21 Periprosthetic Fractures Following TKR

Chandeep Singh and S. K. S. Marya

21.1 Introduction

A combination of an increasing number of replacements with an increase in life expectancy and an increase in implants' in situ, the number of periprosthetic fractures is expected to rise. The periprosthetic fractures offer a unique set of problems for the surgeon as well as the patient. It has been debated as to which subspecialty of orthopedic surgeons should handle the periprosthetic fractures: the "trauma team" or the "arthroplasty team." In our experience, managing the periprosthetic fracture involves a team approach and needs the surgeon to be well-versed in handling fractures and arthroplasty situations.

The incidence of Periprosthetic fractures around TKR is around 3.5%, with supracondylar fracture femur being the most common [1]. There is an urgent need to manage and address these fractures efficiently as the morbidity and mortality associated with these fractures are as high as proximal femoral fractures. A retrospective study conducted by Streubel regarding mortality associated with the periprosthetic femur fractures reported that patients carry a significantly higher mortality risk as compared to primary hip or knee arthroplasty or distal femur fractures [2]. Shields et al. have reported mortality rates of 8%, 24%, and 27% at 30-day, 6-month, and 1-year follow-up, respectively, for patients with periprosthetic distal femur fractures [3]. This increased mortality is similar to patients with proximal femoral fractures. Thus, these fractures need to be handled early and efficiently.

21.2 Risk Factors for Periprosthetic Fractures Around TKR

There are various risk factors associated with periprosthetic fractures in TKR. Increased age is considered a significant risk factor on its own as it is associated with osteoporosis and increased frequency of falls. Meek et al. reported that females older than 70 years were at an increased risk of periprosthetic fractures [4]. However, Singh et al. described the U-shaped distribution of the age-associated risk of postoperative fracture; patients between 61 and 80 years of age had a 45% to 50% reduced risk of periprosthetic fracture compared to patients younger than or 60 years of age and those older than 80 years [5].

Inflammatory arthroplasty, such as rheumatoid arthritis, also constitutes a risk factor. This is partly due to the localized osteoporosis, and also, these patients tend to have multiple joint involvements and are thus prone to falls. Prolonged intake of steroids leads to weakening of bones and it increases the likelihood of fractures on trivial falls [6]. Neurological conditions, which affect gait and balance, also increase the inci-

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dence of periprosthetic fractures. Diabetes, especially of prolonged duration, tends to be a risk factor as it affects balance and leads to falls [7].

Revision TKR is described as a major risk factor for the development of periprosthetic fractures. Singh et al. reviewed 17,633 primary TKR patients and 4090 revision TKR patients from the Mayo clinic database [5]. They established an incidence of 1.1% in primary TKR and 2.5% in revision TKR patients of a postoperative periprosthetic fracture. Similarly, Meek et al. collected data from the Scottish database from April 1997 and March 2008 and studied 44,511 primary TKR, and 3222 revision TKR surgeries [4]. The authors reported that periprosthetic fracture risk after primary TKR was 0.6% versus 1.7% after revision TKR.

There are certain risk factors, which are fracture specific. Anterior femoral notching during the femoral cut and implantation has gained much notoriety as a precursor of supracondylar periprosthetic fracture. Notching essentially means a violation of the anterior femoral cortex. The depth may vary on the severity of the breach. Lesh et al. did a biomechanical study on the cadaveric bone with full-thickness loss of the anterior femoral cortex [8]. They found that notching reduced the torsional strength by 39% and bending strength by 18% compared to the intact femur.

Gujarati et al. [9] reviewed 200 knees at a follow-up of 9 years average and classified notching in four grades.

- *Grade I*: violation of the outer table of the anterior femoral cortex.
- *Grade II*: violation of the outer and the inner table of the femoral cortex.
- *Grade III*: violation up to 25% of the medullary canal (from the inner table to the center of the medullary canal).
- *Grade IV*: violation up to 50% of the medullary canal (from the inner table to the center of the medullary canal).

Only three patients had supracondylar fractures, of which only one patient had grade II supracondylar notching, and the other two did not have any notching.

Harish et al. followed up 200 knees for 2 years and used the grading as mentioned by Gujararti et al. They had grade I notching in 13%, grade II in 6.5%, grade 3 in 1%, and grade 4 in 0.5% of the 200 knees. No periprosthetic fractures were seen [10]. The authors believe in the clinical scenario, the correlation between anterior femoral notching and supracondylar periprosthetic fracture is yet to be conclusively established. Having said that one should avoid notching as far as possible, and if violation of the inner table happens, one should stem the femoral component if possible. Another specific risk factor for supracondylar periprosthetic fractures is the use of pins for computer-assisted surgery. The incidence has gone down with the help of single pins and a reduction in pin diameter [11].

21.3 Classification

Several classifications have been devised to classify periprosthetic fractures around a TKR. They have attempted to describe the fracture patterns, the stability of the components, and, in some cases, the bone quality. The idea of classification is to help classify the severity of injury and help in planning. The initial AO classification was alphanumerically denoting the femoral, tibial, and patellar fractures with codes 33, 41 and 34, respectively. They did not take into consideration the bone quality or the presence of implant. That is why AO has recently adopted the Unified Classification System (UCS), which is based closely on the Vancouver classification of the proximal femoral periprosthetic fractures [12]. In the UCS classification, they have given numbers to the bones as in the AO classification and then have classified the fractures as types.

Location	Types
I: Shoulder	A—Apophyseal
II: Elbow	B—Bed of implant
III: Wrist	C—Clear of implant
IV: Hip	D—Dividing the bone between implant
V: Knee	E—Each bone supporting one arthroplasty
VI: Ankle	F—Facing and articulating with a Hemiarthroplasty

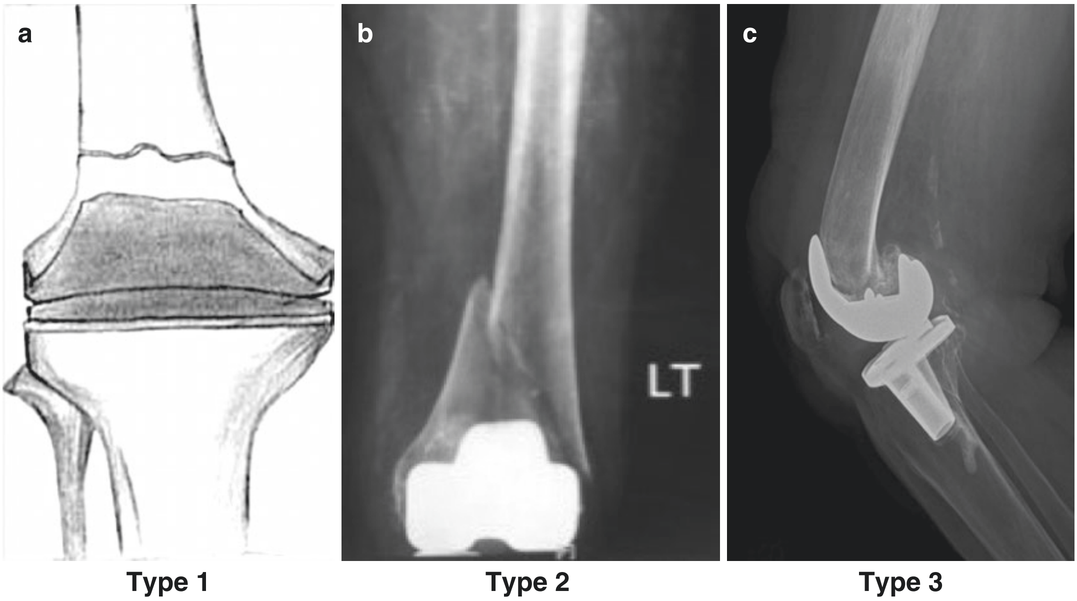


Fig. 21.1 Rorabeck and Taylor Classification for Supracondylar periprosthetic fracture. (**a**) Type 1. (**b**) Type 2. (**c**) Type 3

Type B—Bed of Implant is further divided into:

- B1—Good bone with no loosening
- B2—Good bone with loosening
- B3—Poor bone with loosening

However, some classifications for individual fractures are more popular. The Rorabeck and Taylor classification is most popular for the supracondylar periprosthetic fractures [13]. It considers fracture displacement as well as the stability of the component (Fig. 21.1).

- Type I: Non-displaced; component intact
- Type II: Displaced; component intact
- Type III: Displaced; component loose or failing

The tibial periprosthetic fractures though lesser in number have been classified by Felix et al. who reported 102 tibial periprosthetic fractures at the Mayo clinic [14] (Fig. 21.2).

The classification is:

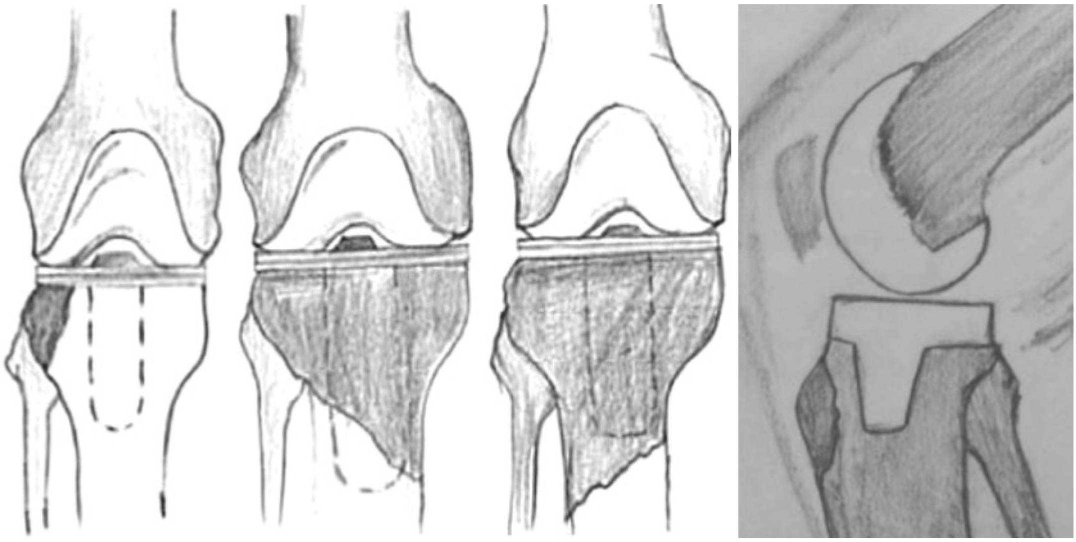
Type	Subclass
Type I: Fracture of tibial plateau	A—Stable implant
Type II: Fracture adjacent to tibial stem	B—Loose implant
Type III: Fracture of tibial shaft	C—Intraoperative
Type IV: Fracture of tibial tubercle	

The patellar periprosthetic fracture classification has been based on the component stability, bone quality, and integrity of the extensor mechanism. The classifications are given by Goldberg et al. [15].

Type	Description
Type1	Midbody or superior pole fractures not involving the implant, cement, or quadriceps mechanism
Type 2	Fractures disrupting the quadriceps mechanism or implant/bone/cement composite
Type 3	Further subdivided in 3a and 3b
Type 3a	Inferior pole fracture with patellar ligament rupture
Type 3b	Inferior pole fracture without patellar ligament rupture
Type 4	Fracture dislocations

21.4 Evaluation and Planning

Evaluation of periprosthetic fractures entails a detailed history about the trauma (significant or trivial fall), details of the implant, date of implantation, revisions, ambulatory status, comorbidities, and antecedent pain. The presence of antecedent pain may indicate infection or aseptic loosening of the implant. Getting the last X-rays for comparison would help delineate the presence of lysis or loosening of implants post the injury.



Type 1 Type 2 Type 3 Type 4

Fig. 21.2 Felix classification for tibial periprosthetic fracture

The diagnosis of periprosthetic joint infection (PJI) is particularly challenging in patients with periprosthetic fractures. Roshan et al. evaluated 121 patients with periprosthetic fractures and assessed the infective parameters [16]. They implied that the synovial fluid total and differential WBC count are the best tests and the cutoff remains the same as in patients without periprosthetic fractures. ESR and CRP remain sensitive but overall have a lower predictive value when compared to the WBC count.

The authors also feel if the periprosthetic fracture is anywhere near the implant, a CT scan should be done. The CT machines have improved pictures that reduce the scatter due to the implant and help delineate the fracture fragments and look at lysis if present. The CT may help in defining any loosening of implant if in doubt.

21.5 Supracondylar Periprosthetic Fracture Femur

Periprosthetic supracondylar distal femoral fracture is the most common type of periprosthetic fracture after total knee arthroplasty with an incidence ranging from 0.3% to 3.5% in the first 4 years after surgery [1, 17]. The risk factors and the associated morbidity with these fractures have already been discussed. Once we see the patient in the emergency or the outpatient the patient as a whole needs to be assessed and any history of infection needs to be ruled out. The whole limb X-rays need to be done and in our set up a CT scan is done if the fracture line is near the flange of the femoral implant.

The aim of the management of the supracondylar periprosthetic fractures is to achieve a painless stable well-aligned knee. The fixation should allow for an early range of motion and mobilization of the patient. The various classification systems will enable us to determine the presence of displacement or comminution, the amount and quality of available bone stock in the distal fragment, and the presence of a well-fixed or loose femoral component—these help in determining the plan and treatment.

21.5.1 Non-operative Treatment

Non-operative treatment of supracondylar periprosthetic fractures is reserved for undisplaced fractures in individuals who are otherwise unfit for surgery, or the risks for surgery are very high. In very rare cases, undisplaced fractures in otherwise healthy individuals may be considered to be treated conservatively. Non-operative management may be undertaken with the use of a hinged knee brace or casting. In some patient's initial traction application, followed by casting may be used. In 1986, Merkel et al. had reported treatment of 36 supracondylar fractures out of which 26 were treated conservatively [18]. They stated that 17 patients out of the 26 healed and showed promising results at 2 years follow up, but the rest (35%) needed revision surgery later. Other studies suggest a malunion rate of 12%–40% and a high rate of subsequent surgeries between 15 and 30% when non-operative treatment is the treatment mode. Even in cases of undisplaced fractures, patient may develop arthrofibrosis and the fracture may displace over a period of time, thus the choice of non-operative treatment needs to be carefully considered [19, 20].

In author's opinion, non-operative treatment is considered if the fracture is non-displaced and the component is stable, patient is medically unfit for surgery or if the risk of the operation is very high. The patient though needs to be followed up regularly with serial X-rays.

21.5.2 Operative Treatment

Operative treatment remains the principal method of treating periprosthetic distal femoral fractures so that early range of motion of the knee and mobilization of the patient can be started. The type of fixation method depends mainly on fracture pattern, component stability, quality of the bone, and whether there is a sufficient amount of bone stock. The plan also depends on the surgeon's training and the implants available with the particular setup. Both plate and screw constructs and intramedullary nail constructs have been used with varying degrees of success in situations where the femoral implant is stable. If the component is loose then revision TKR or use of endoprosthesis may be needed.

21.5.2.1 Plate Fixation

Initially, the plates used were the conventional plates (non-locking) and nowdays, the locking plates are used. Though in the 1980s and 1990s, the traditional non-locked plates were used to fix these fractures along with an attempt of open reduction the results though better than conservative had their share of complications like delayed union, malunion, nonunion, and infection. The problem with the conventional plates was the motion of the screw heads within the plates, which lead to loss of reduction in cases where there was comminution. The plates were applied on the lateral surface and the medial comminution led to a predisposition of varus collapse for the same reason with the use of conventional plates.

Modern locked plating technology was developed to tackle the difficulties with treatment of osteoporotic and metaphyseal fractures. Locked plates allow the screw heads to screw into the plate, creating "fixed-angle" constructs, which are theoretically better able to resist varus displacement forces across the fracture. These plates have become an essential tool to achieve stable fixation in periprosthetic fractures with well-fixed implants. Locking plates allow for both rigid and bridging techniques for the metaphyseal or diaphyseal fracture component and can be placed utilizing minimally invasive, soft-tissue-sparing techniques.

Hoffman et al. reported the complications and clinical outcomes of locking plates in treatment of distal femoral fractures [21]. They collected data on 111 fractures and reported 74.8% union rates with 20% nonunion rates. They also reported that fewer nonunions were found in the submuscular group (10.7%) compared to open reduction (32.0%). They also mentioned that the fracture above a prosthesis had a worse clinical outcome and a greater failed hardware rate. Thukral et al. retrospectively reviewed 31 patients with comminuted supracondylar periprosthetic fractures reported 100% union though the time to union was faster for the closed reduction group [22]. Systematic reviews of periprosthetic distal femoral fractures treated with locked plating have shown nonunion rates of 5–13% and malunion rates of around 5% [23, 24].

There has been an introduction of variable angle plates, which helps change the angle of the distal screws. This is helpful in very distal fractures and also in cases where the femur implant has a big box. Though Nikolas et al. conducted a multicenter prospective randomized pilot trial with 40 patients and found no difference in union rates between the fixed or variable angle plates [25].

However, locking plates are not without shortcomings and healing complications occur. Several studies cite concerns that locking plates are too stiff and do not allow induction of callus necessary for secondary bone healing (Fig. 21.3). There have been instances of delayed union and nonunion with locking plates. These plates tend to hold the fracture in position and the surgeon should be cautious of fixing the fracture in a malaligned state, so proper reduction before application of these plates is key and when using these plates for reducing the fractures one needs to remember the sequence of screws, cortical before locking. Henderson et al. retrospectively examined 86 distal femur fractures treated with lateral locking plates and found bridge span length, plate length, and bridge span to plate length ratio was not significantly associated with union, leaving the hole adjacent to the fracture open (without a screw) resulted in significantly more unions than nonunions [26]. William et al. retrospectively reviewed 96 patients and found constructs with all locking screws used in the diaphysis when bridge-plating distal femur locking plates were 2.9 times more likely to experience a nonunion [27]. So they recommended to keep the locking screw density to <0.5 in the diaphyseal region.

Fig. 21.3 Showing nonunion at 6 months

Few Key Points for Plating

Position

- Supine on a radiolucent table.
- Drape the opposite lower limb (Fig. 21.4).
- A bump (bolster) under the knee help control the flexion of the distal fragment (Fig. 21.4).

Plate

- Lateral plate as the first option.
- Reduce the pericondylar area.
- Anatomical plate can be used as a reduction method—careful to use cortical screws.
- Distal screws direction to maintain the 5°-8° valgus in built-in anatomical plates.
- Where possible use the minimally invasive approach (Figs. 21.5 and 21.6).
- Reduce soft tissue dissection.
- The length of the plate should ideally be double the comminuted length.
- Four screws minimal proximally and 4–5 in the distal fragment.
- Hybrid fixation in the proximal fragment (mix of cortical and locking).
- Always check lateral views.
- If Open reducing—consider bone grafting.

Fig. 21.4 The bolster under the knee and the draping of the opposite limb to get a good lateral view

Fig. 21.5 Showing MIPO or slide plate

Case 1

A 66-year-old lady 5 years post-op bilateral TKR fell in the market, comorbidities include hypertension and hypothyroid (Figs. 21.7, 21.8, 21.9, 21.10, and 21.11).

21.5.2.2 Intramedullary Nails

Intramedullary nails are another method to fix these supracondylar periprosthetic fractures. Antegrade and Retrograde nails may be used depending on the fracture pattern. However, retrograde nails are preferred as they have a better fixation in the distal femur segment. The nails can only be used in femoral implants that have an open box and will accommodate the starting point and the nail's width. The presence of an ipsilateral hip implant is another contraindication for the use of nail as a fixation method.

The retrograde nailing does offer a few benefits, the use of a previous skin incision, no stripping of the soft tissue around the fracture, retention of the fracture hematoma. In length stable fractures, intramedullary nail is a load-sharing implant compared to lateral plate which is a load-bearing implant. There are some concerns with intramedullary nails as well, especially with their point of entry. Jones et al. studied eight implants and four nails and found that only two implants were compatible [28]. The rest were not compatible as they needed more force for entry leading to metal debris or had a posterior entry which may lead to anterior cortical perforation or an extension deformity. Pelfort et al. found a 23% incidence of an extension deformity of more than 10° with the use of retrograde intramedullary nails for periprosthetic distal femoral fractures [29].

Meneghini et al. reviewed 85 fractures comparing intramedullary nails with locking plates and reported only 2 nonunions in the nailing group as compared to 12 in the locking plate group [30]. They also mentioned that the nailing group achieved full weight-bearing status 3 weeks earlier than the plating group. However,

Fig. 21.6 Slide plate fixation

Ristevski et al. reviewed 719 fractures and presented a clear advantage of locked plating over intramedullary nailing when comparing malunion rates [24]. Ebraheim et al. have compared nailing with locked plating and found similar time to union though some trend toward malunion is seen in the nailing group [31].

21.5.2.3 Revision Total Knee Replacement

In situations where the femoral prosthesis is loose, the treatment option that remains is a revision total knee replacement. The revision total knee replacement can be achieved by fixing the fracture and using revision knee implants, using a distal femur allograft prosthesis composite or a megaprosthesis.

In the case of a loose femoral component, the fracture is assessed on the table for reducibility and the collateral ligaments' functionality. These things define the choice of femur prosthesis to be used for revising the distal femur implant. In scenarios where the fracture can be reduced and the collaterals are intact, the distal femur's revision is done by using a stem in the femur with or without the use of a constraint femur. The choice of constraint is dependent on the intactness and functionality of the collaterals and the flexion-extension

Fig. 21.7 Pre-op Lewis Rorabeck type 2 (displaced fracture with stable implant)

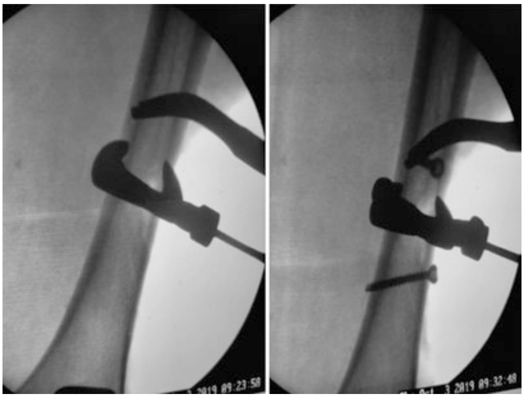


Fig. 21.8 Intra-op reduction of the Spiral fracture held with inter-fragmentary screws

Fig. 21.9 Distal length of the plate verified and the screw passed parallel to the joint line

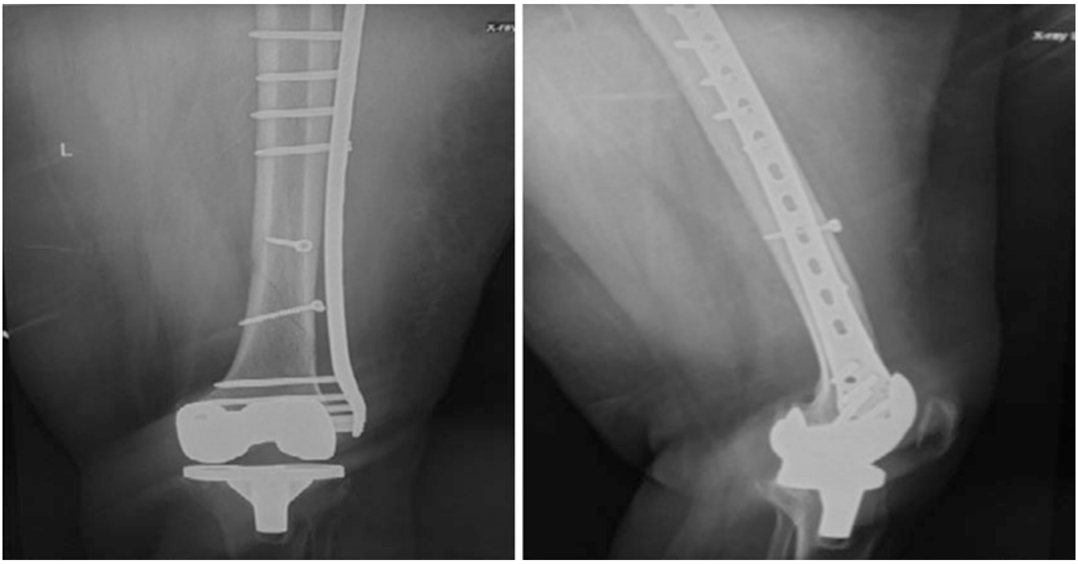


Fig. 21.10 Immediate post-op

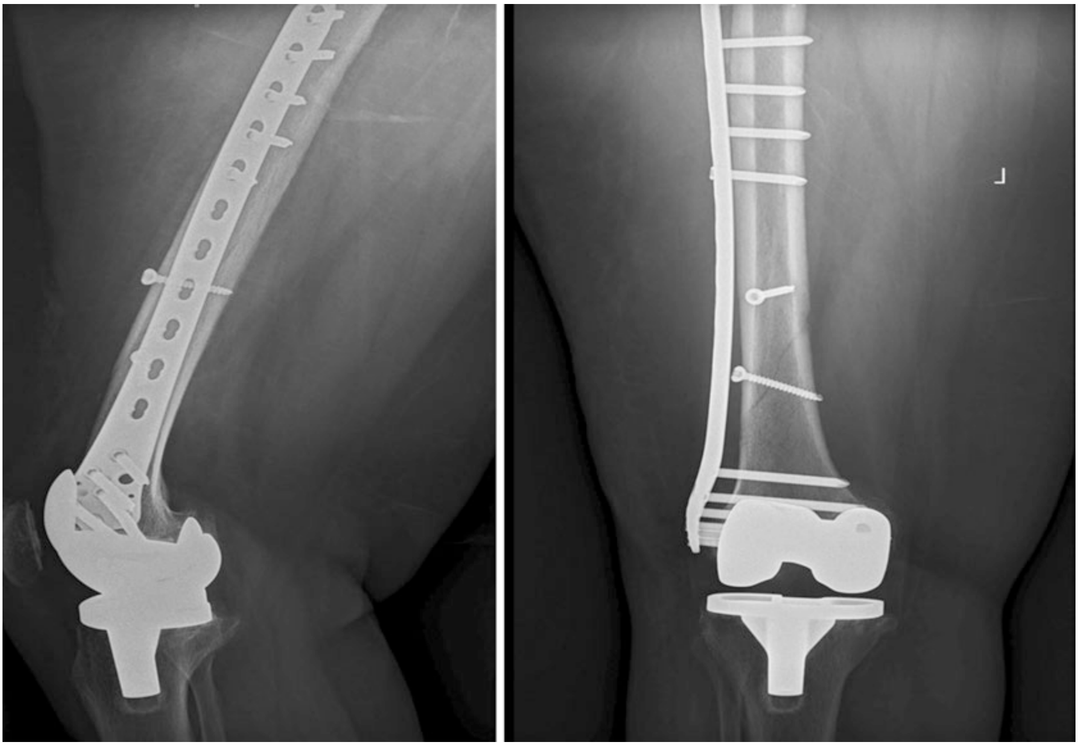


Fig. 21.11 Showing full union at 4 months

balance achieved on table. It is always recommended to have all the combinations available on table when revising such fractures.

In scenarios where there is a lot of comminution and the collateral attachments are also involved then an allograft prosthesis composite or distal femur replacement prosthesis (megaprosthesis) is considered. The relative success of megaprosthesis for managing bone loss secondary to tumor resection, has increased the advocacy for use of distal femoral arthroplasty for the management of distal, comminuted supracondylar femur fracture around well-fixed or lose implants, especially in elderly patients who can benefit from early mobilization has gained popularity. This can be considered even in cases of stable implants in the elderly subset of population. Rahman et al. reviewed 17 distal femoral arthroplasty for periprosthetic supracondylar femoral fracture for a mean follow-up of 34 months [32]. There were three re-operations (18%) and two periprosthetic fractures (one managed non-operatively and one with revision TKA) and one deep infection. Mortazavi et al. followed up 22 periprosthetic fractures of the distal femur treated with distal femoral replacement with a mean follow up of 59 months. Eighteen knees were available at final follow-up 5 knees underwent additional surgery (28%) [33]. There was one case of aseptic loosening and three periprosthetic fractures. Distal femoral arthroplasty can be a successful tool for managing distal femur periprosthetic fractures provided the surgeon has experience in these scenarios.

Case 2 Treating Periprosthetic Fracture with Revision TKR Implants

An 84-year-old female with a history of fall at home with 16 years post TKR sustained fall at home. Medical history includes diabetes, hypertension, and chronic kidney disease (Figs. 21.12, 21.13, 21.14, and 21.15).

Fig. 21.12 Low Periprosthetic fracture with Loose implant

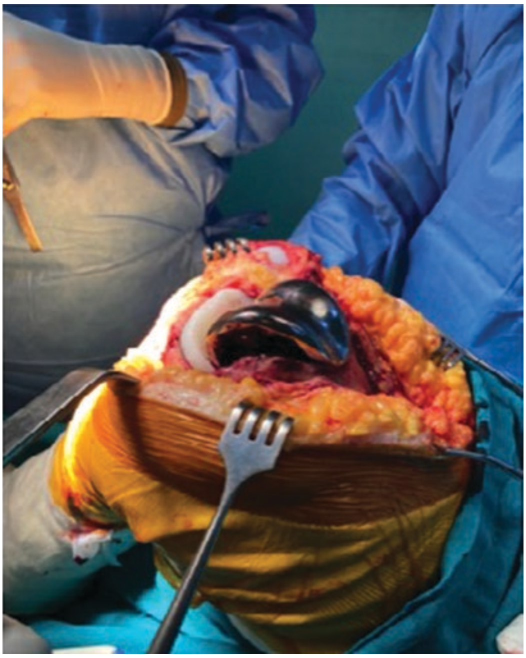
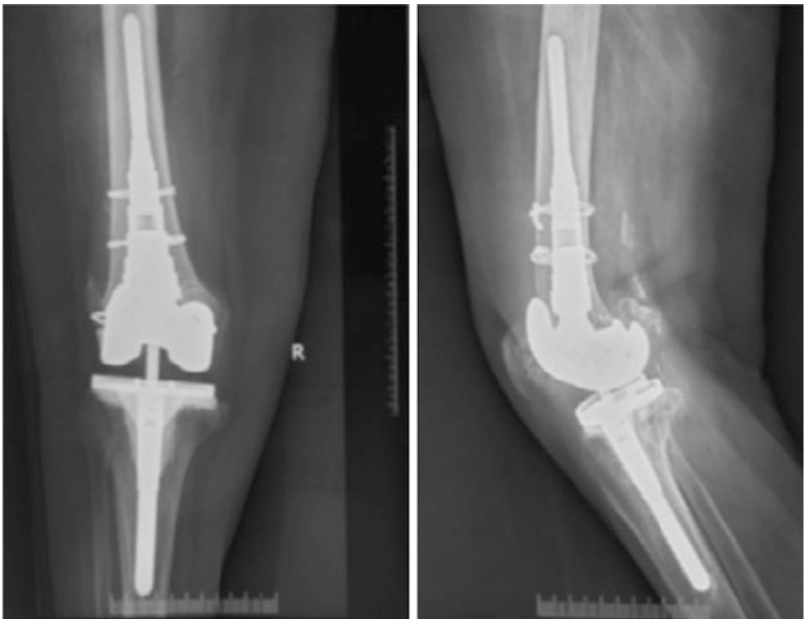


Fig. 21.13 Intra-op loose implant

Fig. 21.14 Wiring of the distal femur

Fig. 21.15 Postoperative X-ray use of Sleeve with a TC3 implant



Case 3

A 77-year-old lady sustained a fall 10 days post-operative after bilateral TKR presented in the emergency with a small gaping of the fracture line and periprosthetic fracture (Figs. 21.16, 21.17, 21.18, 21.19, and 21.20).

21.6 Tibial Periprosthetic Fractures

Tibial periprosthetic fractures are encountered less frequently and somehow have gotten less attention in literature over the years as compared to the distal femur periprosthetic fractures. The prevalence of periprosthetic fractures of the tibia is 0.4–1.7%, which is relatively low compared to that of the femur [34]. The tibial fracture can occur intraoperatively or later on in the postoperative period. The intraoperative fractures can be the ones that are seen on the table or seen on immediate post-op X-rays. The most common causes of intraoperative fractures are tibial tubercle osteotomy, lateral placement of tibial tray in a post-high-tibial osteotomy patient, excessive retraction, and removal of the prosthesis in revision surgery. The tibial fractures in the postoperative period are caused due to trauma, stress fractures, and in rare cases malalignment of tibia. Rand et al. noted malalignment of tibia as a cause in their series of tibial periprosthetic fractures [35].

Felix et al. formulated the classification system where the fracture's location defined the types, and the subtypes described the status of the tibial component fixation [14]. Type I fractures are at the tibial plateau, type II fractures occur just below the tibial plateau adjacent to the prosthetic stem, type III fractures arise distal to the tibial stem, and type IV fractures comprise the tibial tubercle. Type A is assigned to a fracture with a stable prosthesis on radiographs, type B is defined as fractures with radiographic evidence of component loosening, and type C refers to intraoperative fractures.

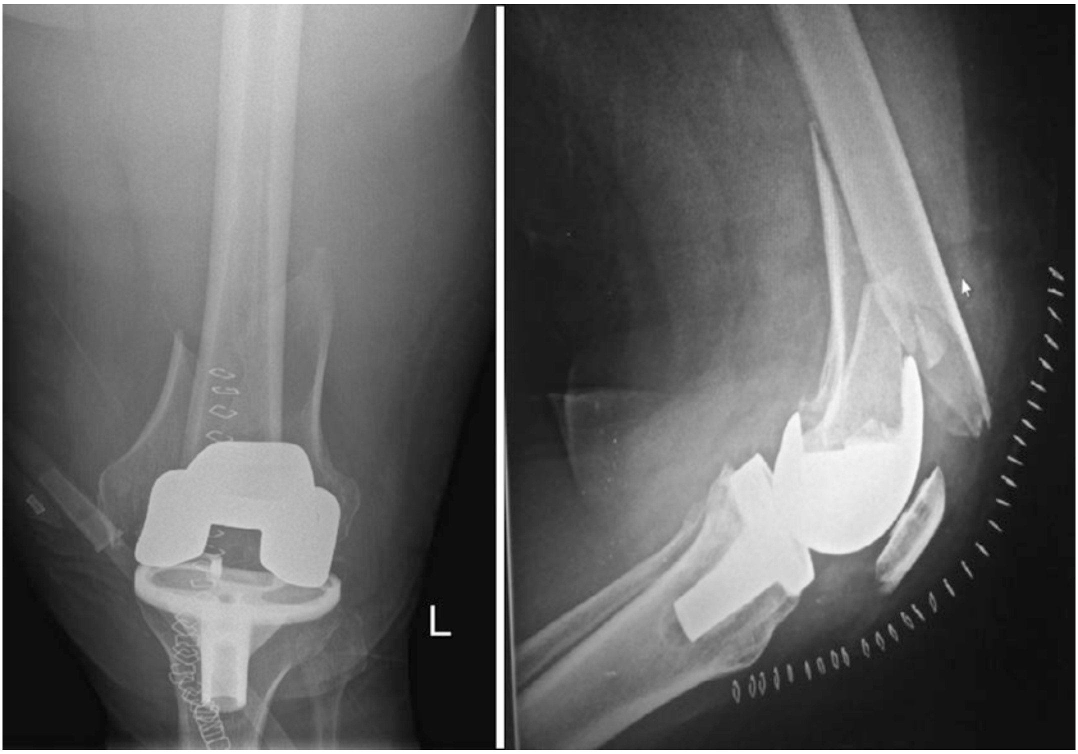


Fig. 21.16 Preoperative X-ray of the above-mentioned lady, the skin staples are still present

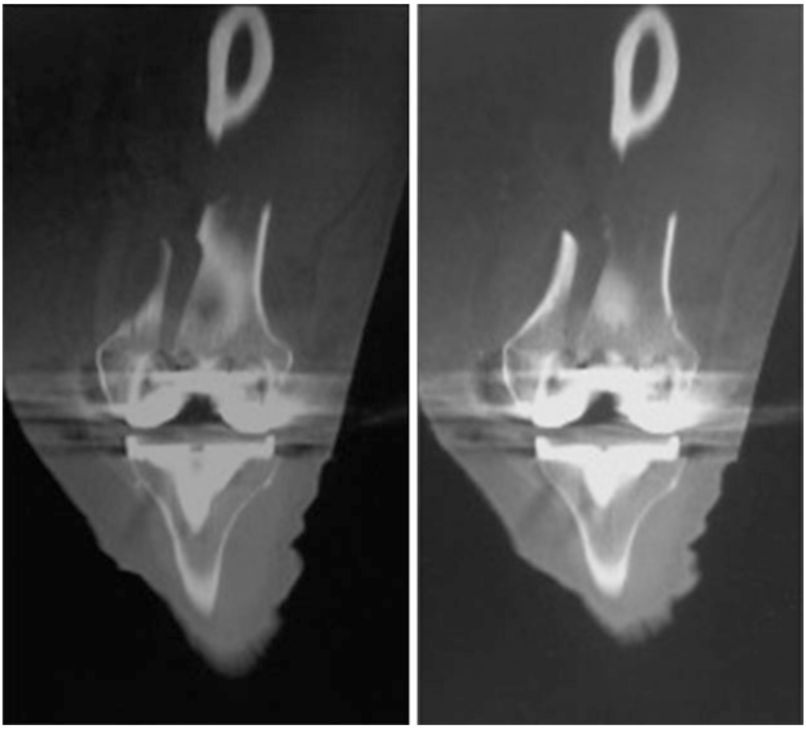


Fig. 21.17 CT scan Grab showing fracture line extending till the implant

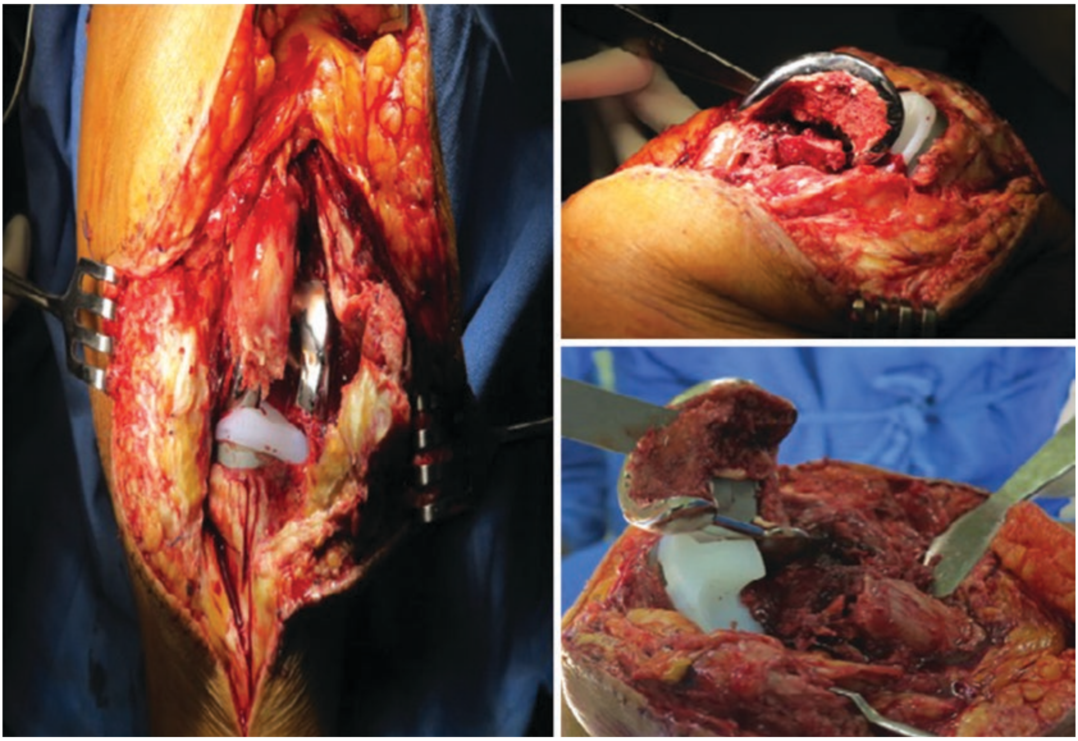


Fig. 21.18 Intra-op pics showing a loose implant

Fig. 21.19 Measuring the distal femur which needs to be resected, the tibia needed to be changed to use a rotating hinge knee

Fig. 21.20 Postoperative picture

21.6.1 Treatment

The status of the tibial component outlines the treatment, if the tibial component is stable and intact standard fracture fixation principles fix the fracture. The treatment aims to provide a well-aligned knee that allows for early movement of the knee and mobilization of the patient.

In subclass A where the tibial implant is stable the Type 1 fractures if undisplaced can be treated by conservative method or by screw fixation. If the fragment of the tibial plateau is big it should be supported by a locking plate as well (Fig. 21.21). In Type 2 fractures, the plates are used and the fracture is kept in position for it to heal. Locking plates are preferred option these days. Type 3 fractures are treated by standard principles with either a plate or a nail (Fig. 21.22). During nailing one has to choose a nail that avoids the tibial keel. The Type 4 tibial tuberosity fractures will need to be wired or held with screws and washers, the extensor mechanism need to be carefully handled in these situations.

In subclass B, where the tibial implant is loose, type 1 and type 2 fractures need a revision of the tibial component. The reconstruction of the proximal part of tibia needs to be done. As a first step the proximal tibia must be reconstructed with the bone available, if there are bone defects or the tibia cannot be satisfactorily reconstructed, then other methods need to be used. This may involve filling the bone defect with metal allograft, metal augments, or the use of sleeves or cones. The revision tibial implant is used with a long tibial stem, which bypasses the reconstructed site Fig. 21.23a, b.

In subclass C if seen intraoperatively, it needs to be managed with screw fixation or use of long-stemmed tibial components which bypass the fracture.

Due to the scarcity of fractures very few reports are available in the literature on the long-term results. Kim et al. reported 16 patients with tibial periprosthetic fractures [36]. They had stable implants with six patients of type 1 and ten patients of type 3 fractures. They used MIPO with locking plate as a fixation method and had good results in 14 patients with two patients needing a secondary procedure. Anna et al. retrospectively reviewed nine patients of

Fig. 21.21 Type 2 Tibial periprosthetic fracture fixed with locking plate and screws

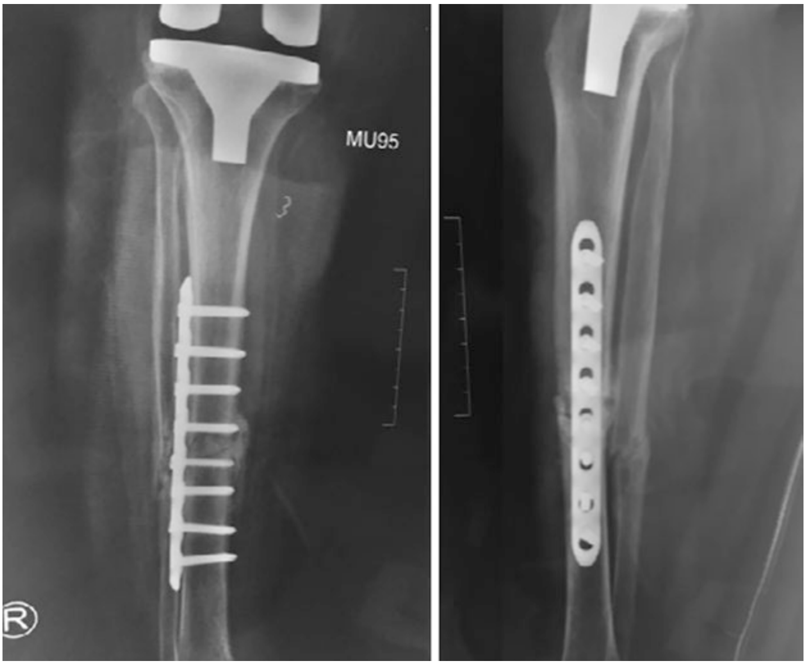


Fig. 21.22 Type 3 Tibial Periprosthetic fracture distal to the tibial implant fixed with plating

tibial fractures and had a mix of subclass A and B fractures [37]. Treatment involved open reduction and internal fixation in six patients, revision arthroplasty in 1, arthrodesis in 1, and amputation in 1. The average age in their subgroup was 77 years and they stress the need for careful planning of these fractures and high rate of complications.

21.7 Periprosthetic Fractures of the Patella

Periprosthetic fracture patella is an uncommon complication having an incidence of around 0.2–21% in resurfaced patella in various studies. In un-resurfaced patella the incidence is about 0.05% [34, 38]. Periprosthetic patella fractures range in severity from a trivial injury, which does not compromise function, to a severely devastating injury that may require advanced reconstructive measures. A retrospective study by Ortiguera et al. at the Mayo clinic of 12,684 TKRs revealed an incidence of around 0.68%. In their study, the prevalence was higher after revision TKR, with most fractures occurring within 2 years of their associated arthroplasty procedure [39].

21.7.1 Risk Factors

Factors contributing to periprosthetic patellar fractures are manifold. They are more commonly seen in men as compared to women, which is unlike the femoral and tibial periprosthetic fractures, it could occur due to higher levels of activities and weights resulting in greater forces across the patella and thus the higher male susceptibility. Osteoporosis, inflammatory arthritis, and increase physical activities constitute the other risk factors.

Patellar periprosthetic fractures can be classified as traumatic and non-traumatic. The traumatic ones happen due to direct injury, dashboard, or sudden increased flexion of the knee due to imbalance. Nontraumatic fractures caused by surgical- and implant-related complications are more prevalent than their traumatic counterparts. The risk factors for nontraumatic periprosthetic patellar fracture are:

21.7.1.1 Vascular Compromise

Studies have been done to reveal that post normal TKR via the medial parapatellar approach the superior genicular artery is the only remaining major vessel providing a significant blood supply

Fig. 21.23 (**a**) Tibial periprosthetic fracture (Intra-op) with a loose implant. (**b**) Treated with Revision Tibial MBT tray

to the patella. This artery is also compromised when a lateral release is done. Scuderi et al. did a postoperative technetium bone scans to establish a higher vascular compromise rate in knees with lateral release (56.4%) than those without lateral release (15%) [40]. Taking it forward Meding et al. established a higher rate of periprosthetic patellar fracture in patients with a lateral release and body mass index >30 kg/m^2 [41]. One needs to be careful of the extensive stripping of soft tissue around the patella.

21.7.1.2 Patellar Thickness

The aim of the patellar replacement is to replace the exact amount of patella which has been resected. Overly thin patellae impart a greater risk of fracture. A biomechanical study proved increased strain with an overall patellar thickness of <25 mm or bony thickness of <15 mm [42]. Disproportionate resection of the patella increases strain on the patella, especially when the subchondral bone or the lateral articular surface is included in the resection. Conversely, insufficient resection results in increased patellar-implant thickness, causing stuffing of the patellofemoral space increasing the patellofemoral joint reaction force and putting strain on the extensor mechanism.

21.7.1.3 Implant Design

The central peg has been shown to increase anterior patellar strain and the peripheral pegs reduce the strain. Thus, the patella's with peripheral pegs are preferred. Metal back patellae were associated with higher loosening rates and failures and hence have gone out of vogue [43].

21.7.1.4 Limb Alignment

Malalignment of the femoral component has a significant role to play in the incidence of periprosthetic patellar fractures. An internal or external rotatory malalignment increases the strain on the patella femoral contact surface and increases fracture chances. The changes in joints are known to increase the patellar strain. Figgie et al. studied the effect of alignment on periprosthetic patellar fractures on 36 knees and found that knees with minor malalignment had mild fractures and one with severe malalignment had fractures with the loosening of implants [44].

21.7.2 Classification of Patellar Periprosthetic Fractures

The basis of classification of these patellar fractures is dictated by the patellar component's stability, the integrity of the extensor mechanism, and the quality of the bone stock. There is no universally accepted classification, we have described the classification given by Goldberg et al. [15]. Type I fractures are located in the periphery of the patella and do not involve the patellar component and the extensor mechanism. Type II fractures disrupt the implant-bone composite or the extensor mechanism. Type III fractures involve the patella's inferior pole, which are subcategorized into type IIIA with patellar ligament rupture and type IIIB without patellar ligament rupture. Type IV fractures refer to patellar fractures accompanied by patellofemoral dislocation.

21.7.3 Treatment

The conservative treatment of periprosthetic patellar fractures where the implant and the extensor mechanism are intact is preferred as multiple studies have shown better results as compared to operative intervention in such cases (Fig. 21.24). Goldberg et al. in a retrospective study of 36 knees showed good or excellent outcomes in 22 of those knees treated conservatively [15].

In cases where the patellar component is loose and the extensor mechanism is intact, it is recommended to remove the patella and the fracture treatment done by the conservative method only. Revising the patella in such a setting has poorer results as compared to patellar resection arthroplasty.

Extensor mechanism discontinuity in the setting of periprosthetic patellar fracture should be treated surgically because this places the entire TKR at risk for failure and impedes functionality. If the patella's bone stock is good an open reduction and internal fixation should be attempted either around a stable component (Fig. 21.25) or after removing the component if it is loose. The chances of difficulties with the union of this ORIF are high as the vascular supply is compromised due to previous surgery. The use of hamstring or Achilles tendon allograft to supplement the repair is advised.

In cases of delayed presentation or failed ORIF scenarios, extensor allograft reconstruction of the extensor mechanism is done using an Achilles allograft on a bone block or synthetic polymer mesh materials can be used.

Fig. 21.24 Lower pole periprosthetic fracture patella with intact implant

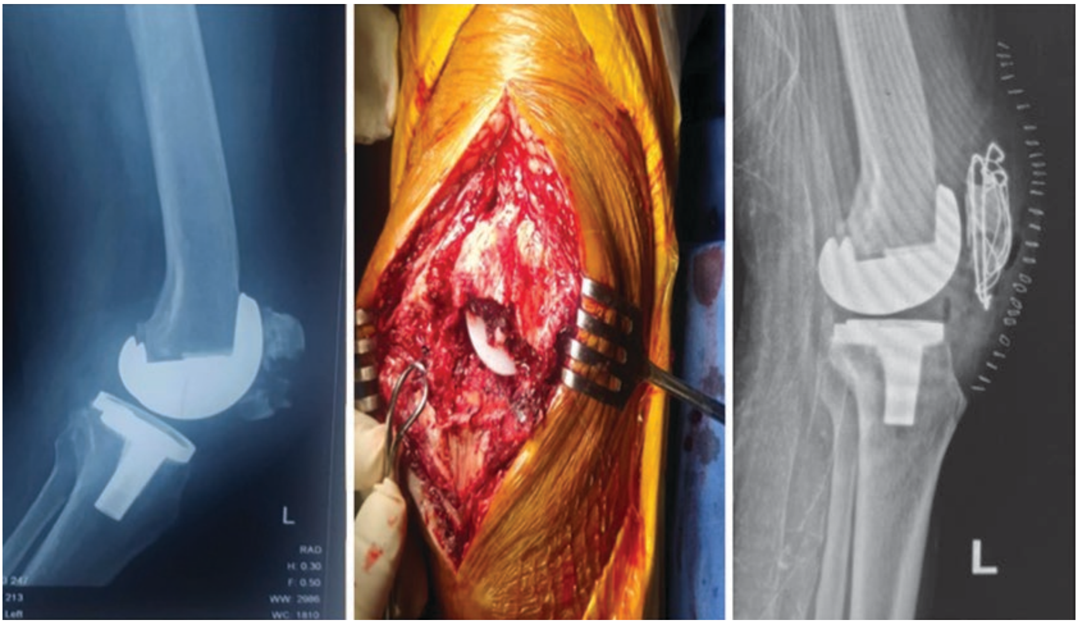


Fig. 21.25 Periprosthetic Fracture mid-body patella with stable implant fixed with TBW

21.8 Summary

These are challenging injuries most of the time, and in our minds, decision-making should be a team effort involving not only the arthroplasty and the trauma teams but also the internal medicine and the anesthetist, as the patient is usually elderly with multiple comorbidities. The aim should be early mobilization achieved via a stable, painless well-aligned joint. The one-solution fits all is not an answer: all fractures should be carefully assessed and classified. The treatment would depend on the fracture location, implant stability, and bone milieu and patient factors.

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