

Patellar Fixation Following Fracture: A Retrospective Review of Outcomes Following Varying Surgical Interventions

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ABSTRACT

PURPOSE: Patella fractures are a common injury in trauma patients and can be treated with a multitude of different fixation methods. With so many fixation techniques available, no current consensus exists on best practices for patients presenting with this injury. The purpose of this analysis is to review the multiple different patella fixation strategies and to evaluate the outcomes and complications associated with each.

METHODS: One hundred and fifteen patients who underwent patellar fracture fixation at an urban Level I-Trauma center were retrospectively reviewed. Operative treatment included open reduction and internal fixation with plate and screw devices, tension band wiring (TBW), cannulated screw tension band wiring (CS-TBW), isolated interfragmentary screw fixation, or partial patellectomy with soft tissue repair and tendon advancement. Patient demographics, fracture and injury characteristics, operative variables, radiographic information, and post-operative outcome measurements were recorded for each patient assessed in the study.

RESULTS: Results demonstrated that plating techniques had the highest overall rate of union. Furthermore, a significant decrease in implant removal with utilization of isolated suture/wire was appreciated compared to other fixation groups ($p < 0.01$).

CONCLUSION: We conclude that plate utilization achieves high radiographic union compared with other fixation methods.

Key words: Patella Fracture; Orthopedic Trauma; Retrospective Review; Extensor Mechanism Disruption; Hardware Removal

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INTRODUCTION

The patella is the largest sesamoid bone in the body^[1]. It serves as a protective shield for the knee joint and enhances the strength of the quadriceps muscle by acting as a fulcrum for knee extension, which plays an essential role in the kinematics of the lower extremity^[1,2]. Though these fractures are relatively uncommon, 10.7 per 100,000 people per year^[1] and 1% of all skeletal injuries^[2-5], they are often encountered following direct impact or from an indirect eccentric contraction. Management of these fractures may be challenging and several factors should be considered when selecting treatment. Patient factors such as previous ambulatory status and medical comorbidities, in addition to physical examination findings of extensor mechanism integrity, fracture displacement, degree of comminution and available bone stock are important.

Fractures of the patella may be treated conservatively or surgically. Conservative management may be ideal for the patient who is non-ambulatory, had a prior failed extensor mechanism, those with an ankylosed joint, or particular fracture characteristics. Typically, this involves immobilization of the extremity in full extension with partial weight bearing for several weeks. If the injury is not amendable to conservative management, then surgical intervention is merited to mitigate disability. However, surgical management of patellar fractures is complicated secondary to its various tendinous attachments, which serve as displacing vectors on fracture fragments making fracture alignment not easily amenable to fixation^[2,6]. Such treatments include tension band fixation utilizing K-wires with tension band wiring, circumferential cerclage wiring, cannulated screws with tension band wiring (Figure 1), interfragmentary screw compression with circumferential cerclage wiring, plating, and partial or complete patellectomy^[7-10]; each of which has advantages and drawbacks. Moreover, the subcutaneous location of the patella renders its fixation with various implants subject to post-operative symptomatic hardware prominence^[7,10-12]. While several small studies have compared outcomes^[13-16], a recent Cochrane review of randomized controlled trials^[1] concluded that overall evidence is of low quality and insufficient to conclude best treatment method for patella fractures. With paucity in the current literature, a comparison of patella fixation methods is merited.

The purpose of this retrospective review was to report on the clinical and radiographic outcomes of patellar fractures treated with various modalities. To our knowledge, no extensive review of various treatment modalities for patella fractures has been reported in the current literature. A more comprehensive understanding of these constructs may improve postoperative patient outcomes.

MATERIALS AND METHODS

A retrospective chart review was conducted on 115 patients who underwent operative fixation following acute patellar fractures between January 1st, 2010 and January 31st, 2017; all patients were treated by one of five fellowship-trained orthopedic trauma surgeons at an urban Level-1 Trauma Center. Operative treatment included open reduction and internal fixation with plate and screw devices, tension band wiring (TBW), cannulated screw tension band wiring (CS-TBW), isolated interfragmentary screw fixation, or partial patellectomy with soft tissue repair and tendon advancement. Selection of surgical intervention technique was based on surgeon preference and patellar fracture characteristics; this was not randomized or controlled for this investigation. Patients were excluded from the study if they met any of the following criteria: (1)

age less than 18 years, (2) having undergone a complete patellectomy, (3) having had previous patellar fracture or extensor mechanism surgery. Electronic and written medical records were utilized to collect patient data, which was assembled in a database (Microsoft Excel, Redmond, WA). Patient demographics, fracture and injury characteristics, operative variables, radiographic information, and post-operative outcome measurements were recorded for each patient assessed in the study. Formal Institutional Review Board (IRB) approval was obtained prior to initiation of this investigation.

Statistical analysis was performed, with means, ranges and confidence intervals calculated for continuous variables and compared using student's t-tests. Frequencies were calculated for continuous variables and compared using Fisher's exact test for increased accuracy in small proportion analysis. A significance level of $p < 0.05$ was set as significant, with a trend defined as a p value being between 0.05 and 0.1.

RESULTS

A total of 115 patients met the inclusion and exclusion criteria, with an average age of 48 years (range, 18-87). Of the patients assessed, 62 patients (53%) were male, 20 patients (17%) had diabetes mellitus, and 19 patients (16%) had a history of osteoporosis. Furthermore, the most common mechanisms of injury were motor vehicle collision and fall; 49% and 41%, respectively. Analysis of demographical data revealed no differences between all the treatment groups except for younger patients, who were more likely to be treated with screw only fixation versus plating. Screw only fixation had an average age of 35 years (range, 26-63), while plating had an average age of 48 years (range, 18-76) ($p = 0.02$). No statistical significance between groups was otherwise detected (Table 1).

Of the patients enrolled in this investigation, 18 (16%) underwent surgical repair with plate and screws, 24 (20%) with tension band wiring, 15 (13%) with tension band wiring augmented by cannulated screws, 9 (8%) with interfragmentary screws, 24 (21%) with suture/wire repair alone, and 24 (21%) received a combination treatment with two or more of the fixation methods. Radiographic union was defined as the presence of cortical continuity and the progressive resolution of fracture lines on post-operative radiographs. Rates of radiographic union and implant removal for the respective treatment groups are shown in Table 2. Plating techniques had the highest rate of union, and was found to have a trend toward increased union as compared to tension band wiring and suture/wire treatment (84% vs 58%, $p = 0.10$). There was no difference in radiographic union rate between plating and cannulated screw tension band wiring (84% vs 67%, $p = 0.40$). A significant decrease in implant removal with suture/wire treatment compared to the other three fixation groups was appreciated ($p < 0.01$), with no discernable differences between plating, tension band wiring, and cannulated screw tension band wiring (Table 2). No difference in post-operative range of motion, hardware failure, duration of procedure, or length of hospital stay was found in any treatment option.

DISCUSSION

Patellar fractures account for a considerable portion of traumatic musculoskeletal injuries, and despite a multitude of proposed treatment options, there exists a lack of evidence-based investigations proposing which method of fixation is superior. Plate and screw devices, tension band wiring, cannulated screw tension band wiring, interfragmentary screw fixation, and partial patellectomy and tendon repair are currently the most commonly conducted fixation methods

for patellar fractures, with no established consensus on best practices for these patients. Our report demonstrates a trend toward increase union rate with the utilization of plate fixation. Additionally, we demonstrate a significant decrease in implant removal following utilization of suture/wire treatment.

The challenge accompanying patellar fixation lies with its extensive soft tissue connections and subcutaneous location. Daily tasks such as maintaining an erect position, rising from a chair, and ambulation, are of paramount importance on a patient’s quality of life. Because the patella is embedded between two large tendons, the quadriceps and patellar tendons, deforming forces provide a significant challenge when dealing with this matter. This comes not only with obtaining adequate fracture reduction, but providing a repair strong enough to withstand the pull of these deforming forces on a daily basis thereafter. Forces up to five times the body weight are transmitted across the extensor mechanism of the knee^[5].

Adult patellar fractures are most commonly classified based on fracture pattern. The position of knee flexion at the time of injury also plays a role in the type of fracture that occurs. With higher degrees of flexion, the proximal aspect of the patella at the patellofemoral joint endures greater stress, which contributes to a higher percentage of proximal pole fractures. Direct force to the knee often results in fracture comminution, and indirect forces are more likely to account for transverse fractures^[2]. However, transverse fractures may also result from direct impact, usually with the knee at ninety degrees of flexion. Despite, the mechanism, operative indications for patellar fractures are well established^[2,5,17]. Among these indications are extensor mechanism failures, open fractures, pediatric patellar sleeve fractures, and articular step off greater than 2 mm. These fracture characteristics play an important role in selecting treatment modality.

Historically, comminuted patella fractures were managed with total patellectomy^[18]. With a better understanding of the importance

of this bone and a growing emphasis on maintaining as much patella as possible^[2], this procedure is rarely utilized today despite reported satisfactory outcomes^[3]. Several surgical fixation strategies have been developed to help manage these fractures and are now frequently employed. Tension band wiring was among the first employed surgical treatments, which allows for the conversion of tension force at the anterior surface of the patella to a compression force at the articular surface^[2,9,19,20]. Poor biomechanical strength in vivo led to the exploration of augmenting this tension band wire technique with

Table 1 Patient Demographics and Injury Characteristics.

Variable	Result
Age (years)	47.8 ± 19.0 (18-87)
Sex (Male)	62 (52.5%)
Diabetes Mellitus	20 (16.9%)
Tobacco Use	62 (52.5%)
Osteoporosis History	19 (16.1%)
Employed	46 (39.0%)
Fully Ambulatory	113 (95.8%)
Mechanism of Injury	
Motor Vehicle Collision	58 (49.1%)
Fall/Crush	48 (40.7%)
Direct Blow	2 (1.7%)
Other	10 (8.5%)
Open Fracture	29 (24.6%)
Laterality (Left)	57 (48.3%)
Isolated Injury	55 (46.6%)

* Categorical variables are given as absolute numbers with percentages in parentheses. Non-categorical variables are given as means ± standard deviations, with ranges in parentheses.

Table 2 Fixation Outcomes.

Technique	Radiographic Union Rate	Implant Removal
Tension Band Wiring	58.30%	50.00%
Tension Band with Cannulated Screws	66.60%	26.70%
Plating	83.30%	44.40%
Suture/Wire Repair	58.30%	4.10%



Figure 1 AP radiograph of a patella fracture treated with cannulated screws and tension band wiring.



Figure 2 Lateral radiograph of a patella fracture in an osteopenic patient treated with a mesh plate.

that of cannulated screws^[9,21,22]. Since, tension band wiring positioned through cannulated lag screws has gained in popularity^[9,22,23], as it was demonstrated to have superior biomechanical performance compared with anterior tension band wiring with Kirschner wire fixation alone^[9,21,24,25]. Additionally, interfragmentary screw fixation has also demonstrated successful use^[24]. Yet most recently, patellar plating has demonstrating even greater biomechanical strength than tension band wiring with cannulated screws, promoting it as a popular treatment modality for patella fractures^[7,8,26-36]. These plates offer several theoretical advantages, including adequate fixation while maintaining a low rate of hardware prominence and failure, and may be used in difficult fractures that typically undergo poor fixation or even excision/partial patellectomy. This may be a good option particularly for the osteopenic patient^[7] (Figure 2).

The fracture characteristic frequently dictates treatment. Generally, fractures that are at either the superior or inferior poles of the patella, or those not amendable to tension band wiring or interfragmentary screw fixation, have been treated with partial patellectomy with variable success^[9,17,19,21,22,26-30,37-40]. Classically, transverse fractures without comminution are commonly treated with Kirschner wire fixation with or without cannulated screw utilization^[10,12,41]. Several small case series have demonstrated significant rates of tension band failures after early rehabilitation^[7,14-16,41]. However newer techniques may reduce the incidence of this implant failure^[6,17]. In addition, wire fixation is relatively poor in regards to its biomechanical stability, and the high rates of hardware failure and loss of fracture reduction reveal this to be a relatively poor construct in vivo. Due to these poor results, there has been a movement to create more stable constructs, including the use of cannulated screws, which have been shown to be biomechanically superior in several studies, as well as have clinical success in several recent reviews^[9,11,21,22]. However, the use of isolated screws is only recommended in simple fracture patterns in the absence of comminution^[10]. Additionally, lag screws are frequently utilized in patellar fractures, most commonly as a substitute to, or in combination with, tension band wiring or for compression of large fragments.

More recently, plating techniques have been described with some considerable success. Previously, we reported on such utilization of plate and screw techniques with successful union rates^[7]. Interestingly, no patient required hardware removal secondary to implant prominence. Both variable angle locking plates (X-plates) and mesh plates were used in the study, with a preference towards mesh plating in the setting of comminution. Success of plating techniques compared to TBW and CS-TBW has since been demonstrated^[10]. Similarly, plating techniques had the least reported symptomatic hardware^[7]. Lastly, with significant comminution, partial or complete patellectomy is considered. Bostman and colleagues compared the outcomes of fragment excision with that of internal fixation for comminuted patellar fractures and found that poor outcomes were observed when greater than 40% of the patella was removed^[37]. Care should be taken to leave as much of the intact bone as possible, as well as, avoid resection of the inferior pole due to the largest arterial contribution to the patella entering inferomedially^[6]. Total patellectomy, on the other hand, should be avoided when at all possible^[37].

Despite several treatment modalities, there are several limitations and drawbacks to their utilization. Due to the superficial nature of the patella, prominence and pain remains problematic and often requires hardware removal^[17]. Lazaro and colleagues found an 80% incidence of anterior knee pain following tension band wiring, cannulated screw tension band wiring, or suture fixation, with 37% undergoing

implant removal^[6]. Hoshino et al. found that patients who were treated with Kirschner wires alone were twice as likely to undergo implant removal than those treated with screw fixation, potentially jeopardizing the repair^[12].

There are several limitations to our study. First, it is susceptible to inherent limitations of its retrospective nature. Despite its inherent limitations, it provides a comprehensive review of various patellar fracture fixation methods in a wide-based trauma population. Secondly, selection of treatment was at the discretion of the operating surgeon. As this was not a blinded study, surgeon preference and familiarity with the implant use may influence postoperative outcomes. Notwithstanding similar demographic patient profiles and operative details, we were unable to discern any differences in rates of hardware removal, length of hospital stay, or other complication rates. Furthermore, it is important to note that radiographic outcomes do not necessarily parallel that of clinical outcomes. Although radiographic union and anatomic fracture reduction will commonly correlate to satisfactory clinical performance, future research could investigate patient-reported functional outcomes a period after surgery, which were not evaluated in this study.

CONCLUSION

Patellar fractures may pose significant challenges for the treating surgeon. In the largest review of surgically managed patellar fracture fixation utilizing varying modalities, our report suggests an increased radiographic union following plating. Despite hardware removal being one of the most commonly reported complications of patellar fracture repair, no significant differences in hardware removal between plating, TBW, and CS-TBW was observed. Larger prospective trials comparing the various modalities are needed.

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