International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Review Article

PATELLAR FRACTURE OPERATIVE AND NON-OPERATIVE MANAGEMENT AND ITS COMPLICATION: A REVIEW

Dr. Roshan sah[1]*, Prof. Lui Ke Bin[1], Dr. Vijay Kumar Sah[1], Dr. Keshav Singh Dhami[2], Dr. Laxmi Narayan Goit[1].

[1] The First Affiliated Peoples Hospital of Yangtze University Jingzhou, Hubei, PR. China.*

[1]Department of Orthopedics, the First Affiliated Peoples Hospital of Yangtze University Jingzhou, Hubei, PR. China.*

[2] Jingzhou central hospital, second clinical medical hospital, Yangtze University, Jingzhou, Hubei, PR. China.

ABSTRACT

The patellar bone is involved in repetitive, load bearing motion sequences every day and functions as a vectorial force translator. A fracture rate of 1% of all skeletal fractures is reported and surgical treatment often required. Beside a direct trauma mechanism, indirect mechanism but as well as fatigue fractures after reconstructive knee surgery are published. The fracture management is dependent on the soft tissue condition and a variety of surgical options are known. New generation of low profile plate's show promising results but the conventional cerclage wiring technique with K-wires is widely preferred. Best functional results with sustainable stability are biomechanically seen after a combined fixation technique using anterior cerclage wiring with cannulated screw fixation. A definite algorithm of treatment of patellar bone fractures is yet not defined but a review of classification and surgical techniques should give assistance in decision making.

INTRODUCTION

The patellar bone is the largest sesamoid bone of the human body and functions as a hypomochlion for the extensor mechanism of the knee joint. The patella conducts the tensile forces of the extensor mechanism to the patella tendon and improves the efficiency of the complex by elevating the extensor mechanism away from the axis of rotation of the knee joint. The patella plays a crucial role in the extensor mechanism to increase the mechanical advantage of the quadriceps. Forces up to 5 times the body weight has been recorded from the extensor mechanism; the patella displaces the quadriceps tendon-patellar tendon link away from the axis of knee rotation, effectively increasing the moment arm of the quadriceps. Therefore the quadriceps muscle is reinforced by 30% due to the accelerated lever arm and serves as a pulley[1, 2]. Remarkable for the patellar bone is its thickness of cartilage surface of 5–7 mm. The patellar bone is embedded into the quadriceps muscle with 50% insertion of its tendinous part to the proximal patella pole. Its superficial tendinous fibers extend distally into the patellar ligament and insert at the tibial tuberosity. Most important for the knee extensor mechanism is the provisional extra function of the medial and lateral retinacula, which are aponeurotic fibers of the quadriceps muscle and may allow an extension of the knee joint even if the quadriceps tendon is injured[3].

Every year, roughly 1 in every 100 fractures will involve the patella[3]. Fractures can be classified based on displacement, comminution, and fracture pattern and often involve concurrent injury to the proximal tibia, distal femur, or knee ligaments. Although conservative treatment remains an option, open reduction and internal fixation (ORIF) and/or partial patellectomy have emerged as the preferred treatment options. Numerous biomechanical and long-term studies highlighted the importance of the patella and tempered enthusiasm for total patellectomy as the treatment of choice for all patella fracture[4-7]. In the 1950s (AO) introduced and promoted the use of anterior tension band principles for patella fracture fixation. Subsequent studies validated its stability[8-10]. Modern treatment options include internal fixation using tension bands with Kirschner (K) wires or cannulated screws, lag screw fixation, and partial patellectomy, all with reasonably good clinical results.

Figure 1: Patellar fracture in sky line view.

Etiology:

Patellar fractures are rare and account for approximately 1% of all osseous fractures[8]. Peak age of affected patients is between 20–50 years of age [11, 12]but in cases of periprosthetic fractures the patella is second most commonly injured after the femur and has a reported incidence of 0.05% – 21% in resurfaced patellae[13, 14] Mechanism of injury is a direct fall or blow ('dashboard injury') on to the patellar bone. An indirect fracture mechanism is an unexpected, sudden flexion or tear through concentric muscle contraction of the quadriceps. This indirect mechanism may lead to an avulsion fracture, equivalent to patella tendon ruptures with less soft tissue damage[15]. Only rarely reported are patellar bone fractures after reconstruction of the anterior cruciate ligament (ACL) using a bone-tendon-bone (patella tendon) graft[16-18]. Incidence of this weak fracture is reported to be 2% due to a surgical, technical mistake, although fatigue fractures during late follow up after ACL reconstruction, following a low velocity mechanism of injury, are published[19]. With the upcoming trend of refixation of the medial patellofemoral ligament (MPFL) in patellofemoral disorders, fatigue patella fractures after replacement of the MPFL are reported. For these rare cases no incidence is yet defined as well as the exact mechanism[20] .An attenuation of the bony structure and consecutively extensor mechanism is suggestible.

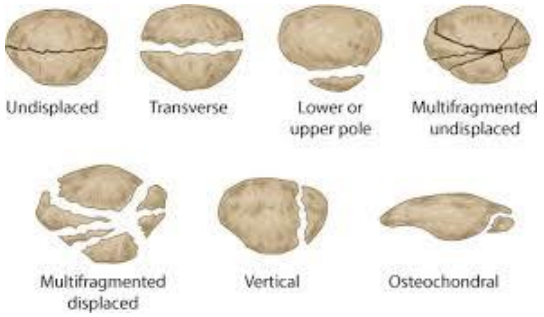

Figure 2: Showing different type of patellar fracture.

Examination and Evaluation:

Definite clinical fracture signs are osseous crepitation, a palpable distance between the fractured bony parts and in open fractures an open praepatellar bursa.Indirect fracture signs are a local hematoma, haemarthros, bruises and contusion marks. Straight leg raise may be impossible, or in undisplaced or incomplete fractures painful and forcefully reduced due to an intact function of the retinacula, iliotibial band and adductor muscle function[21]. the inability to actively extend and lift the leg is relatively indicative of an incompetent extensor mechanism. More than 35% of all patella fractures are nondisplaced and the extensor mechanism remains intact [8, 22].After clinical examination, including palpation, documentation of the muscular force, evaluation of the active and passive ROM, plain X-rays in minimum two planes (ap and lateral, eventually sunrise view (45 degrees flexed knee)) are essential and will give further information about the injury. Moreover, transverse fracture lines can be missed if a lateral view is not performed. In uncertain cases

plain radiographs of the contra lateral side should be performed to exclude bipartite patellae. In case of a high velocity trauma mechanism an additional radiographic examination of the ipsilateral hip joint is mandatory to exclude further injuries. Ultrasound evaluation is sufficient in children or pregnant patients. In very displaced and/or comminuted fractures further investigation by CT scan is helpful for surgical planning[23]. MRI scan is indicated to exclude osteochondral or singular chondral fractures as well as exclusion of additional soft tissue injuries (e.g. ligamental ruptures, meniscal tears).

Indications:

Indications for treatment of patellar fractures are largely determined by the type of fracture encountered. However, the goals of treatment remain the same.

1. restoration of the extensor mechanism and
2. Maintenance of a congruous articular surface.

Thus, the literature often has focused on treatment type rather than fracture type.

Conservative Management:

Nondisplaced, closed patellar fractures, including stellate, transverse, and vertical, or fractures with less than 2-mm articular steps can be treated conservatively[3]. Stellate, transverse, and vertical fractures of the patella often spare the medial and lateral retinaculum, maintaining knee extension[8, 24]. Transverse fractures can present with significant displacement, such as 4 to 5 mm. However, if patients are able to extend their leg actively, the retinaculum is likely intact and can be managed conservatively. Because the distal portion of the patella is extra-articular, fractures of the inferior pole can also be managed conservatively. Conservative management usually includes weight-bearing-as-tolerated (WBAT) ambulation with the knee in fixed extension supported by a splint, knee immobilizer, or hinged knee brace. At 2 to 3 weeks, patients begin passive range of motion (PROM) from 0 degree to 30 degree, increasing the arc of motion by 15 degree per week. At approximately 8 weeks, patients should have nearly a full PROM of the knee and can begin advancing WBAT without immobilization.

Operative management/indication:

Operative Indications: Indications for surgery include open fracture, articular step of 2 mm or greater, and loss of knee extension. Comminuted stellate fractures typically present with intact retinaculum; however, because of the articular incongruity, surgical intervention may be recommended. Highly comminuted and displaced fractures can present as transverse fractures with massive comminution or stellate fractures with massive diastasis. These injuries are often open.

Preoperative Planning: Standard radiographic views for the patella fractures include anteroposterior and lateral radiographs. The patella position and height are readily assessed with this view. A lateral radiograph

will often provide an excellent survey of the fracture as well as an opportunity to determine patellar height. Most reliably, this is accomplished using the Insall technique[25, 26]. A computed tomography scan can provide more detailed information regarding fracture character and articular step, though it is not routinely obtained.

Prep and Patient Positioning: In addition to the implants necessary for fixation, a small-fragment instrument and implant set and pointed bone reduction forceps can be useful. Additionally, wire instruments, such as tensioners, wire forceps, and crimpers, can be helpful. Angiocatheters can provide a convenient conduit for passing suprapatellar and infrapatellar wires. Patients are placed supine on the operating table with an optional tourniquet placed on the proximal thigh. Care should be taken to ensure that the tourniquet is placed as high as possible and inflated during knee flexion to avoid quadriceps trapping.

Surgical Approach: A midline longitudinal or lateral para-patellar incision is most frequently used. This approach facilitates reduction and is safe for future arthroplasty. In addition, this approach avoids the saphenous branch of the femoral nerve, which safely lies medial to the incision. Several case series promote arthroscopically assisted reduction and fixation of minimally displaced patellar fractures[27-29]. However, this technique may not be appropriate for highly comminuted or displaced fractures.

Surgical procedure (steps) Cannulated screw fixation with supplemental wiring

1. A midline longitudinal incision is made through skin and bursa.
2. The fracture edges are cleaned, and the joint is irrigated to remove debris.
3. The K wire is passed in a retrograde fashion through the proximal fragment starting within the fracture line, roughly 5 mm from the articular surface of the patella, and at the junction of a line separating the patella into thirds. The K wire is driven proximally until flush with the fracture edge.
4. A second K wire is passed in a similar fashion parallel to the first K wire.
5. The fracture is reduced and held with Weber or patellar reduction clamps.
6. K wires are advanced across the fracture and out through the patellar tendon.
7. A cannulated drill is used to drill over the K wires followed by placement of 3.5- or 4.0mm cannulated screws.
8. An 18-gauge wire is passed through one cannulated screw and then through an 18-gauge angiocatheter through the patellar tendon. The wire is then loop through the other screw in the opposite direction followed by passing it through the quadriceps tendon. The wire is then tightened on the dorsal surface of the patella.
9. Reduction of the articular surface is examined with the knee in extension by palpation through the retinacular rent and by fluoroscopy.

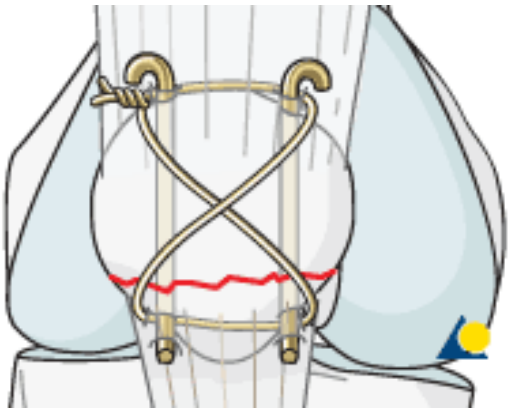

Figure 3: Showing tension band wiring in patellar fracture.

The modern design and new generation of several angle plates, spider or basket plates, allow a less invasive surgical option and elegant reduction in comminuted fracture types or distal pole fractures[30] .Newly designed plates with fixed-angles are comfortable and elegant in use, and showed good to excellent results in biomechanical tests[31] Their design allow for a fixed screw placement and are helpful in comminuted patellar fractures to restore the reductive result and in osteoporotic bone. A recent comparison to lag screw fixation with anterior tension wiring showed a preserved reduction and sustainable fixation in cyclic loading tests[32].

Partial patellectomy or resection of the distal or proximal pole may be indicated in small fracture fragments or non-unions, and is reserved for injuries that involve severe comminution of one patella pole which are not amenable for internal fixation[7, 33, 34]. All attempts should be made to retain all fragments and the articular surface when possible, as even a remaining part of the patella bone is helpful in restoration of the extensor mechanism of the knee joint and lever arm function of the musculo tendinous parts. An osteosynthetic pole refixation is proven to achieve better outcome results compared to pole resection[1, 35]. In situation of a severely comminuted distal pole fracture resection with patella tendon reattachment can be performed. Complications post partial patellectomy may be tilting of the patella and increased contact forces on the femoral condyles. For this reason correct patellofemoral alignement is mandatory.

Total patellectomy should be considered very carefully and still remains a salvage procedure for highly displaced and severely comminuted fractures, which are not primarily reduceable or all other surgical approaches failed, non-unions, chronic infections or type IIIB periprosthetic fractures[34, 36, 37]. Advantages of total patellectomy are shorter immobilization and less complicated surgical technique[31]. Although studies were presented showing good to excellent outcome post total patellectomy[38] other studies demonstrate the importance of retaining even one fragment of the patella to maintain the lever arm of the extensor mechanism[35, 38]. Augmentation of the extensor mechanism are described in multiple ways, e.g. intra operative, primary repair of excess tendon[39] or the turndown procedure in the absence of prepatellar

tissue with a tendon weave technique. The most common turndown procedure is the V-plasty by Shorbe and Dobson[40] when a full-thickness V-shaped flap of the quadriceps tendon is turned down and sutured into the proximal portion of the patella tendon. For large defects a free fascial or tendinous strip weaved into the quadriceps tendon is described by Gallie and Lemesurier[41].

Treatment of periprosthetic patellar fractures can be guided by three main criteria: integrity of the extensor mechanism, stability of the patellar implant and quality of the remaining bone stock[42]. Surgical approach is depending on the fracture classification and varies between open reduction and internal fixation, partial or complete patellectomy, revision of the patellar component or resection of the patellar component and patelloplasty.

Postoperative Care:

Following anatomic reduction and stable fixation of the patellar fracture, patients are encouraged to begin careful and protected motion. Use of a continuous passive motion machine can be used; however, caution is recommended to prevent failure of fixation. Starting on postoperative day 1, patients are allowed to begin quadriceps isometric exercises. All drains in place are removed on postoperative day 2. Patients can then be placed in a removable knee brace locked in extension and unlocked for physical therapy targeting range of motion. Physical therapy is instructed not to begin these exercises until the wound is completely healed, typically at 2 to 3 weeks following surgery.

At 6 weeks, radiographic evidence of healing is available and progressive resistance exercises are introduced. Gradually, the brace is weaned and can be discarded at 3 months when fracture healing can be confirmed. Physical therapy may be continued up to 6 months following surgery, at which point restrictions on sport are lifted.

The protocol is modified if operative fixation failed to produce a stable construct. A hinged knee brace is locked in extension, with isometric quadriceps strengthening exercises delayed until 2 weeks following surgery. Flexion is limited to the degree determined during surgery. Active flexion exercises are restricted until there is evidence of fracture healing. Although weight bearing in full extension is permitted as tolerated, weight bearing in flexion is deferred until fracture healing is confirmed. Under these circumstances, it is important to counsel patients that these precautions to protect the repair often lead to stiffness and weakness. Once fracture healing is confirmed, aggressive physical therapy is permitted to improve range of motion and strength.

Outcomes after surgery:

Nondisplaced fractures treated conservatively have good outcomes, defined as no arthrosis, weakness, or pain as well as full range[8, 43, 44] of motion. Bostrom[8] examined 422 patellar fractures, of which 219 were treated nonoperatively. All had less than 4-mm articular incongruity, and 98% exhibited

good or excellent results. Other studies agree with these findings. Surgeons often allow the type of fracture to dictate the surgical technique used. Therefore, many report results based on fracture type and surgical technique, seldom with direct comparison. Modified anterior tension band wiring currently gives the best results, with 85% of patients reporting good or excellent outcomes according to 2 studies providing a combined cohort of 59 patients[9, 45]. The same studies also compared it with cerclage wiring, showing only 19 of 31 (61%) with good or excellent outcomes. Additionally, Weber and colleagues[10] reported the biomechanical superiority of tension band wiring compared with cerclage wiring. However, the high occurrence of symptomatic fixation implants has spurred the development of novel constructs. Chen and colleagues proposed a transosseous suturing technique indicated for transverse or comminuted fractures of the patella. They reported good results with lower complication rates compared with tension bands; however, their case series was only 25 patients. Hoshino and colleagues,[46] compared the use of K wires with cannulated screws in the tension band construct. They found cannulated screws to have a higher rate of failure (7.5% vs. 3.5%) but a much lower rate of elective implant removal (23% vs 37%). Other constructs that have been biomechanically tested include locking plate with tension band, fixed-angle plate, and compressive cannulated locking bolt and nut, though rigorous studies evaluating clinical results have not been published[47-49]. A recent Cochrane review identified 5 randomized controlled trials and concluded that evidence overall is limited for guiding the management of patellar fractures in adults[50].

More recent reports have evaluated outcomes using validated outcome instruments[51-53]. LeBrun and colleagues[51], evaluated 40 patients with isolated patellar fractures treated with ORIF or partial patellectomy. On the Knee Injury and Osteoarthritis Outcome Score, all showed significant disability, with longitudinal anterior banding with cerclage scoring the highest in the small sample size. Lazaro and colleagues[52] evaluated 30 patients with low energy patellar fractures treated with ORIF. Using the Knee Outcome Survey–Activities of Daily Living Scale, they reported that significant deficit persists at1year.Bonnaig and colleagues[53] retrospectively compared ORIF with partial patellectomy and found both methods resulted in similar functional scores and complication rates. However, higher energy injuries were more likely to have received a partial patellectomy compared with ORIF in their system, complicating the data. Because of the important role played by the patella in the extensor mechanism, patellectomy would seem to significantly decrease function. In fact, the literature supports this notion[8, 9, 54]. Einola and colleagues[5] reported outcomes of 28 patients an average 7.5 years following patellectomy. Only 6 patients reported good results (21%), with the most predominant complaint being weakness and pain on movement and exertion. Quadriceps atrophy was also a problem, with power being within 75% of the normal knee in only 7 cases (25%). Another study by Scott[43] reported that out of 71 patients, only 4 (6%) were happy with their long-term outcome following patellectomy. Nearly everyone experienced aching in the joint, and 60% complained of weakness. All patients exhibited quadriceps wasting. Given the poor outcomes, patellectomy should be considered only in massive comminution in which repair is futile. There are no studies to provide

guidance on how much patella should be saved to preserve function.

Complications and Management:

Beside general peri- and postoperative complications for invasive surgical treatment like wound infection, bleeding and haemorrhage, specific complications are known. A fracture re-dislocation is found in 12.6%, infection rate is 2.3% and irritation of the soft tissue is found in 10.3% due to a study from Smith et al[55]. In up to 20% of the cases a loss of reduction and or fixation after surgical treatment is described[46]. Loosening of K-wires and tension band wires are mainly seen and repeat ORIF should be the treatment of choice. Biomechanical studies and clinical reviews reported a combination of screw fixation with anterior band wiring have significant higher failure loads ($p<0.05$) and are superior in the treatment of patellar fractures[45, 56-58]. A singular Kirschner-wire-based tension band risks to fail in 22%[55]. The majority of the patients are disturbed by the prominent hard metal and claims for an early removal of the hard metal as the patellar bone is prominent and the hard metal can interfere with the extensor mechanism of the knee joint. It is the most commonly reported complication following fixation of a patellar fracture, and rates for implant removal range from 0–50%[22, 59]. Nonunion of the refixed patellar bone is rarely reported but occurs in up to 12.5% of the cases and should be treated with re-fixation +/- interposition of cancellous bone. Prolonged postoperative immobilization can lead to joint stiffness and loss of knee motion[55]. The most common complications are related to fixation implants and postoperative pain. Often, an additional surgery is necessary to remove the symptomatic implant. Lazaro and colleagues[52], reported 11of 30 (37%) patients with patellar fracture requiring removal of symptomatic implants. Additionally, 24 (80%) of the patients reported anterior knee pain[52]. Functionally, decreases in strength, power, and endurance of knee extension by about 40% persisted at 1 year. Lebrun and colleagues[51] reported 14 of 27 patients (52%) requiring removal of symptomatic implants and 5 of 13 (38%) with retained implants reporting anterior knee pain. Other complications of patellar fracture treatment include infection, fixation failure, delayed union and malunion, loss of motion, osteoarthritis, and tendon rupture[60]. Infection can be treated by standard protocols depending on the soft tissue involvement. If severe osteomyelitis develops, a total patellectomy may be required. Tension band failure may occur with premature motion and requires revision if the fracture fragments are displaced by more than 3 mm or the articular surface has a step of more than 3 mm. With modern surgical techniques, nonunion is rare. However, if detected, a period of restricted motion will often unite the fracture. Loss of knee motion is uncommon because of the early motion therapy protocols; however, if flexion is restricted several months following fixation, aggressive physical therapy to restore motion is recommended. In severe cases, manipulation under anesthesia may be beneficial, exercising extra caution in patients with a patellectomy. Arthroscopy to lyse intra-articular adhesions is also a reasonable option. If no improvement is noted after 12 months, a quadricepsplasty may be necessary. Osteoarthritis may develop and can be associated with an incongruous joint surface. Rarely, the extensor mechanism may rupture following total patellectomy, usually occurring at the proximal edge of the patellar tendon.

CONCLUSION

Patella fractures represent a broad spectrum of injuries ranging from subtle nondisplaced fractures to open comminuted fractures with significant bone loss. Treatment should be directed to obtaining an anatomic reduction and using a fixation method that maximizes stability while minimizing hardware prominence. Surgeons should select fixation techniques that best address the fracture pattern being treated, as there is little high-quality evidence comparing treatment methods. Despite all of the advances in surgical treatment options, functional impairment, pain, and decreased quadriceps strength and endurance persist to 12 months postoperatively and beyond.Knee joint mobilization and range of motion as early as fixation stability permits will help to minimize posttraumatic arthritis and allow optimal postoperative recovery.

REFERENCES

1. Kastelec, M. and M. Veselko, *Inferior patellar pole avulsion fractures: osteosynthesis compared with pole resection.* J Bone Joint Surg Am, 2004. **86-a**(4): p. 696-701.
2. Kaufer, H., *Mechanical function of the patella.* J Bone Joint Surg Am, 1971. **53**(8): p. 1551-60.
3. Galla, M. and P. Lobenhoffer, *[Patella fractures].* Chirurg, 2005. **76**(10): p. 987-97; quiz 998-9.
4. Depalma, A.F. and J.J. Flynn, *Joint changes following experimental partial and total patellectomy.* J Bone Joint Surg Am, 1958. **40-a**(2): p. 395-413.
5. Einola, S., A.J. Aho, and P. Kallio, *Patellectomy after fracture. Long-term follow-up results with special reference to functional disability.* Acta Orthop Scand, 1976. **47**(4): p. 441-7.
6. Albanese, S.A., et al., *Knee extensor mechanics after subtotal excision of the patella.* Clin Orthop Relat Res, 1992(285): p. 217-22.
7. Jakobsen, J., K.S. Christensen, and O.S. Rasmussen, *Patellectomy--a 20-year follow-up.* Acta Orthop Scand, 1985. **56**(5): p. 430-2.
8. Bostrom, A., *Fracture of the patella. A study of 422 patellar fractures.* Acta Orthop Scand Suppl, 1972. **143**: p. 1-80.
9. Levack, B., J.P. Flannagan, and S. Hobbs, *Results of surgical treatment of patellar fractures.* J Bone Joint Surg Br, 1985. **67**(3): p. 416-9.
10. Weber, M.J., et al., *Efficacy of various forms of fixation of transverse fractures of the patella.* J Bone Joint Surg Am, 1980. **62**(2): p. 215-20.
11. Ashby, M.E., C.L. Shields, and J.R. Karmy, *Diagnosis of osteochondral fractures in acute traumatic patellar dislocations using air arthrography.* J Trauma, 1975. **15**(11): p. 1032-3.
12. Zeier, F.G. and C. Dissanayake, *Congenital dislocation of the patella.* Clin Orthop Relat Res, 1980(148): p. 140-6.
13. Berry, D.J., *Epidemiology: hip and knee.* Orthop Clin North Am, 1999. **30**(2): p. 183-90.
14. Windsor, R.E., G.R. Scuderi, and J.N. Insall, *Patellar fractures in total knee arthroplasty.* J Arthroplasty,

1989. **4 Suppl**: p. S63-7.

15. Seybold, D., et al., *[Avulsion fractures of the lower pole of the patella].* Unfallchirurg, 2005. **108**(7): p. 591-6.
16. Christen, B. and R.P. Jakob, *Fractures associated with patellar ligament grafts in cruciate ligament surgery.* J Bone Joint Surg Br, 1992. **74**(4): p. 617-9.
17. Stein, D.A., et al., *The incidence and outcome of patella fractures after anterior cruciate ligament reconstruction.* Arthroscopy, 2002. **18**(6): p. 578-83.
18. Stern, R.E. and S.F. Harwin, *Spontaneous and simultaneous rupture of both quadriceps tendons.* Clin Orthop Relat Res, 1980(147): p. 188-9.
19. Tay, G.H., S.K. Warrier, and G. Marquis, *Indirect patella fractures following ACL reconstruction: a review.* Acta Orthop, 2006. **77**(3): p. 494-500.
20. Lippacher, S., H. Reichel, and M. Nelitz, *[Patellar fracture after patellar stabilization].* Orthopade, 2010. **39**(5): p. 516-8.
21. Koval, K.J. and Y.H. Kim, *Patella fractures. Evaluation and treatment.* Am J Knee Surg, 1997. **10**(2): p. 101-8.
22. Melvin, J.S. and S. Mehta, *Patellar fractures in adults.* J Am Acad Orthop Surg, 2011. **19**(4): p. 198-207.
23. Benli, I.T., et al., *The computed tomographic evaluation of patellofemoral joint in patellar fractures treated with open reduction and internal fixation.* Kobe J Med Sci, 1992. **38**(4): p. 233-43.
24. Griswold, A.S., *Fractures of the patella.* Clin Orthop, 1954. **4**: p. 44-56.
25. Carson, W.G., Jr., et al., *Patellofemoral disorders: physical and radiographic evaluation. Part II: Radiographic examination.* Clin Orthop Relat Res, 1984(185): p. 178-86.
26. Insall, J., V. Goldberg, and E. Salvati, *Recurrent dislocation and the high-riding patella.* Clin Orthop Relat Res, 1972. **88**: p. 67-9.
27. Makino, A., et al., *Arthroscopic-assisted surgical technique for treating patella fractures.* Arthroscopy, 2002. **18**(6): p. 671-5.
28. Tandogan, R.N., et al., *Arthroscopic-assisted percutaneous screw fixation of select patellar fractures.* Arthroscopy, 2002. **18**(2): p. 156-62.
29. Turgut, A., et al., *Arthroscopic-assisted percutaneous stabilization of patellar fractures.* Clin Orthop Relat Res, 2001(389): p. 57-61.
30. Matejcic, A., et al., *The basket plate in the osteosynthesis of comminuted fractures of distal pole of the patella.* Injury, 2006. **37**(6): p. 525-30.
31. Wild, M., et al., *Fixed-angle plates in patella fractures - a pilot cadaver study.* Eur J Med Res, 2011. **16**(1): p. 41-6.
32. Thelen, S., et al., *Cyclic long-term loading of a bilateral fixed-angle plate in comparison with tension band wiring with K-wires or cannulated screws in transverse patella fractures.* Knee Surg Sports Traumatol Arthrosc, 2013. **21**(2): p. 311-7.

33. Andrews, J.R. and J.C. Hughston, *Treatment of patellar fractures by partial patellectomy.* South Med J, 1977. **70**(7): p. 809-13, 817.
34. Hung, L.K., et al., *Partial patellectomy for patellar fracture: tension band wiring and early mobilization.* J Orthop Trauma, 1993. **7**(3): p. 252-60.
35. Veselko, M. and M. Kastelec, *Inferior patellar pole avulsion fractures: osteosynthesis compared with pole resection. Surgical technique.* J Bone Joint Surg Am, 2005. **87 Suppl 1**(Pt 1): p. 113-21.
36. Gosal, H.S., P. Singh, and R.E. Field, *Clinical experience of patellar fracture fixation using metal wire or non-absorbable polyester--a study of 37 cases.* Injury, 2001. **32**(2): p. 129-35.
37. Kelly, M.A. and J.N. Insall, *Patellectomy.* Orthop Clin North Am, 1986. **17**(2): p. 289-95.
38. Saltzman, C.L., et al., *Results of treatment of displaced patellar fractures by partial patellectomy.* J Bone Joint Surg Am, 1990. **72**(9): p. 1279-85.
39. Wilkinson, J., *Fracture of the patella treated by total excision. A long-term follow-up.* J Bone Joint Surg Br, 1977. **59**(3): p. 352-4.
40. Shorbe, H.B. and C.H. Dobson, *Patellectomy; repair of the extensor mechanism.* J Bone Joint Surg Am, 1958. **40-a**(6): p. 1281-4.
41. Jagow, D.M., et al., *Recurrent patellar tendon rupture in a patient after intramedullary nailing of the tibia: reconstruction using an Achilles tendon allograft.* Am J Orthop (Belle Mead NJ), 2015. **44**(5): p. E153-5.
42. Ortiguera, C.J. and D.J. Berry, *Patellar fracture after total knee arthroplasty.* J Bone Joint Surg Am, 2002. **84-a**(4): p. 532-40.
43. Scott, J.C., *Fractures of the patella.* J Bone Joint Surg Br, 1949. **31b**(1): p. 76-81.
44. Sorensen, K.H., *THE LATE PROGNOSIS AFTER FRACTURE OF THE PATELLA.* Acta Orthop Scand, 1964. **34**: p. 198-212.
45. Bostman, O., et al., *Fractures of the patella treated by operation.* Arch Orthop Trauma Surg, 1983. **102**(2): p. 78-81.
46. Hoshino, C.M., et al., *Complications following tension-band fixation of patellar fractures with cannulated screws compared with Kirschner wires.* J Bone Joint Surg Am, 2013. **95**(7): p. 653-9.
47. Banks, K.E., et al., *An alternative patellar fracture fixation: a biomechanical study.* J Orthop Trauma, 2013. **27**(6): p. 345-51.
48. Thelen, S., et al., *Biomechanical cadaver testing of a fixed-angle plate in comparison to tension wiring and screw fixation in transverse patella fractures.* Injury, 2012. **43**(8): p. 1290-5.
49. Domby, B., et al., *Comparison of cannulated screw with tension band wiring versus compressive cannulated locking bolt and nut device (CompresSURE) in patella fractures-a cadaveric biomechanical study.* J Orthop Trauma, 2012. **26**(12): p. 678-83.
50. Sayum Filho, J., et al., *Interventions for treating fractures of the patella in adults.* Cochrane Database Syst Rev, 2015(2): p. Cd009651.
51. LeBrun, C.T., J.R. Langford, and H.C. Sagi, *Functional outcomes after operatively treated patella fractures.* J

Orthop Trauma, 2012. **26**(7): p. 422-6.

52. Lazaro, L.E., et al., *Outcomes after operative fixation of complete articular patellar fractures: assessment of functional impairment.* J Bone Joint Surg Am, 2013. **95**(14): p. e96 1-8.
53. Bonnaig, N.S., et al., *Fix it or discard it? A retrospective analysis of functional outcomes after surgically treated patella fractures comparing ORIF with partial patellectomy.* J Orthop Trauma, 2015. **29**(2): p. 80-4.
54. Duthie, H.L. and J.R. Hutchinson, *The results of partial and total excision of the patella.* J Bone Joint Surg Br, 1958. **40-b**(1): p. 75-81.
55. Smith, S.T., et al., *Early complications in the operative treatment of patella fractures.* J Orthop Trauma, 1997. **11**(3): p. 183-7.
56. Berg, E.E., *Open reduction internal fixation of displaced transverse patella fractures with figure-eight wiring through parallel cannulated compression screws.* J Orthop Trauma, 1997. **11**(8): p. 573-6.
57. Burvant, J.G., et al., *Evaluation of methods of internal fixation of transverse patella fractures: a biomechanical study.* J Orthop Trauma, 1994. **8**(2): p. 147-53.
58. Carpenter, J.E., et al., *Biomechanical evaluation of current patella fracture fixation techniques.* J Orthop Trauma, 1997. **11**(5): p. 351-6.
59. Luna-Pizarro, D., et al., *Comparison of a technique using a new percutaneous osteosynthesis device with conventional open surgery for displaced patella fractures in a randomized controlled trial.* J Orthop Trauma, 2006. **20**(8): p. 529-35.
60. Kakazu, R. and M.T. Archdeacon, *Surgical Management of Patellar Fractures.* Orthop Clin North Am, 2016. **47**(1): p. 77-83.