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Patellar Fractures Following Total Knee Arthroplasty: A Review

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ABSTRACT: There are several periprosthetic complications associated with total knee arthroplasty, with femoral fracture as the most common and patellar fractures as the second most common. Patellar fractures are challenging complications that occur almost exclusively on the resurfaced patellae, although unresurfaced patellar fractures have been reported in literature. The purpose of this study is to describe the anatomy of the patella, the etiology of patellar fractures, and strategies to treat and manage these fractures following knee arthroplasty. The vascular supply to the patella may be compromised during total knee arthroplasty and special care must be taken to preserve it. Vessel injury may result in further complications, most notably avascular necrosis with subsequent fracture. Other patient-, surgical-, and prosthetic-related factors can contribute to increased risk of patellar fracture. Patellar fractures are classified into three types. Type I fractures have an intact extensor mechanism with a stable implant. Type II fractures have a complete disruption of the extensor mechanism with or without a stable implant. Type III fractures, which are further subclassified into types IIIa and IIIb, have an intact extensor mechanism but a loose patellar component. While type IIIa fractures have reasonable remaining bone stock, type IIIb fractures have poor bone stock. Type I patellar fractures may be best managed nonoperatively, but types II and III patellar fractures often necessitate surgical intervention. Patellectomy should be reserved for comminuted fractures, as well as fractures in patients with poor bone stock. Larger prospective randomized studies are necessary to better evaluate the treatment algorithm for patellar fractures following total knee arthroplasty.

KEY WORDS: Patella; fractures; total knee arthroplasty; replacement

I. INTRODUCTION

Complications related to the extensor mechanism following total knee arthroplasty (TKA), including patellofemoral instability, fracture, loosening, wear, clunk, patellar tendon rupture, subluxation, and avascular necrosis,[1] may account for as much as 50% of all revisions associated with TKA. In particular, the incidence of patellar fracture, which has been reported to be as high as 21%, stands as one of the most challenging complications to orthopaedic surgeons performing knee arthroplasties.[2] The burden of this complication may be underestimated, as some patients are asymptomatic and are not diagnosed until incidental findings are made on radiographic examination.[3]

Fractures of resurfaced patellae appear much more frequently than fractures of unresurfaced patellae,[3] and surgeons often choose not to resurface the patella to avoid this complication. In addition, femoral components that are believed to be friendly to patellofemoral

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congruency have been associated with low fracture rates. Furthermore, increased understanding of knee kinematics has led to improved surgical techniques, component design, and patient education, which have helped to further reduce patellar fracture complications.[3] Despite these advances in care, patient factors including poor bone stock and decreased capacity to heal with advanced age have made elimination of patellar fracture a significant challenge to orthopaedic surgeons.[4]

In the existing literature, several risk factors have been associated with patellar fracture following total knee arthroplasty. Patient factors include body habitus, osteoporosis, and increased postoperative flexion (see Figs. 1 and 2). Surgical factors include excessive patellar dissections such as fat pad excision, lateral release, excessive resection, and patellar turndown for exposure. Prosthetic factors include a large central peg, cementless fixation, and metal-backed patellae.[2]

Treatment for patellar fracture following knee arthroplasty can be demanding, and both nonoperative and operative techniques have been described for patellar fractures and/or extensor mechanism disruptions.[1,5,6] More importantly, functional gains from the total knee arthroplasty can be compromised, with arthrofibrosis, extensor lag, loss of flexion, pain, and infections reported as potential adverse outcomes following surgical correction of patellar fracture.[2,7,8]

In this report, we will briefly review (1) anatomy and biomechanics of the patellae; (2) etiology and predisposing factors associated with patellar fracture; (3) treatment options, including nonsurgical and surgical management; and (4) preferred corrective techniques of the senior authors.

II. ANATOMY

The patella is classified as a sesamoid bone of the quadriceps tendon. Its shape is similar to a triangle in which its articular surface is covered by hyaline cartilage, which is believed to be the thickest in

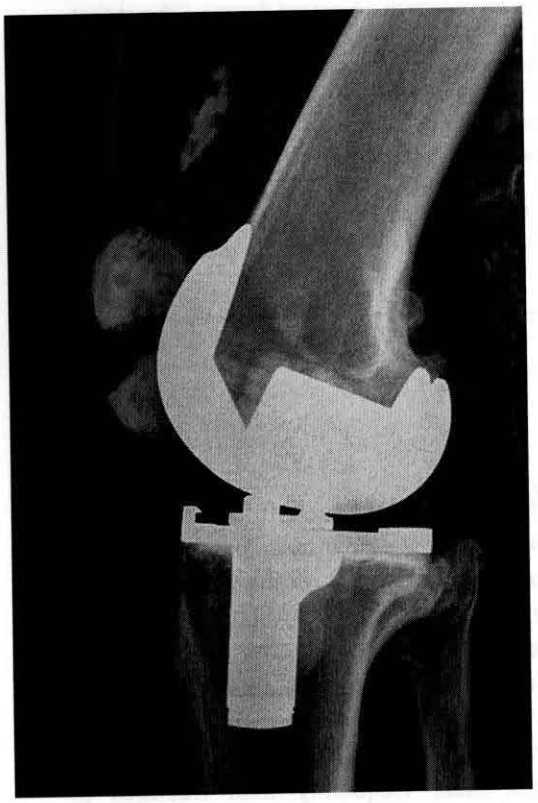

FIGURE 1. Lateral knee radiograph demonstrating patellar fracture after total knee arthroplasty.

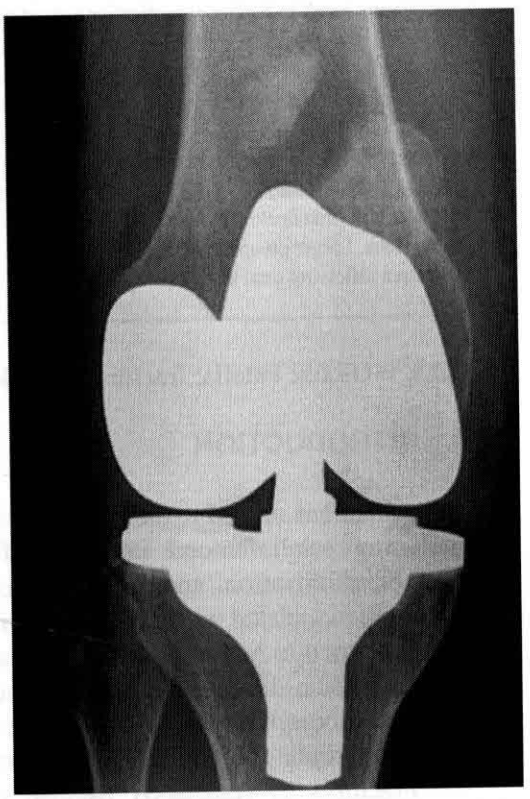

FIGURE 2. AP knee radiograph demonstrating patella fracture after total knee arthroplasty.

the body. In a study by Jiang looking at patellar thickness in total knee replacements, the average preoperative thickness was 21.2±1.8 mm.[9] The lateral facet is much larger than the medial surface. Its anterior surface is proximally covered by fibers of the quadriceps tendon and distally it provides the origin of the patellar ligament.

The blood supply of the patella is via an intraosseous as well as an extraosseous vascular system. The extraosseous system is a peripatellar ring that receives contributions from multiple sources. These include the supreme genicular, medial superior genicular, the medial inferior genicular, the lateral superior genicular, the lateral inferior genicular, and the anterior recurrent arteries. The intraosseous blood supply is composed of the mid-patella, as well as the polar vessels. It is this blood supply that is at risk during a knee arthroplasty. The most common approach utilized for a knee arthroplasty is the medial parapatellar with a partial or complete excision of the patellar fat pad. This may result in the disruption of the medial genicular arteries. If a lateral release is performed, then the lateral superior genicular vessels are also at risk or compromised. This can lead to an avascular patella that can lend itself to avascular necrosis and subsequent fracture.[7] In a systematic review by Chalidis et al., 51.2% of patients who were diagnosed with patellar fractures had an associated lateral release performed. They recommended that if a lateral release was necessary, that it be performed at a distance from the patella to preserve the lateral vessels as it was important to preserve the superior lateral genicular artery and whenever possible, the fat pad should not be resected.[10]

Biomechanically, the patella is well recognized as providing an important function in both gait as well as strength. The patella ensures the mechanical advantage of the quadriceps muscle by centralizing its forces and increasing its moment arm, in addition to providing an articulating surface with a low coefficient of friction. During weight bearing, the patellofemoral joint can bear one to one and a half times body weight while walking on an even surface. The forces across the joint can increase to four to seven times body weight during stair climbing and squatting, respectively.

III. ETIOLOGY OF FRACTURE

Patellar fracture has been reported as the second most frequent periprosthetic fracture of the knee joint, with the femur being the most common.[7] In Berry's series, 0.9% of primary and revision total knee arthroplasties performed since 1970 have experienced a periprosthetic patellar fracture (n=178 out of 19,810 TKAs)[7] Periprosthetic patellar fractures can occur in the unresurfaced as well as the resurfaced patella and typically occur within the first 2 years after total knee arthroplasty. In the resurfaced patella, component loosening has been associated with fracture. There have been numerous reported etiologic factors for patellar fractures. In the largest reported series, Ortiguera and Berry found that only 38% (n=30 out of 78 fractures) of patients had a known precipitating event directly preceding their fracture.[8] Eleven were caused by a direct blow to the anterior aspect of the knee, six were sustained when the patient stood from a deep-seated position, six occurred when the knee was hyperflexed or overloaded, five occurred when the knee spontaneously gave way during walking, and two were preceded by a known patellar subluxation.[8]

Surgical factors have been reported to include limb or component malalignment, excessive bony resection or under-resection, and excessive lateral release and fat pad removal during exposure. Figgie et al. reported that in 36 knees with patellar fracture, there were 20 knees with major and 16 knees with minor implant malalignment.[11] Reuben et al. found that a patellar thickness of less than 15 mm increased the strain in the anterior patellar region and the risk of fracture.[12] Bourne pointed out that resurfacing of a patella less than 10 to 15 mm was an important predisposing factor for fracture.[13] In Grace and Sim's series, 27% of patients with fracture had a lateral release combined with fat pad excision. They recommended avoiding aggressive lateral release with excessive fat pad removal to minimize injury to the vascular network to the patella.[14] With regard to implant choice, the use of metal-backed, uncemented, or patellar components with one large central peg have also been reported to increase the risk of periprosthetic patellar fracture.[15,16] Larson et al. reported that a central pegged patellar

design doubled the prevalence of patellar fracture in their series.[16] Other surgical related factors that have been reported are revision surgery and thermal necrosis from the heat of polymerization of polymethylmethacrylate (PMMA).[7,10,13,17,18]

Patient-related factors have been reported to include osteoporosis/osteopenia, obesity, osteolysis, bone loss, male sex, rheumatoid arthritis, high activity levels, and knee hyperflexion that increases the strain on the patellar component.[10,13,18] While the surgeon cannot control for all of these factors, he/she must be cognizant of them prior to proceeding with arthroplasty.

IV. FRACTURE TREATMENT OPTIONS

A number of factors must be taken into consideration prior to planning a strategy for treatment. These include location of the fracture, displaced compared to nondisplaced, comminution, and patellar component fixation.[5] Several classifications for periprosthetic patella fractures have been reported in the current literature.[8,19,20] The most widely used classification system is that of Ortiguera and Berry which categorizes fractures based on the status of fixation of patellar component, the quality of residual bone stock, and the integrity of the extensor mechanism.[4,8] Two important questions to ask include whether or not the patellar component is loose and whether or not there is greater than 20° of extensor lag.[6] Type I fractures have an intact extensor mechanism with a stable implant. Type II fractures have a complete disruption of the extensor mechanism with or without a stable implant. Type III fractures have an intact extensor mechanism with a loose patellar component. Type III fractures are subclassified into types a and b. Type IIIa fractures have reasonable remaining bone stock and type IIIb have poor bone stock. Knowledge of the bone stock is vital when deciding among surgical options.[4] Poor bone stock is defined as having patellar bone thickness of <10 mm or marked comminution making the bone too thin and unsatisfactory for fixation or revision patellar resurfacing.[8]

Based upon this classification system, a treatment algorithm has been generated. Treatment of type I fractures is generally nonoperative with good to excellent results. Patients initially can be placed in a knee immobilizer locked in full extension or cylinder cast if noncompliant, with partial weight bearing for 4–6 weeks followed by progressive range of motion and weight bearing.[13] In contrast, operative treatment of a type I fracture leads to almost universally poor results. Operative treatment is advocated, however, in the event of a displaced fracture in order to regain maximum functional potential of the joint postoperatively.[4]

Type II fractures with complete disruption of the extensor mechanism generally necessitate surgical treatment. Extensor mechanism repair with open reduction and internal fixation plus or minus component resection arthroplasty, patelloplasty with tendon advancement to bone, and complete patellectomy have been described.[8,13,21] The complication rate for surgical treatment of this category can be up to 50%.[8] In a report by Hozack et al., with regard to patellar tendon ruptures associated with distal pole fractures, the authors recommend fragment excision with reattachment of the patellar tendon with sutures.[19] This method of treatment resulted in 50% of patients with extensor lags of 25° or greater associated with poor quadriceps strength.[19]

For type III fractures, nonoperative treatment generally leads to poor results with surgical treatment only providing a fair to good outcome. Surgical treatment has been associated with increased complications. Operative management is indicated with extensor mechanism disruption, loosening of patellar component, and in cases of patellar maltracking. The surgical treatment options consist of open reduction internal fixation, revising a component, partial or total patellectomy, or a resection of the patella and fixation.[22] In Ortigurea and Berry's series, of 20 patients treated operatively, 8 had complications with 3 patients requiring reoperation.[8] Patelloplasty with component revision, component resection arthroplasty, and complete patellectomy have all been described for symptomatic patients.[8,13,21] Patellectomy may be the only option for type II or IIIb fractures. Hozack reported that 66% of patients (n=4 out of 6) that were treated with patellectomy had a decrease in quadriceps muscle strength by at least 1 grade.[19] In addition, Chang reported extensor lags in 50% (n=4 out of 8) of patients and poor knee scores

with regard to function in patients who underwent patellectomy for comminuted periprosthetic patellar fractures.[23] Every attempt should be made to preserve the patella if possible in order to increase the mechanical advantage of the quadriceps mechanism. Quadriceps muscle weakness can result from a patellectomy and this should only be performed in those patients who demonstrate very poor bone stock and fracture with a high degree of comminution. In these cases, a partial patellectomy may be favored over a complete patellectomy.[5]

In general, the management of periprosthetic patellar fractures can be quite challenging to the adult reconstructive surgeon with only fair to good patient outcomes. The incidence of periprosthetic fractures is increasing due to the rise in total number of total knee arthroplasties.[22] With surgical intervention, complication rates tend to be high with modest outcomes.[5] Previous reports have favored more nonoperative treatment due to the likelihood of nonunion and infection associated with surgery.[1] The component stability, quality of bone stock, as well as the extensor mechanism integrity are the keys to guiding treatment. It is important that patients be advised to avoid deep flexion following total knee arthroplasty.[3] The most effective management technique is, however, understanding the etiology of periprosthetic patellar fractures and avoiding the common surgically related factors that increase risk.

V. AUTHORS' PREFERRED TREATMENT

To avoid this difficult complication, the authors prefer the quadriceps-sparing midvastus and subvastus approaches. If a parapatellar arthrotomy is made, great care is taken during the exposure to preserve the fat pad. In addition, if a lateral release is performed, it is performed at least 2 cm lateral to the lateral border of the patella. During patellar arthroplasty, a caliper is used to measure the thickness of the patella prior to resection. The patella is never resected past a level of 12 mm in a primary total knee arthroplasty. If there is less than 10 mm of bone in a revision situation, the patella is left unresurfaced.

Patella fractures are categorized and managed as per the classification system described by Ortiguera and Berry.[8] All type I fractures are treated nonoperatively. We place the patient in a non-weight-bearing knee immobilizer locked in full extension for 6 weeks. We then allow progressive range of motion, starting at 0°–30°, and progressive partial weight bearing. We increase the range of motion by 15°–20° each week thereafter. Once full range of motion is achieved by 12 weeks, we allow weight bearing as tolerated.

The treatment rationale is the same for the bony injury for type II, IIIa, and IIIb fractures. If the fracture fragments are amenable to open reduction and internal fixation, a heavy gauge wire is used in a cerclage technique. If the fracture fragments cannot be salvaged, then a patelloplasty is performed for minor fragments. Patellectomy is reserved for severely comminuted fractures. The extensor mechanism is always repaired with heavy suture for type II fractures.

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