postoperatively.

Our study has several strengths. First and foremost, to our knowledge, this study is the largest compilation of primary patellar fractures that were initially treated with patellar plating. Another strength was the long follow-up period, specifically obtaining PROs from patients who had been treated ≥12 months to almost an entire decade ago. Furthermore, our study included >10 surgeons (including some fellows) who used this technique, which offers credence to a low learning curve for patellar plating. Additionally, our study may provide the most generalizable results for surgeons to appraise when critically evaluating the use of patellar plating for their practices.

This study was not without its limitations. Although we had a relatively large sample size, our data were retrospective in nature, and prospective data regarding this topic would be preferable. In addition, obtaining a substantial amount of long-term patient-reported data proved difficult (we were unable to obtain patient-reported functional outcome scores from over half of our patients). Furthermore, it is possible that patients who were lost to follow-up had subsequent reoperations or complications that were treated by other surgeons, which would not have been captured in our review. Future research is needed on patellar plating, and large prospective randomized studies evaluating long-term objective and subjective data points would provide the necessary data to determine the overall utility of this method of fixation.

In summary, patellar plating in our cohort proved to have a much lower reoperation rate than other techniques that have been described in the literature. In addition, our sample had a lower reoperation rate than many other recently published patellar plating studies. Our retrospective data and prospective PROs, along with evidence from previously published studies, provide evidence of the utility, safety, and efficacy of patellar plating, especially for complex or comminuted patellar fractures. Dorsal plating may allow for early return of function and less postoperative bracing. The lower reoperation and complication rates found among patellar fractures that were treated with plating indicate a possible societal benefit to both patients and health-care systems. Future research is needed to solidify the use of and indications for patellar fracture plating. ■

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