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Mini Review

Surgical Management of Patella Fractures: A Review

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Abstract

Patella fractures are a common orthopaedic injury caused by either a direct blow to the anterior knee or excessive tension through the extensor mechanism. These fractures can result in acute disruption of the knee extensor mechanism, knee stiffness, and post-traumatic patellofemoral arthritis. Indications for operative fixation of patellar fractures are either disruption of the extensor mechanism or >2-3mm articular step-off and >1-4 mm of fracture displacement. Multiple operative techniques exist for surgical fixation of patella fractures, however there is a high risk of postoperative complications, most frequently symptomatic hardware. This review will highlight the anatomy, mechanism of injury, and treatment algorithm for patella fractures, including recent advancements in surgical technique to optimize outcomes and minimize complications.

Keywords: Patella fracture, Knee, Trauma, Review, Tension band, Plate fixation, Patellectomy

Introduction

Patella fractures account for 1% of fractures in adults and are seen in all age groups. The treatment options for fractures requiring surgery have evolved over time in response to postoperative complications and with the advent of new technologies which optimize fixation [1]. The most commonly used historic treatment technique is open reduction with a tension band construct utilizing longitudinal Kirschner wires (K-wires) with stainless-steel wires bent into a figure of 8 pattern anterior to the patella [2,3]. Complications of this technique however include symptomatic hardware requiring reoperation for removal, and loss of fixation requiring reosteosynthesis [4]. As a result of these complications, alternative techniques for patella fracture fixation have been developed [5]. These techniques, which may be used in the treatment of different fracture patterns, include the use of cannulated compression screws, non-metal tension bands, and anterior patellar plating. Multiple surgical techniques currently exist, each with their own indications, risks, and benefits.

Patellar Biomechanics and Anatomy

The patella is the largest sesamoid bone in the body and is located anterior to the knee joint. The quadriceps tendon and fascia lata insert into the anterosuperior margin while the patellar tendon originates from the inferior margin. The medial retinaculum which is formed by the vastus medialis and quadriceps aponeurosis, and lateral retinaculum which is formed by the vastus lateralis and the iliotibial band, together aid in knee extension. The anterior aspect of the patella is subcutaneous, and the posterior aspect is covering with the thickest articular cartilage in the body. The posterior articular facet is composed of the medial and lateral facets, separated by a median vertical ridge. The most medial aspect of the medial facet also contains the odd facet, which articulates with the femur during deep flexion. The patella primarily functions as the articulating fulcrum to increase the moment arm of the quadriceps and improve effective knee extension capacity [6].

Mechanism of Injury

Patella fractures can result from a direct blow to the patella, or an indirect mechanism of forceful eccentric contraction of the quadriceps. Direct blows, such as those from falls or dashboard injuries, commonly result in stellate or comminuted fracture patterns. In contrast, when the patella fails under tension during forced rapid knee flexion against a contracted quadriceps, a transverse fracture with wide displacement but less articular impaction is mostly commonly seen. Diagnosis of the injury can be made by taking a comprehensive history and correlating with physical exam findings. The patient will often present with difficulty ambulating with a swollen painful knee. An acute hemarthrosis is usually present, and a defect may be palpable between the proximal and distal fracture fragments. A lack of effusion may indicate more extensive soft tissue damage with tearing of the retinaculum. Evaluation of the extensor mechanism is essential; competency of the extensor mechanism is tested by asking the patient to perform a straight leg raise or extend the knee against gravity. Assessment of the skin for abrasions or lacerations is critical, as 6-9% of patella fractures are open [7,8].

Clinical and Radiographic Assessment

Imaging plays an essential role in the diagnosis, classification, and management of patella fractures. Plain radiographs including anteroposterior, lateral, and an axial view is required for accurate diagnosis. The absence of extensor mechanism deficiency does not rule out the presence of a fracture, and radiographs are required in these patients. While standard radiographs are often adequate to diagnose a fracture, obtaining a CT scan may better assess occult or comminuted fractures, and has been shown to change operative management of patella fractures in nearly 49% of cases [9].

Classification

The classification of patella fractures is most frequently descriptive and is based on fracture pattern, degrees of articular involvement, and the amount of fracture displacement. Commonly described fracture patterns are transverse, vertical, stellate, superior pole, or inferior pole. Displacement is categorized as either nondisplaced or displaced.

Treatment

The optimal management in treatment of patellar fractures is to reestablish the extensor mechanism while restoring the articular congruency in the patellofemoral joint [10].

Nonsurgical management: Nondisplaced fractures with an intact extensor mechanism can be treated conservatively with immobilization in a knee immobilizer, locked hinged knee brace, or cast, with full weight bearing. Indications for conservative management include fracture fragment displacement less than 3 mm or articular displacement less than 2 mm.

Surgical management: Indications for operative fixation include disruption of the knee extensor mechanism and fracture patterns with >2-3 mm of articular step-off and >1-4 mm of displacement. Surgical management is selected in patients with injuries fitting these characteristics, unless contraindicated by infection, non-ambulatory preoperative patient status, or critical illness. Multiple surgical methods exist to treat these fracture; the technique is selected on a case by case basis and is guided by fracture pattern and patient characteristics.

Historically, circumferential or intraosseous stainless steel K wires or compression screws alone were utilized and resulted in mixed patient outcomes [3,6,11]. These singular fixation methods required prolonged postoperative immobilization due to the risk of fracture displacement and the relative lack of compression along the articular surface. To address these concerns, the tension band contract was introduced into the fixation and successfully utilized. Tension banding converts the tensile force of the extensor complex at the anterior cortical side of the patella, into a compressive force at the articular surface allowing primary bone healing.

Tension band fixation: A tension band construct is the most common technique for repairing displaced patella fractures, and the technique has progressively evolved to increase rates of union and decrease complications [1,12]. The historic tension band technique involves obtaining an anatomic fracture reduction then placing two transosseous 2.0 mm parallel K-wires along the subchondral bone perpendicular to the fracture. Subsequently, a low gauge stainless steel wire is then wrapped around the K-wires anterior to the patella in a figure of 8-pattern. The subcutaneous nature of the anterior tension band, combined with reported migration of the transosseous K-wires however has resulted in unacceptably high rates of postoperative complications and reoperations. Symptomatic hardware requiring hardware removal and loss of fixing requiring reosteosynthesis are the most common complications. Studies have reported rates of hardware irritation requiring second surgeries for removal of hardware to be as high as 37% [13,14].

Concerns over these frequent complications have prompted modification of the tension band technique [4,5,15]. A modification of the tension band technique utilizes partially threaded cannulated compression screws placed perpendicular to the fracture instead of K-wires. A wire is then passed through the cannulated screws in a figure of 8-pattern to create a tension band anterior to the patella. This modification introduces several advantages when compared to historic K-wires with a tension band. Multiple studies have demonstrated that use of cannulated screws result in high union rates [13,16,17]. Furthermore, biomechanical cadaveric studies comparing K-wires with compression screws have found that screws have significantly higher load to failure and provide superior stability and resistance to fracture displacement than K-wires [18-20]. Compression screws also have lower rates of migration and symptomatic hardware requiring hardware removal when compared to K-wires [4,13,17,21]. Improving the method of transosseous fixation however did not address the hardware irritation resulting from the subcutaneous stainless steel tension band construct lying anterior to the patella.

Tension band technique through cannulated screws has continued to evolve, with the historic metal wires having been replaced by high strength non-absorbable sutures. Studies have demonstrated that facture fixation with suture tension bands result in excellent patient outcomes and high rates of fracture union [22-24]. In addition, suture tension bands cause less hardware irrigation and resultant revision surgery than metal wires [2,3,15]. Busel et al. reported 96% rate of union with 8% rate of symptomatic hardware, comparing very favorably with historic techniques [23,25,26]. Biomechanical studies specifically investigating FiberWire (Arthrex, Naples, FL), an example of a braided nonabsorbable high strength suture, have revealed greater failure strength and superior ability to maintain a tension band under force, when compared to stainless steel tension band wiring [26].

This author's preferred method of fixation is utilizing cannulated compression screws with synthetic high strength nonabsorbable sutures functioning as the tension band (FiberTape Cerclage System; Arthrex, Naples, FL). The FiberTape Cerclage System utilizes the proven combination of cannulated screws and non-absorbable suture, with the added benefit of precise reproducible tensioning [27].

Plate fixation: Fixation of patella fractures with plating is gaining popularity. With the development of more plate options for patella fractures, plating has become a viable option for comminuted stellate fractures, transverse fractures, and inferior pole fractures [3]. Plating options include fixed-angle locking plates and variable-angle mesh-type plates which can be contoured to fit fracture morphology. Thelen et al. showed that a 2.7 mm fixed-angle patella plate prevented fracture displacement under cyclical loading better than cannulated screws and tension banding [19,20]. In addition, mesh plating results in construct stiffness similar to compression screws and tension band, while also improving and maintaining fragment reduction [28,29]. Furthermore, biomechanical models have demonstrated that use of a tension band constructs results in 5 times greater fracture displacement than use of a patella plate [30].

In addition to providing superior fracture stability, low profile plates demonstrate a decreased rate of postoperative complications when compared to traditional fixation methods [31]. These new plate designs have also advanced treatment of inferior pole fractures, enabling these injuries to be effectively fixed. These fractures were difficult to manage; the historic treatment of partial patellectomy has been demonstrated to cause patella baja with mixed clinical results.

Partial patellectomy and suture fixation: Fractures of the inferior pole of the patella are complex; comminution in short segments of distal bone often prevents the use of reconstruction with standard fixation methods. As a result, multiple techniques have been described to address these challenging injuries [3]. In reconstructable inferior pole fractures, fixation with plates, sutures, and suture anchors have been described.

Use of a basket plates and mini-fragment fixation have shown excellent outcomes for the treatment of comminuted distal pole fractures [32]. For non-reconstructable inferior pole fractures which are not amenable to plate fixation, repair using non-absorbable sutures is a viable alternative. Sutures are placed within the patella tendon, passed through the distal fracture fragments and into transosseous tunnels spanning the intact patella proximally, and then tied over the superior pole of the patella [33]. Alternatively, suture anchors can be placed in the inferior aspect of the patella and sutured to the proximal patellar tendon [34]. Both techniques have shown acceptable results while reducing rates of hardware irritation which is frequently seen in distal pole metal constructs.

Highly comminuted inferior pole fracture may also be treated with partial patellectomy. These fractures may have extensive fragmentation and poor bone quality, which may prevent successful anatomic reduction and reconstruction with the techniques listed above. In these fractures, the goals of treatment focus on retaining the stable proximal aspect of the patella in order to maintain a functional knee extensor mechanism [35]. The inferior pole can be excised and the superior patellar tendon is reattached to the remaining intact patellar remnant. Retention of at least 60% of the native patella, with advancement of the patella tendon, has demonstrated satisfactory clinical results [8]. However, partial inferior pole patellectomy decreases the functional lever arm of the extensor mechanism and can results in abnormal patellar tilt and patella baja in 33% and 42% of patients, respectively [35,36]. In addition, 55% of patients undergoing partial patellectomy have been shown to develop osteoarthritis of the patellofemoral joint at 2 years [35,36]. Further studies investigating patellar retention and distal pole fixation are warranted to reduce these unfavorable postoperatively sequela.

Total patellectomy: Total patellectomy may be indicated in patients with failure of previous internal fixation, severely comminuted fractures, nonambulators, or in the setting of infection or tumor. Total patellectomy results in dramatically altered patellofemoral and extensor mechanism mechanics, with a 50% reduction in quadriceps strength [18,37]. Advances in fixation methods however have resulted in notable decreases in the indications and utilization of total patellectomy.

Postoperative Management

No current standardized evidence-based postoperative protocol exists for management and rehabilitation following treatment of patella fractures. Most protocols generally allow immediate postoperative weight-bearing as tolerated while initially keeping the knee fully extended in a knee immobilizer, hinged knee brace, or cylinder cast. After a brief period of immobilization, early knee range of motion of 0 to 30 degrees for 4 to 6 weeks is allowed in patients with stable fixation. After this point, knee range of motion is slowly progressed and exercise programs can be initiated. In patients with partial patellectomy, poor bony fixation, tenuous anterior knee soft tissue, or noncompliance, a long leg cylinder cast in full knee extension can be considered for 6 weeks prior to initiating range of motion [6].

Summary

Patella fractures are common and present in a variety of fracture patterns. Multiple techniques exist for management and the treatment options are dictated by fracture comminution, displacement, and integrity of the extensor mechanism. The goal of all fixation methods is to achieve an anatomic reduction with a construct that can tolerate early knee range of motion while resisting fracture displacement. Modern techniques and implants attempt to achieve these goals while minimizing symptomatic hardware irritation. Careful consideration of the fracture pattern and the use of non-absorbable suture tension bands through cannulated compression screws or low profile patella plates can improve patient outcomes and decrease complications.

Declarations of Interest

None.

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