Review Article

Patellar Fractures in Adults

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Abstract

Patellar fracture is a common injury caused by excessive tension through the extensor mechanism or a direct blow. The intact patella increases the leverage and efficiency of the extensor mechanism and articulates with the femoral trochlea. Patellar fractures can lead to stiffness, extension weakness, and patellofemoral arthritis. Nonsurgical management is indicated for nondisplaced fractures with an intact extensor mechanism. Surgical fixation is recommended for fractures that either disrupt the extensor mechanism or demonstrate >2 to 3 mm step-off and >1 to 4 mm of displacement. Anatomic reduction and fixation with a tension-band technique is associated with the best outcomes; however, symptomatic hardware is a frequent complication. Open fractures are associated with more complications than closed fractures. These complications can be mitigated with timely débridement, irrigation, and internal fixation.

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Patellar fractures account for approximately 1% of all fractures.[1] Historically, treatment methods changed as fixation strategies were debated. More recently, the vital role of the patella in maximizing extensor mechanism efficiency has become clear, and treatment methods directed at preservation have led to improved outcomes. However, management of patellar fracture remains challenging because of the subcutaneous and intra-articular location of the patella as well as the desire for early active knee motion.

Anatomy

The patella is the largest sesamoid bone in the body. The quadriceps tendon and the fascia lata blend to the anterosuperior margin of the patella. The patellar tendon originates on the inferior border. Portions of the fascia lata, vastus medialis, and vastus lateralis aponeurosis pass along the margins of the patella to form the patellar retinaculum, which aids in knee extension.

Its subcutaneous position makes the patella prone to open fracture and injury from direct blows. Posteriorly, the superior three fourths of the patella is covered with the thickest articular cartilage in the body. The posterior articular surface is composed of two large facets—medial and lateral—separated by a vertical ridge[1] (Figure 1).

The patella typically forms from a single ossific nucleus. However, in 2% to 3% of the population, a secondary ossific nucleus fails to unite with the primary nucleus, resulting in a bipartite patella.[2] Bipartite patella is bilateral in 50% of patients and occurs most frequently at the superolateral edge.[2] Bipartite patella should not be confused with fracture (Figure 2).

The patella receives its blood supply from an anastomotic ring that originates from the geniculate arteries.[3] The superior portion of the ring lies anterior to the quadriceps tendon, and the inferior portion passes posterior to the patellar tendon. Vessels from the ring penetrate the middle of the anterior patella and the inferior pole along the infrapatellar fat pad. Although the incidence of osteonecrosis secondary to fracture has been reported to be as high as 25%, clinical outcomes were not affected.[3] Circumferential dissection or excessive stripping of the anterior surface should be avoided given the centripetal blood supply.

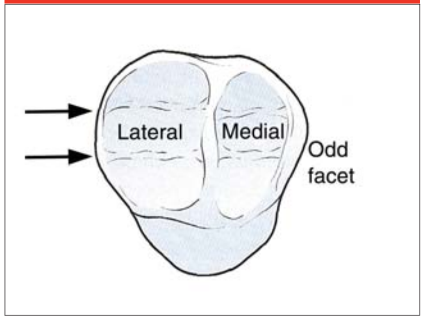
Patellar Biomechanics

The knee extensor mechanism generates torque and keeps the body upright against gravity. The patella acts as a pulley, shifting the pull of the quadriceps anteriorly, thereby increasing the moment arm of the quadriceps by up to 30%.[4]

Loading patterns about the patella are complex. The quadriceps loads the patella in tension (Figure 3, A). Knee flexion results in compressive forces along the posterior patella. Three-point bending stresses are created within the patella during flexion (Figure 3, B).

Maximal tensile forces through the quadriceps and patellar tendons have been recorded to be as high as 3,200 N and 2,800 N, respectively.[5] Activities such as stair climbing and squatting may generate patellofemoral compressive forces greater than seven times body weight and anterior patellar surface strains close to values that result in fracture.[5,6]

Figure 1

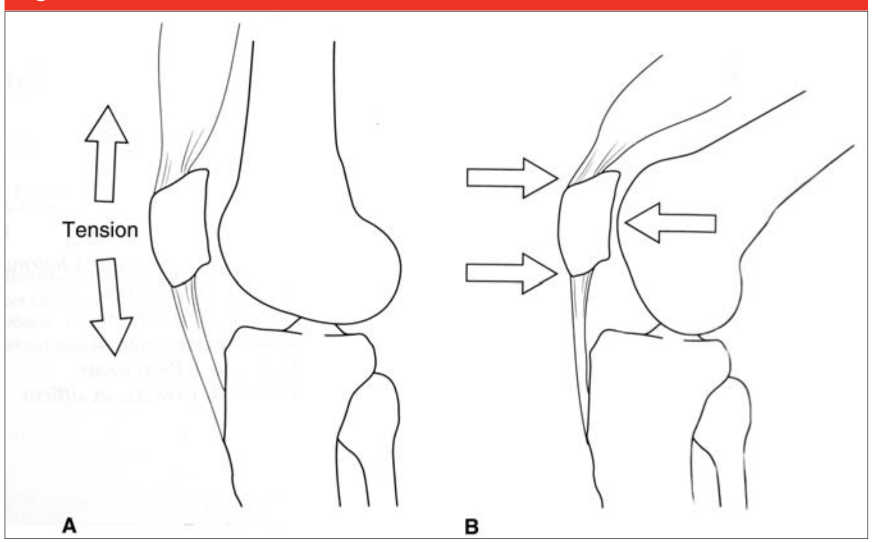


Articular facets of the patella. The arrows indicate the location of the transverse ridges. (Reproduced with permission from Harris RM: Fractures of the patella and injuries to the extensor mechanism, in Bucholz RW, Heckman JD, Court-Brown CC, eds: *Rockwood and Green's Fractures in Adults*, ed 6. Philadelphia, PA, Lippincott Williams & Wilkins, 2006, vol 2, p 1975.)

Figure 2

AP radiograph demonstrating bipartite patella. (Reproduced from Atesok K, Doral MN, Lowe J, Finsterbush A: Symptomatic bipartite patella: Treatment alternatives. *J Am Acad Orthop Surg* 2008;16:455-461.)

Figure 3



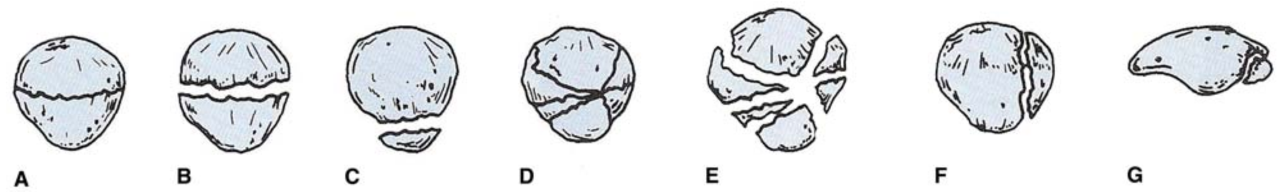
A, The patella is loaded primarily in tension with the knee in full extension. **B,** During flexion, the patella experiences a combination of tension, compression and three-point bending forces (arrows). (Reproduced with permission from Carpenter JE, Kasman R, Matthews LS: Fractures of the patella. *J Bone Joint Surg Am* 1993;75:1550-1561.)

Mechanism of Injury

Patellar fracture may occur as a result of direct or indirect forces. The type of force determines the fracture pattern. A direct force consists of a direct blow to the anterior knee, which often results from a fall or dashboard injury.[6] This mechanism causes the patella to fail in compression, resulting in a comminuted or stellate fracture pattern. Although >50% of these fractures are nondisplaced, with the extensor mechanism remaining intact, significant chondral damage may occur.[1]

More commonly, the patella fails in tension as indirect force from the extensor mechanism exceeds the

Figure 4



Descriptive classification of patellar fractures. **A,** Nondisplaced. **B,** Transverse. **C,** Lower or upper pole. **D,** Multifragmented nondisplaced. **E,** Multifragmented displaced. **F,** Vertical. **G,** Osteochondral. (Adapted with permission from Harris RM: Fractures of the patella and injuries to the extensor mechanism, in Bucholz RW, Heckman JD, Court-Brown CC, eds: *Rockwood and Green's Fractures in Adults*, ed 6. Philadelphia, PA, Lippincott Williams & Wilkins, 2006, vol 2, p 1974.)

strength of the bone.[6] Typically, this fracture type is caused with rapid knee flexion against a fully contracted quadriceps muscle, resulting in transverse fracture or avulsion of the inferior pole. The force often continues beyond the patella, extending in a transverse fashion through the retinaculum and causing fracture displacement and loss of active knee extension.[6]

Clinical Presentation and Assessment

Evaluation of a patient with knee pain begins with a detailed history and physical examination. History of a direct blow to the knee or eccentric loading should raise suspicion for patellar fracture or other extensor mechanism injury. Associated injuries, such as femoral neck fracture, posterior wall acetabular fracture, and knee dislocation, should be sought for high-energy dashboard mechanisms.

The knee examination begins with inspection of the soft-tissue envelope. Suspected open fractures are best evaluated with a saline load test performed with intra-articular injection of 150 mL of sterile saline.[7] In closed patellar fractures, further inspection and palpation reveal hemarthrosis, pain with palpation, and a palpable defect. The continuity of the extensor mechanism may be evaluated with a straight leg raise examination. When the test is limited by pain, aspiration of the hemarthrosis and injection of local anesthetic may allow the patient to attempt this maneuver.

Radiographic Evaluation

Standard AP and lateral radiographs of the knee should be obtained. Because of superimposition of the patella on the femoral condyles, the AP view may be difficult to interpret. Lateral radiographs are useful in assessing displacement and articular congruity in patients with transverse fracture. Axial views are of limited use except with vertical fracture patterns. Advanced imaging techniques such as arthrography, CT, MRI, and bone scans are rarely indicated for isolated acute patellar fractures.

Classification

Patellar fractures may be classified as displaced (ie, step-off >2 to 3 mm and fracture gap >1 to 4 mm) or nondisplaced.[6] Classification often predicts treatment. However, more commonly, patellar fractures are classified descriptively according to fracture pattern, which may offer information regarding the mechanism of injury but does not direct treatment[1,6] (Figure 4). The Orthopaedic Trauma Association classification is based on degree of articular involvement and number of fracture fragments; however, the clinical utility of this system is uncertain.[8]

Management

The goals of management include restoring the extensor mechanism while maximizing articular congruency. Every effort should be made to preserve as much patellar bone as possible.

Nonsurgical

Nonsurgical management is indicated for fractures with a clinically intact extensor mechanism and minimal step-off and/or fracture displacement (<2 to 3 mm and <1 to 4 mm, respectively).[1,6] Successful results have been reported with two different treatment regimens.

Braun et al[9] retrospectively reviewed 40 nonsurgically managed fractures with an intact extensor mechanism and <1 mm of fracture displacement. Fractures were managed with a long leg splint for a few days followed by partial weight bearing and physiotherapy. At an average follow-up of 30.5 months, 80% of patients were pain free, and 90% had full range of motion (ROM). In a large series, Boström[1] used plaster immobilization for a mean duration of 4 weeks to manage patellar fractures with an intact extensor mechanism, <3 mm of articular step-off, and <4 mm of fracture widening. Good or excellent outcomes were reported in 99% of fractures at a mean 9-year follow-up (210/212).

These reports suggest that good to excellent results can be expected for minimally displaced fractures with an intact extensor mechanism. We typically recommend early weight bearing with a hinged knee brace locked in extension. Isometric quadriceps exercise and straight leg raises are begun when pain has subsided. Active and active-assisted ROM is begun at 1 to 2 weeks, and resistance exercises are added at 6 weeks. One week after motion is allowed, radiographs are obtained to evaluate for displacement.

Nonsurgical management should be considered for displaced patellar fractures in the patient with significant medical comorbidities. Pritchett[10] reported a series of 18 patellar fractures with >1 cm of displacement managed with a Velcro closure splint, early full weight bearing, and straight leg raises. Of the 12 patients available at 2-year follow-up, only 3 considered their outcome to be poor. No patient had severe pain, but all patients had extensor lag of ≥20°.

Surgical

An incompetent extensor mechanism is the most common indication for surgery. In some cases, despite active knee extension, fracture separation >1 to 4 mm or step-off >2 to 3 mm may be relative indications for surgical management. Additional surgical indications include intra-articular loose bodies and osteochondral fracture.

Open Reduction and Internal Fixation

Open reduction and internal fixation is the preferred treatment for most displaced patellar fractures. Although the techniques and materials used in patellar fixation have changed substantially, the goals of restoration of normal anatomy and extensor function remain constant.[1,11]

Several incisions may be used to expose the patella; however, a longitudinal midline extensile incision centered over the patella is preferred. For transverse fractures, full-thickness medial and lateral flaps allow access to retinacular tears while enabling palpation to confirm reduction of the joint surface. Gardner et al[12] advocated lateral parapatellar arthrotomy with internal rotation of the patella to 90° for direct visual reduction of comminuted fractures. In general, transverse incisions should be avoided because they compromise approaches for future knee procedures.

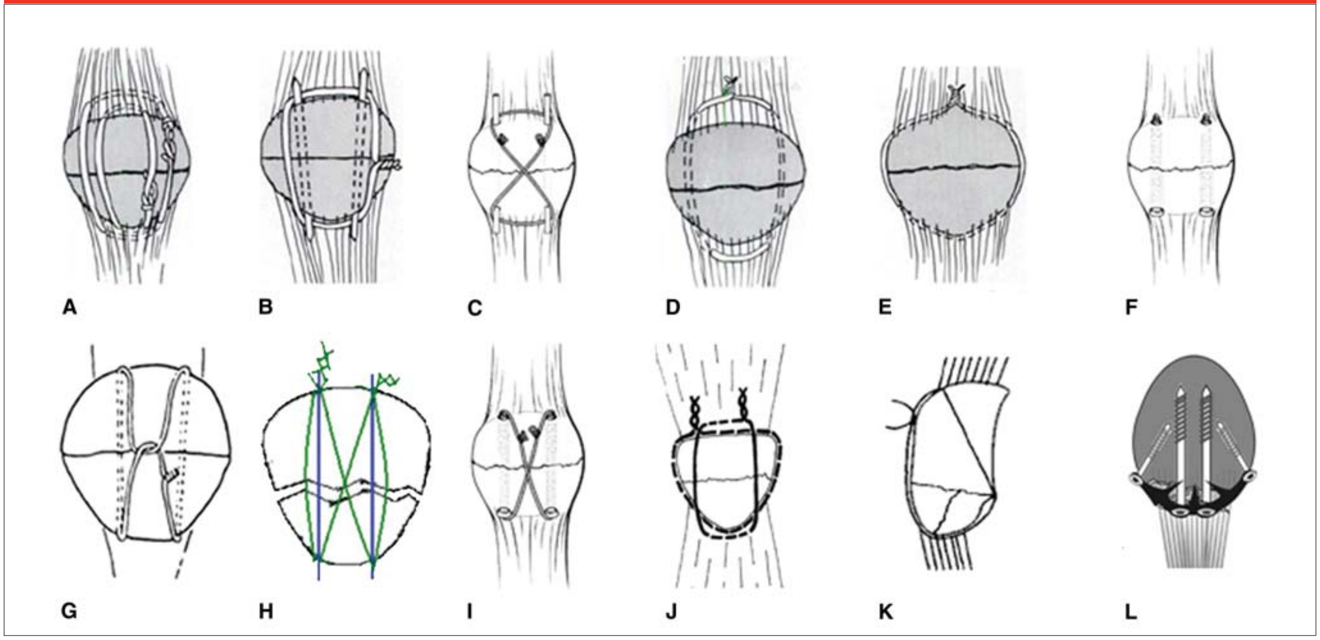
Historically, tension-band wiring has been the most commonly used technique for the management of patellar fracture. This technique converts the anterior tension forces produced by the extensor mechanism and knee flexion into compression forces at the articular surface. Numerous tension-band wiring techniques have been described (Figure 5). Early techniques, such as the standard tension band (Figure 5, A) and the modified anterior tension band (MATB) (Figure 5, B), were further modified to create an MATB technique involving longitudinal Kirschner wires (K-wires) and 18-gauge stainless steel wire in a figure-of-8 pattern looped over the anterior patella[13] (Figure 5, C). Currently, this construct is the most widely accepted method of fixation for transverse and comminuted patellar fractures.

Many tension-band techniques have undergone biomechanical testing. In a cadaver model, Weber et al[14] demonstrated that Magnusson wiring (Figure 5, D) and MATB wiring permitted less separation of fracture fragments than either circumferential wiring or standard tension-band wiring. Additionally, they found that repair of the retinacular defect contributed to the overall stability of the construct. Fortis et al[15] demonstrated increased compressive strain in a transverse fracture model with the addition of a cerclage wire (Figure 5, E) to the MATB construct. In a cadaver model, Benjamin et al[16] showed that screw fixation alone (Figure 5, F) was adequate for transverse fractures with good bone stock; however, the MATB performed better for fractures with comminution or osteopenia. Simple wiring techniques, such as the Magnusson and Lotke longitudinal anterior band (Figure 5, G) techniques, may not allow sufficient fixation for early activity.[11]

The figure-of-8 wire pattern plus tensioning has been investigated, as well. In testing on wooden patellas, John et al[17] found that incorporating a horizontal figure-of-8 pattern with four strands crossing the fracture site and tensioning the wire with two twists at the corners of the tension band improved interfragmentary compression by 63% compared with a vertically oriented MATB with a single tensioning twist (Figure 5, H).

Screws offer better biomechanical performance than do longitudinal K-wires in the MATB construct. Screws provide greater rigidity than do K-wires and provide resistance against tensile loading with the knee in full extension. In a cadaver model, Burvant et al[18] found that the MATB technique with cancellous screws performed better than the MATB technique with K-wires. However, in

Figure 5



Illustrations of patellar fixation techniques. **A,** Standard tension band. **B,** Modified anterior tension band (MATB). **C,** MATB with vertical figure-of-8 wire. **D,** Magnusson wiring. **E,** Cerclage wiring. **F,** Parallel cancellous lag screws. **G,** Lotke longitudinal anterior band. **H,** MATB with horizontal figure-of-8 wire. **I,** Figure-of-8 tension band through cannulated screws. **J,** Pyrford technique. **K,** Separate vertical wiring (lateral view). **L,** Basket plate. (Panels A, B, D, and E reproduced with permission from Weber MJ, Janecki CJ, McLeod P, Nelson CL, Thompson JA: Efficacy of various forms of fixation of transverse fractures of the patella. *J Bone Joint Surg Am* 1980;62:215-220. Panels C, F, and I reproduced with permission from Carpenter JE, Kasman RA, Patel N, Lee ML, Goldstein SA: Biomechanical evaluation of current patella fracture fixation techniques. *J Orthop Trauma* 1997;11:351-356. Panel G reproduced with permission from Hughes SC, Stott PM, Hearnden AJ, Ripley LG: A new and effective tension-band braided polyester suture technique for transverse patellar fracture fixation. *Injury* 2007;38:212-222. Panel H reproduced with permission from John J, Wagner WW, Kuiper JH: Tension-band wiring of transverse fractures of patella: The effect of site of wire twists and orientation of stainless steel wire loop. A biomechanical investigation. *Int Orthop* 2007;31:703-707. Panel J reproduced with permission from Chatakondu SC, Abhaykumar S, Elliott DS: The use of non-absorbable suture in the fixation of patellar fractures: A preliminary report. *Injury* 1998;29:23-27. Panel K reproduced with permission from Yang KH, Byun YS: Separate vertical wiring for the fixation of comminuted fractures of the inferior pole of the patella. *J Bone Joint Surg Br* 2003;85:1155-1160. Panel L reproduced with permission from Kastelec M, Veselko M: Inferior patellar pole avulsion fractures: Osteosynthesis compared with pole resection. *J Bone Joint Surg Am* 2004;86:696-701.)

the clinical setting, it is often difficult to place the tension-band wires around the tips and heads of screws. A revised method in which a figure-of-8 tension-band wire is passed through parallel cannulated screws was devised to avoid this difficulty (Figure 5, I). In a cadaver fracture model, Carpenter et al[19] found that tension-band wiring through parallel 4.0-mm cannulated lag screws provided optimal stability. Berg[20] treated 10 patients with this construct and reported clinical union in all patients, including three revisions.

Alternative Tension-band Materials

Traditionally, MATB fixation has incorporated stainless steel wire fashioned in a figure-of-8 configuration with two strands crossing the fracture. However, because of the difficulty in manipulating stainless steel wire and because of high reoperation rates secondary to painful hardware or wire migration, techniques employing alternatives to wire have been investigated. Braided polyester suture is the most extensively researched alternative. It has been studied in biomechanical testing and clinical series.

McGreal et al[21] compared MATB with braided polyester suture (No. 5 Ti-cron [Covidien, North Haven, CT]) with 18-gauge stainless steel wire in a cadaver model. Although braided polyester suture was found to have 75% the tensile strength of 18-gauge stainless steel wire, it performed as well as wire over 2,000 knee cycles. Patel et al[22] evaluated the MATB and Lotke longitudinal anterior band techniques with either braided polyester suture (No. 5 Ethibond [Ethicon, Somerville, NJ]) or 1.25-mm stainless steel wire to manage transverse patellar fracture in 10 cadaver knees. No fixation failures were noted.

Two series reported the outcomes of patellar fractures managed with tension-band techniques fastened with braided polyester suture. Chatakondu et al[23] managed transverse patellar fractures in seven patients with the Pyrford tension band technique (Figure 5, J) using braided polyester suture (No. 5 Ti-cron). At 6-week follow-up, all fractures had united, and pain-free knee function was achieved. Two patients required outpatient suture removal for knot symptoms. Gosal et al[24] compared 21 patellar fractures managed with MATB with stainless steel wire to 16 cases managed with two braided polyester sutures (No. 5 Ethibond). At a mean follow-up of 30 months, reoperation was required in eight patients treated with wire compared with 1 patient treated with suture. Polyester suture compared favorably with stainless steel wire.

Based on the available literature, our preferred method of fixation for mid patella transverse fracture is to use figure-of-8 tension-band wiring with stainless steel wire passed through parallel cannulated screws, as described by Carpenter et al[19] and Berg.[20] For comminuted fracture, we use interfragmentary screws and/or cerclage wiring to supplement cannulated screw tension banding.

Minimally Invasive Techniques

The incidence of soft-tissue injury in conjunction with patellar fracture has led to the study of less invasive management techniques. Luna-Pizzaro et al[25] used radiography to confirm reduction and a percutaneous osteosynthesis device to place an MATB. Percutaneous fixation resulted in reduced surgical time, less pain, and higher functional scores compared with open surgery. Several authors have reported favorable results with arthroscopic reduction and various percutaneously placed screw-and-wire constructs in the management of noncomminuted patellar fractures.[26,27] Successful outcomes also have been reported following application of a circular external fixator with arthroscopic reduction in the management of comminuted patellar fractures.[28] Although these small studies appear promising, the methods described have not gained widespread acceptance. The authors of these articles stress careful selection of patients suitable for these techniques and acknowledge the inability to address tears of the retinaculum.

Partial Patellectomy and Inferior Pole Fracture

Partial patellectomy was developed as an alternative to total patellectomy, and partial patellectomy has been described in the management of various fracture patterns. Retention of a portion of the patella is thought to preserve some of the patellar moment arm and improve strength.[4,29]

Saltzman et al[30] reported the results of 40 patients with displaced transverse or comminuted fractures managed with partial patellectomy and reapproximation of the patellar or quadriceps tendon to the articular edge of the remaining patella. At an average 8.4-year follow-up, good or excellent results were reported in 78% of patients, and mean quadriceps strength was found to be 85% that of the contralateral extremity. The authors concluded that partial patellectomy is effective in the management of select patellar fractures.

Böstman et al[31] reported poor outcomes with removal of >40% of the patella. In a cadaver study published in 1993, Marder et al[32] evaluated the effect of patellectomy size and the location of tendon reattachment on patellofemoral contact patterns and stresses. They found that patellofemoral contact stress increased as the size of the discarded portion of the patella increased. Additionally, in contrast to the technique used by Saltzman et al,[30] Marder et al[32] found that reattachment of the patellar tendon to the anterior surface of the remaining patella—which most closely resembles native anatomy— substantially minimized contact stresses.

Partial patellectomy is most strongly indicated for comminuted fractures of the inferior patellar pole. Some fractures involving the inferior pole are effectively managed like patellar tendon avulsions, with fragment excision and tendon reattachment via suture and transosseous tunnels or suture anchors (Figure 6). Cerclage reinforcement of the repair with a heavy suture or wire passed through the quadriceps tendon and a tibial tubercle bone tunnel has also been described.[33]

Newer methods of fracture fixation have been described in an effort to preserve patellar bone and allow for early ROM. Yang and Byun[34] described the technique of separate vertical wiring in 25 patients and reported a 100% union rate and no wire breakage at an average follow-up of 22 months (Figure 5, K). The basket plate technique has been investigated in two clinical series[35,36] (Figure 5, L). This plate conforms to the shape of the inferior patellar pole and is secured to the patellar body with superiorly directed screws.

Total Patellectomy

As our knowledge of knee biomechanics and internal fixation has improved, the indications for total patellectomy have diminished. Total patellectomy may result in a >49% reduction in quadriceps strength.[6,29] Few excellent clinical outcomes have been observed with total patellectomy.[1,6] Thus, every attempt should be made to retain all or part of the patella. Total patellectomy may be indicated in rare cases of failed internal fixation, infection, tumor, or patellofemoral arthritis. When total patellectomy is performed, consideration should be given to advancing the vastus medialis obliquus muscle over a longitudinally closed defect. Strength and outcomes are better with this technique than with standard total patellectomy[37] (Figure 7).

Open Patellar Fracture

Six percent to 9% of patellar fractures are open.[1,38,39] More than 90% of these injuries occur as a result of motor vehicle collisions, with nearly 70% accompanied by other injuries.[38-40] In contrast, closed patellar fractures occur most commonly secondary to falls, are more often isolated, and are less likely to be comminuted or to result in infection.

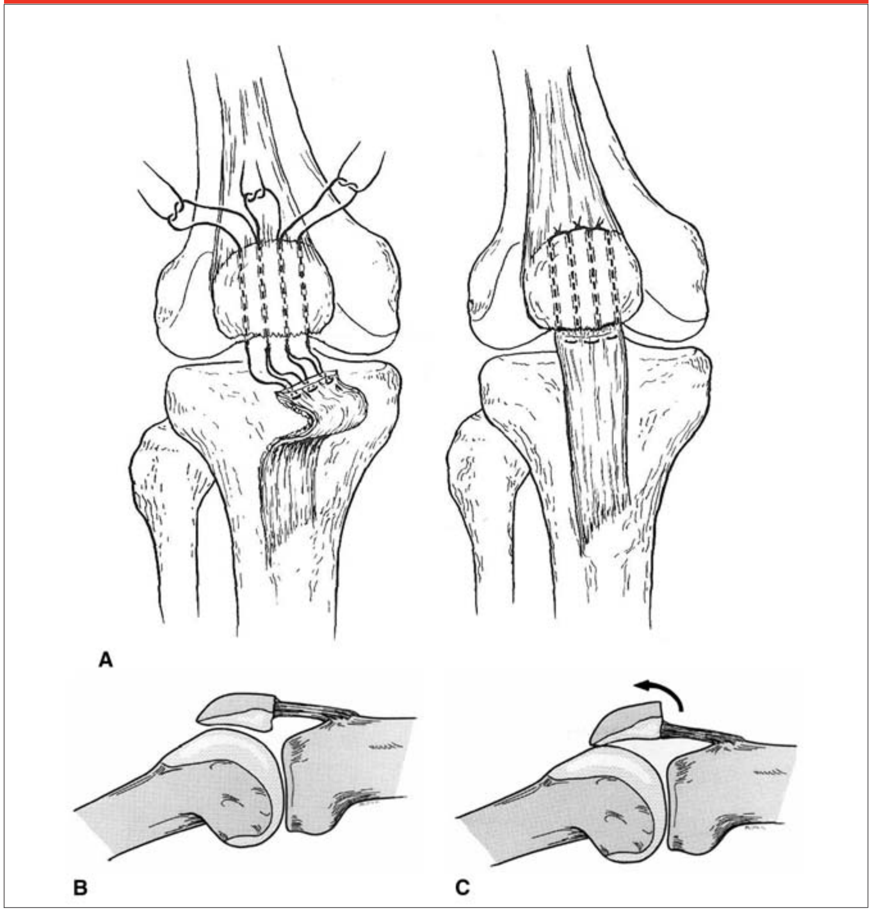
Data on the management and outcomes of open patellar fractures are limited to a few clinical series and case-control studies. Despite the high-energy nature of these injuries, satisfactory outcomes have been reported.

Catalano et al[40] reported on a series of 76 patients with 79 open patellar fractures (12 Gustilo and Anderson type I, 42 type II, 25 type III). Seventy-seven fractures were managed with immediate irrigation and débridement followed by definitive fixation and antibiotics. Despite a high percentage of secondary procedures (65%), good to excellent ROM (mean, 112°) and outcomes were attained.

Torchia and Lewallen[38] presented a series of 47 open patellar fractures in 44 patients with a mean follow-up of 9.4 years. Soft-tissue injury was classified according to the system of Gustilo and Anderson in 55 patients (8 type I, 42 type II, 1 type IIIA, 4 type IIIB). Osteosynthesis was performed in half the cases, and the remainder were managed with patellectomy or partial patellectomy. According to the Böstman grading scale, 77% achieved good or excellent results. Deep infection occurred in six cases, all of which had excessive delays in wound closure or coverage. Nonunion occurred in two cases in which nonrigid fixation was used. No infections or nonunions were reported for the cases managed with primary fracture fixation and wound closure.

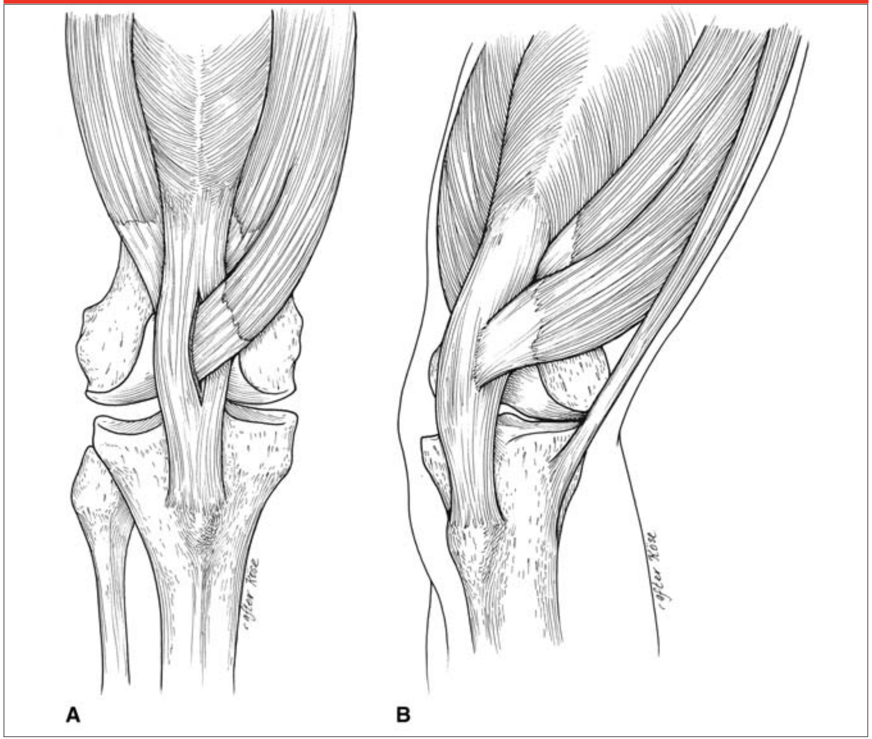
Anand et al[39] recently presented a case-control study comparing the results of 16 open patellar fractures with matched closed patellar fractures at a mean follow-up of 45 months. Patients with open patellar fractures had higher injury severity scores and a greater number of associated injuries (mean, 22.75 versus 7.06; and mean, 13 versus 5, respec-

Figure 6



A, Illustrations demonstrating partial patellectomy with tendon advancement through bone tunnels. **B,** Lateral view with tendon advancement to the anterior patella, which more closely restores anatomy. **C,** Lateral view with tendon advancement to the articular surface, which causes patellar rotation. The arrow indicates rotation. (Panel A adapted with permission from Azar F: Traumatic disorders, in Canale ST: *Campbell's Operative Orthopaedics*, ed 10. Philadelphia, PA, Mosby, 2003, vol 3, p 2470. Panels B and C reproduced with permission from Marder RA, Swanson TV, Sharkey NA, Duwelius PJ: Effects of partial patellectomy and reattachment of the patellar tendon on patellofemoral contact area and pressures. *J Bone Joint Surg Am* 1993;75:35-45.)

Figure 7



Illustrations demonstrating the anterior (**A**) and medial (**B**) view of total patellectomy with advancement of the vastus medialis obliquus muscle over a longitudinally closed defect. (Redrawn with permission from Günal I, Taymaz A, Köse N, Göktürk E, Seber S: Patellectomy with vastus medialis obliquus advancement for comminuted patellar fractures: A prospective randomised trial. *J Bone Joint Surg Br* 1997;79:13-16.)

tively). Although there were trends toward more pain and complications as well as lower functional scores in the open fracture group, these differences did not reach statistical significance.

We recommend urgent débridement, irrigation, and definitive fixation for open patellar fracture. Débridement should be meticulous, with removal of all devitalized tissue. However, soft-tissue attachments to remaining bone fragments must be maintained. All attempts are made to preserve bone; patellectomy is reserved for substantial bone loss. Primary closure should be performed when tension-free closure is possible. Should skin grafting or flap coverage be required, it is done within 7 days to minimize the risk of infection.

Postoperative Management and Rehabilitation

No data exist on outcomes for specific postoperative protocols, but several clinical protocols have been described. Early knee motion and full weight bearing in a hinged knee brace is recommended in patients with stable fixation.[14,20] Postoperative continuous passive motion is thought to reduce stiffness and improve healing of articular cartilage.[6] Prolonged immobilization is generally discouraged.

For fractures with stable internal fixation, we recommend early physiotherapy and weight bearing as tolerated while limiting flexion to 30° for 4 weeks. After 4 weeks, ROM is progressed. In the setting of tenuous fixation, partial patellectomy, or a noncompliant patient, full weight bearing in a cylinder cast in extension for 6 weeks is instituted before progressing to a hinged knee brace. Isometric quadriceps exercises and straight leg raises are encouraged as soon as pain subsides. ROM may be delayed in the setting of tenuous soft-tissue envelope, wound closure, or fracture fixation.

Complications

Symptomatic hardware is among the most frequently encountered complications. Overall symptomatic hardware rates from zero to 60% have been reported, often requiring hardware removal; however, rates vary widely and have been inconsistently reported with regard to specific fixation techniques.[6,11,20,23-25,38,41] Symptomatic hardware appears to be more common in open fractures, possibly because of increased damage to the soft-tissue envelope.[38,39]

Hardware failure is rare. Smith et al[42] reported catastrophic hardware failure resulting in loss of reduction in 8% of cases managed with MATB. Wire migration into the popliteal fossa and the right ventricle has also been reported secondary to late hardware failure.[43,44]

Knee stiffness is a known complication related to patellar fracture.[6,42] Many surgeons advocate internal fixation to allow early ROM; however, internal fixation has not been proved to mitigate stiffness. Others have reported that length of immobilization does not affect stiffness; thus, the cause of stiffness remains unclear.[31] Substantial knee extensor weakness has been observed with total and partial patellectomy. Internal fixation is associated with less extensor weakness; however, residual articular step-off and pain have been shown to correlate with decreased quadriceps strength in patients treated with internal fixation.[36,45]

Nonunion is rare in closed fractures. Most series report rates of ≤1%; however, open fractures may be complicated by nonunion in up to 7% of cases.[6,40,42] Deep infection is rare, as well (zero to 5%); however, the rate is higher for open fractures (11%).[38,40]

Reported rates of radiographic osteoarthritis (OA) are rare in the recent literature. In 1964, Sorensen[46] reported a 70% rate of patellofemoral OA at 10- to 30-year follow-up. In 1972, Boström[1] reported significantly less OA with nonsurgical management compared with surgical management at 9-year follow-up (16% versus 35%, respectively). However, he found similar rates of OA when comparing osteosynthesis with partial patellectomy (32% versus 35%, respectively). In 1990, Saltzman et al[30] reported patellofemoral arthrosis in 53% of patients 8.4 years after partial patellectomy. Although patellar fracture has been associated with increased rates of patellofemoral OA compared with uninjured knees, the relative contribution of the injury force compared with the quality of reduction remains unclear.[1,6,30]

Summary

Patellar fractures are a frequent occurrence and may be associated with extensor weakness, stiffness, and patellofemoral arthritis. Fracture displacement, comminution, and integrity of the extensor mechanism typically dictate treatment. Fractures that disrupt the extensor mechanism or demonstrate articular step-off >2 to 3 mm or widening measuring >1 to 4 mm should be managed surgically. Tension-band techniques employing cannulated screws enable early ROM and are associated with the best outcomes. Every effort should be made to preserve patellar bone stock. Total patellectomy should be avoided except in rare instances. Open fractures may be managed successfully with antibiotics, débridement, and early fixation. These fractures are associated with a higher rate of complications than are closed fractures.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, reference 7 is a level I study. References 25, 27, and 37 are level II studies. References 24, 35, 36, 39, and 45 are level III studies. References 1, 9-12, 20, 23, 26, 28-31, 34, 38, 40-42, and 46 are level IV studies.

References printed in **bold type** are those published within the past 5 years.

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