17 Periprosthetic Fractures in Total Knee Arthroplasty

E. Carlos Rodríguez-Merchán, Carlos A. Encinas-Ullán, and José M. Martínez-Diez

17.1 Introduction

With the augmenting number of total knee arthroplasties (TKAs) being carried out, the incidence of periprosthetic fractures adjacent to a TKA is increasing [1]. The incidence of periprosthetic fractures following TKA is between 0.3 and 2.5%. Most periprosthetic fractures involve the distal femur, followed by the patella and the tibia. Tibial fractures occur disproportionately during implantation. The rate of fracture following revision TKA is double that reported following a primary procedure. Periprosthetic fracture is a challenging problem following TKA, with high rates of mortality (11% in the first year) and complications of treatment (up to 30%) whatever treatment modality is used [2].

17.2 Risk Factors and Preoperative Outcome Measures that Predispose to Periprosthetic Fractures after Primary TKA

Risk factors for periprosthetic fracture are age (>70 years); female gender; reduced bone stock due to rheumatoid arthritis, osteoporosis, and steroid use; cementless implants; posterior-stabilized designs; component malpositioning; tubercle osteotomy (risk of fracture in the tibia); and patellar problems (large resections, malalignment, and patella baja) [2].

In 2017 Lim et al. analyzed whether preoperative patient-reported outcome measures (PROMs) would affect the risk of periprosthetic fractures after primary TKA. Forty-two patients were identified and matched for gender, age, and body mass index to a control group of 84 patients who had primary TKA without periprosthetic fracture in a 2:1 ratio. A lower Short Form-36 (SF-36) physical functioning and vitaly scores were associated with higher risks of sustaining a periprosthetic fracture after primary TKA. These findings can allow the preoperative identification of patients at higher risk of periprosthetic fracture, and appropriate preoperative counseling, optimization, and close follow-up can be instituted for this at-risk group [3].

17.3 Management of Femoral Periprosthetic Fractures

Lewis and Rorabeck classified periprosthetic femoral fractures into three types: types I and II are nondisplaced and displaced fractures, respectively, adjacent to a well-fixed prosthesis; type III is any fracture adjacent to a loose prosthesis [4] (Fig. 17.1). The authors advised that type I

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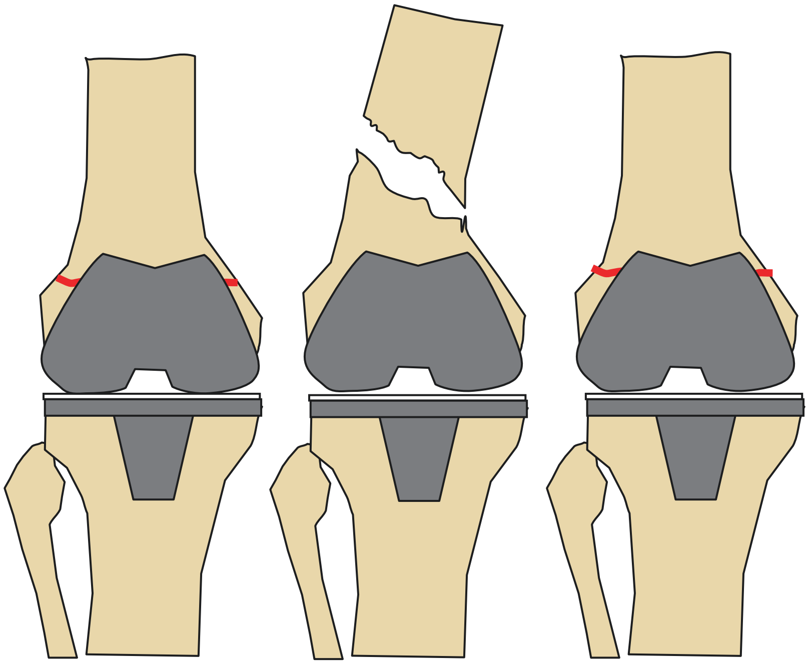

Fig. 17.1 Lewis and Rorabeck classification of periprosthetic supracondylar femoral fractures [4]. Type 1: nondisplaced fracture and prosthesis is well fixed; type II: displaced fracture and prosthesis is well fixed; type III: prosthesis is loose, fracture may be displaced or nondisplaced

fractures be managed nonoperatively, type II fractures be treated with fixation, and type III fractures be managed with revision surgery.

Fixation of periprosthetic femoral fractures in the presence of a stable implant may utilize locked intramedullary (IM) nailing or plate osteosynthesis (Figs. 17.2 and 17.3). Cases where the implant is loose need management with revision TKA, either stemmed revision implants or megaprostheses, depending on the fracture type and bone stock. Revision surgery can be used either as a primary treatment strategy in patients with loose implants or who are unable to tolerate prolonged periods of immobilization or as a treatment for failed primary fixation. While attempting primary fixation preserves bone stock, the use of revision prostheses in the acute setting reduces the risk of reoperation and is associated with a lower rate of complications compared to revision for failed fixation [2].

17.3.1 Minimally Invasive Plate Osteosynthesis (MIPO)

MIPO techniques may be particularly suited to periprosthetic fractures and may make the surgical repair of these fractures safer and more reliable. When considering MIPO for any fracture, Borade et al. recommended prioritizing an acceptable reduction with biological fixation and resorting to mini-open or open approach when necessary to achieve it [1].

17.3.2 Polyaxial Locking Plates

In 2019 Lotzien et al. evaluated polyaxial locking plate treatment of periprosthetic femoral fractures with retained TKA using polyaxial locking plates in regard to quality of life, functional outcome, and complications. The study included 45 patients with periprosthetic supracondylar femoral fractures with a well-fixed knee prosthesis initially treated with NCB plate (Non-contact bridging plate, Zimmer Inc., Warsaw, IN). The mean age was 74 years (10 males; 35 females). Body mass index (BMI) averaged 27.4 kg/m^2. Follow-up averaged 52 months. Mortality rate was 26.7%. Union was achieved in 35 of 45 fractures (78%) 6 months after the index procedure. The union rate including following procedures at last follow-up was 95.6%. Many patients after

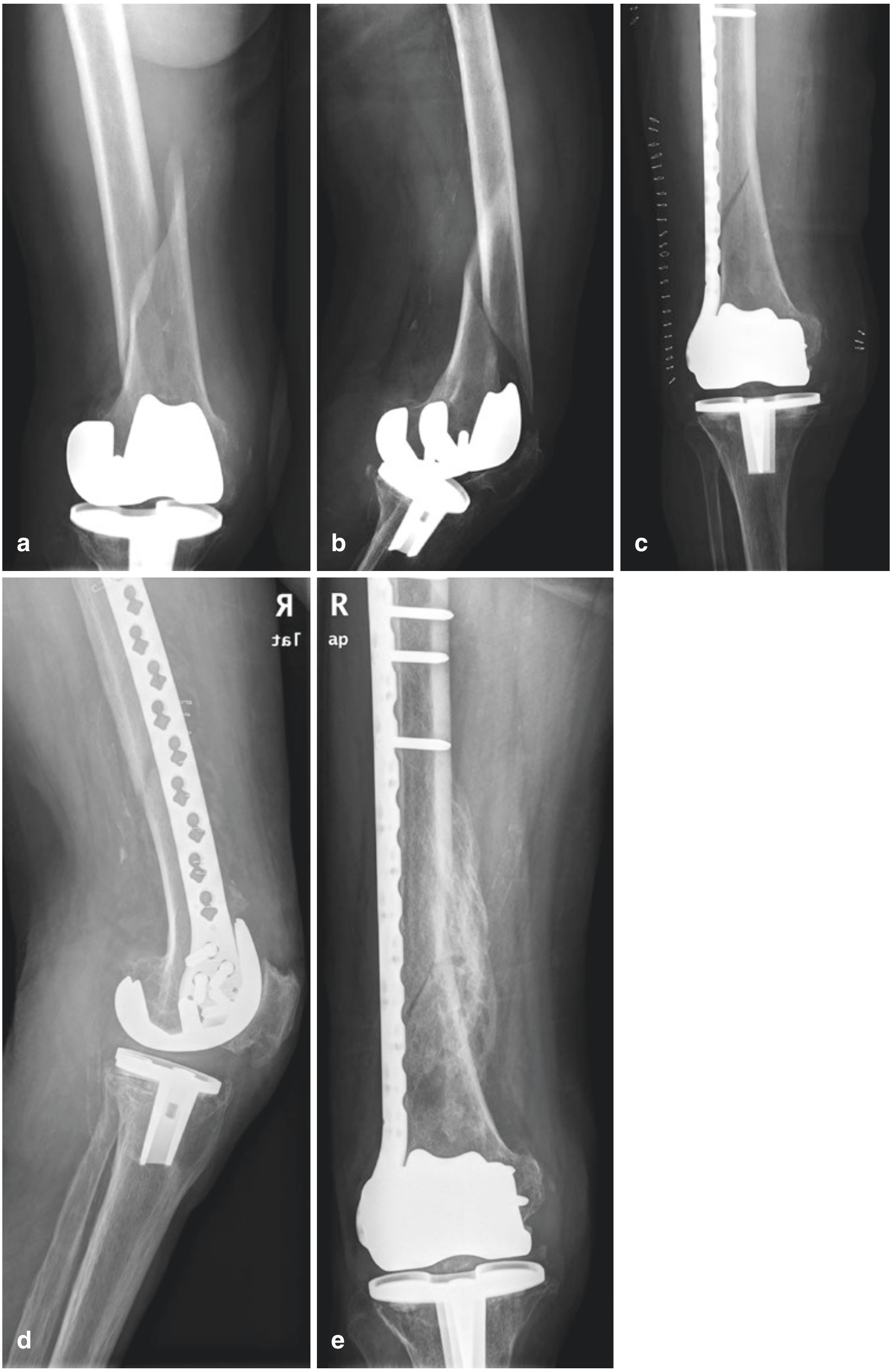

Fig. 17.2 (**a**–**e**) Periprosthetic supracondylar femoral fracture in a 78 year-old woman. The fracture was fixed with a VP-LCP (variable angle—low contact plate), DePuy Synthes, Oberdorf, Switzerland). Bone healing was achieved at 4 months. The result was satisfactory: (**a**) Anteroposterior preoperative radiograph; (**b**) Lateral preoperative view; (**c**) Anteroposterior postoperative radiograph; (**d**) Lateral postoperative view; (**e**) Anteroposterior radiograph at 4 months

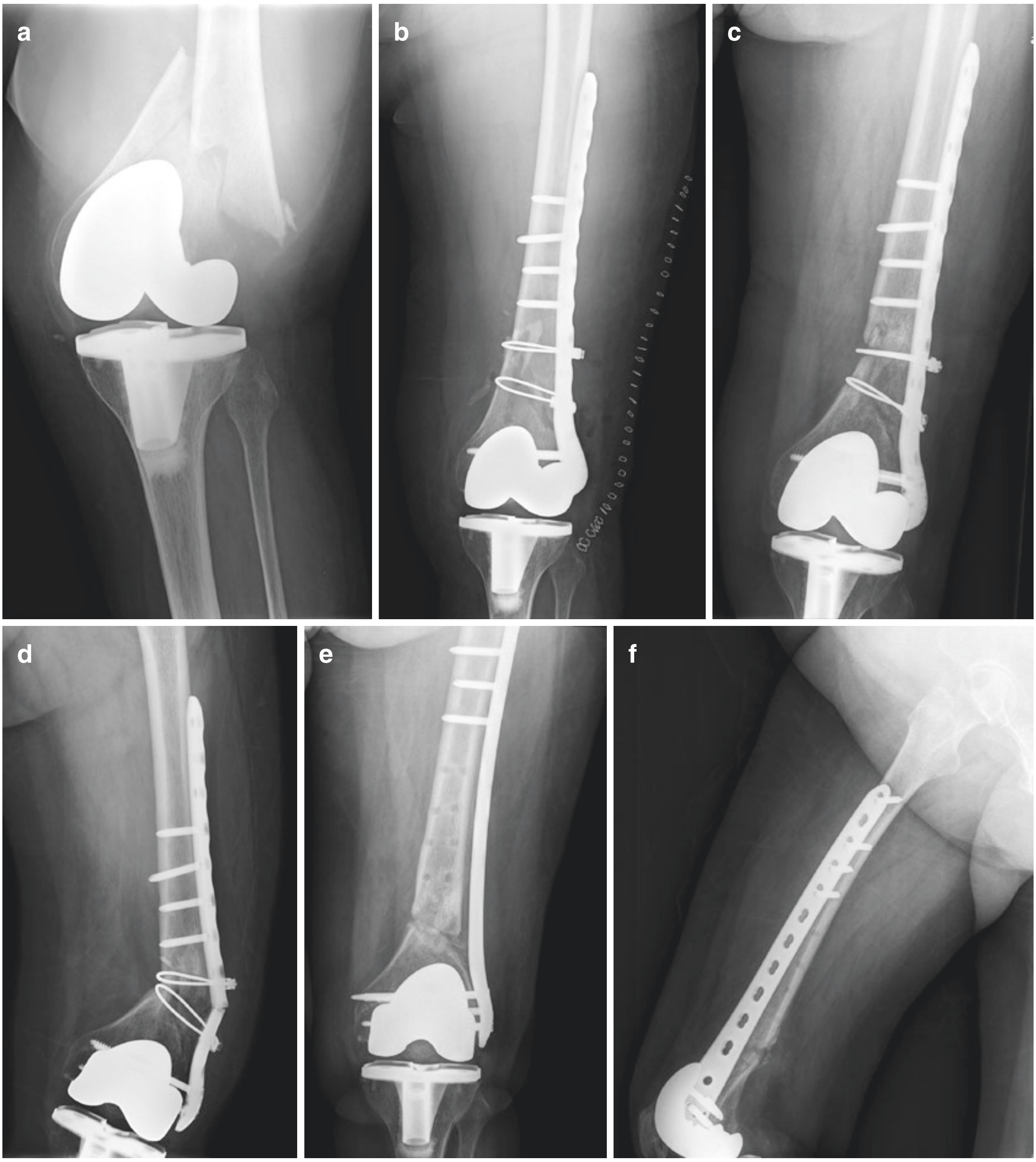

Fig. 17.3 (**a**–**i**) Periprosthetic supracondylar femoral fracture in a 76 year-old woman. The fracture was fixed with a locked plate and wires. Varus collapse happened at 9 months. This complication was solved by means of a new osteosynthesis with a LISS (less invasive stabilization system) LCP (low contact plate) of distal femur (DePuy Synthes, Oberdorf, Switzerland). Bone healing was achieved at 18 months: (**a**) Anteroposterior preoperative radiograph; (**b**) Anteroposterior postoperative radiograph; (**c**) Anteroposterior view at 7 months; (**d**) Anteroposterior view at 9 months (varus collapse); (**e**) Anteroposterior radiograph after new osteosynthesis; (**f**) Lateral view after new osteosynthesis; (**g**) Closer lateral view after new osteosynthesis; (**h**) Anteroposterior radiograph at 18 months; (**i**) Lateral view at 18 months

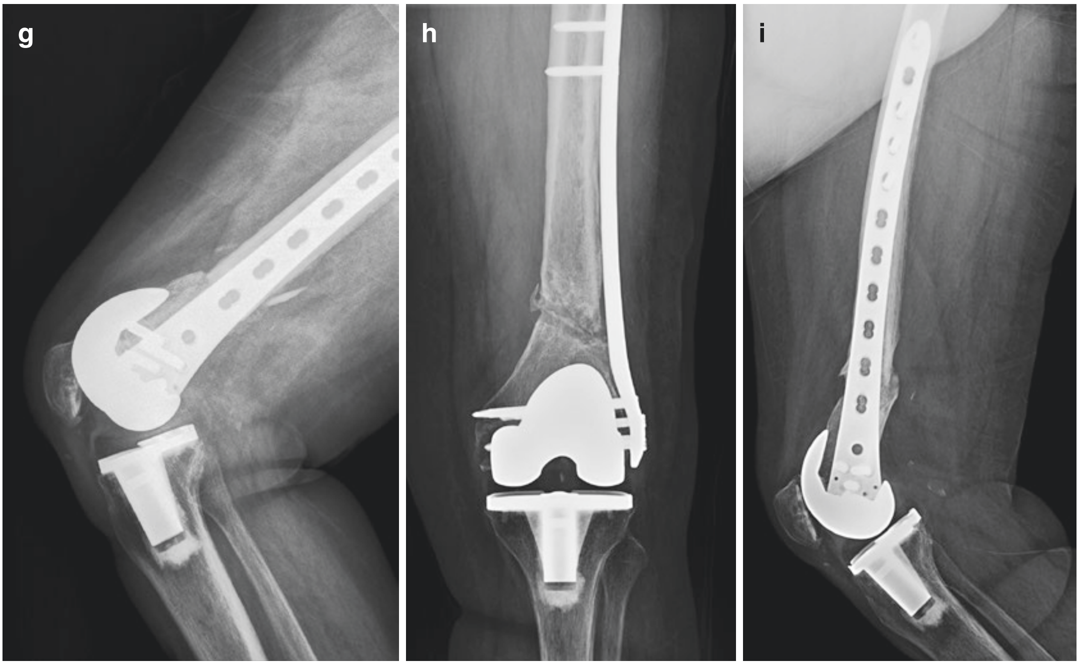

Fig. 17.3 (continued)

surgery were not self-reliant mobile or on orthopedic aids [5].

17.3.3 Comparative Studies: Plate Versus Intramedullary Nail

A meta-analysis published in 2016 by Li et al. found no statistically significant difference in 6 month union rate, union time, operation time, and complication rate between locked plate and retrograde IM nail for periprosthetic femur fractures above TKA. The mean union time was 4 months in the locked plate group and 3.7 months in the retrograde IM nail group [6].

In 2016 Park and Lee [7] compared retrograde IM nailing and MIPO for treatment of periprosthetic supracondylar femur fractures [Orthopedic Trauma Association (OTA) 33-A] (Fig. 17.4) [8]. Forty-one patients treated with either retrograde IM nailing (n = 20) or MIPO (n = 21) for periprosthetic supracondylar femoral fractures were reviewed. There was no statistical difference between the IM nail and MIPO groups in age, 1-year postoperative arc range of motion, preoperative Western Ontario and McMaster University (WOMAC) score, postoperative 1-year WOMAC score, and union time. The mean union time of the IM nail group and the MIPO group was 4.3 months and 3.6 months, respectively. There were three cases of malalignment in the IM nail group, whereas there was one case of malalignment in the MIPO group. One case of nailing using a short nail developed nail breakage. Although retrograde IM nailing was encountered to have a slightly higher rate of malunion compared to MIPO, there was no statistically significant difference between both treatment options in terms of clinical results. Regardless of which implant is used, the proper application is essential in management of periprosthetic supracondylar femoral fractures above TKA [7].

A meta-analysis reported in 2017 by Shin et al. found similar results, including nonunion and revision rates, of locking compression plating and retrograde IM nailing for periprosthetic supracondylar femoral fractures following TKA [9].

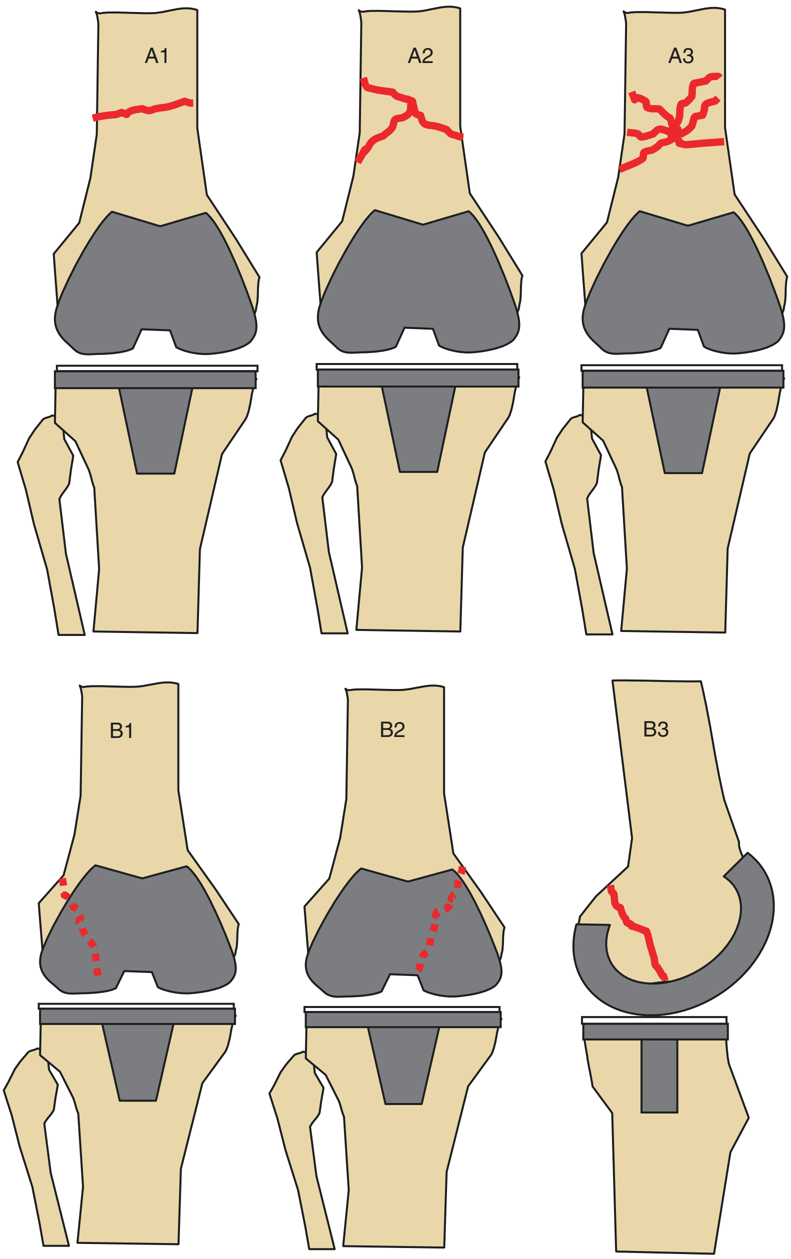

Fig. 17.4 Orthopedic Trauma Association (OTA) classification of periprosthetic supracondylar femoral fractures [8]

According to Matlovich et al., fracture location is an important consideration in managing supracondylar periprosthetic femur fractures. They compared the results of locked plating (38 patients) and IM nail fixation (19 patients) based on fracture location, being above or at/below the TKA flange. Mean follow-up for IM nail and locking plate fixation was 13.9 and 15.6 months, respectively. There was no statistical difference between groups in the mean time to fully weight bear, the incidence of postoperative pain, ROM, use of gait aids, time to full radiographic union,

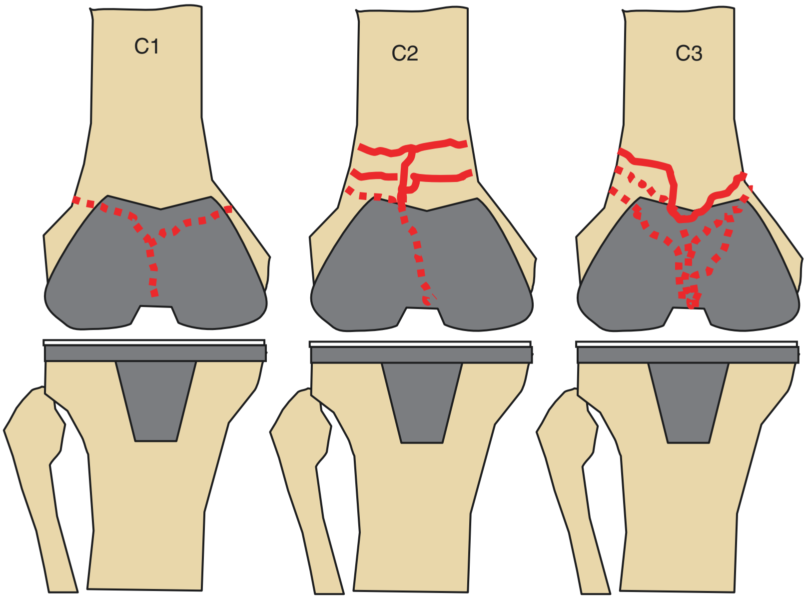

Fig. 17.4 (continued)

or the overall radiographic alignment of a healed fracture. Comparison based on fracture location yielded similar results. Nonunion was only demonstrated in the IM nail group, particularly for fractures below the TKA flange ($n = 2$). The use of either IM nail or locking plate fixation for supracondylar periprosthetic fractures provided comparable clinical results. Caution was recommended in using IM nails for fractures below the flange where limited fixation may augment the risk of nonunion [10].

17.3.4 Lateral Locked Plating or Distal Femoral Replacement

In 2018 Hoellwarth et al. found equivalent mortality and complication rates following periprosthetic distal femur fractures managed with either lateral locked plating (LLP) or a distal femoral replacement (DFR). They performed a retrospective review of patients at least 55 years old who sustained femur fractures near a primary TKA (essentially OTA-33 or subtypes 1, 2, or 3) assigning cohort based on treatment: LLP or DFR. They excluded patients having prior care for the injury, whose surgery was not for fracture (e.g., loosening), or having other surgical intervention (e.g., IM nail). Groups were similar based on BMI and age adjusted Charlson Comorbidity Index (aaCCI). LLP was more common than DFR for fractures above and at the level of the implant, but similar for fractures within the implant for patients with aaCCI ≥ 5. LLP and DFR had similar mortality at 90 days (9% vs 4%) and 365 days (22% vs 10%), need for additional surgery (9% vs 3%), and survivors maintaining ambulation (77% vs 81%). Patients whose surgery occurred three or more days after presentation had similar mortality risk to those whose surgery was before 3 days. The mean age of 1 year survivors was 77, whereas for patients who died it was 85. Neither surgical choice nor aaCCI was associated with increased risk in time to surgery. The main conclusion was that fracture location, remaining bone stock, and patient's prior mobility and current comorbidities must guide treatment. This study suggested that 90- and 365-day mortality, final mobility, and reoperation rate were not statistically different with LLP vs DFR management [11].

17.3.5 Revision TKA

In 2016 Windhager et al. published a systematic review on the role of megaprostheses in the treatment of periprosthetic fractures of the knee joint. Revision rates after implantation of megaprostheses ranged from 0% to 55%, all primarily performed for mechanical and nonmechanical failures (20 and 25, respectively). However, infection was the most predominant reason for nonmechanical failure. Mortality rates ranged from 6.6% after 1 year to 45% after a mean follow-up of 34 months. Infection was the most frequent nonmechanical complication [12].

17.3.6 Does Time to Surgery Affect Outcomes for Periprosthetic Femur Fractures?

Sellan et al. found that the timing of fixation of periprosthetic femur fractures does not appear to affect postoperative length of stay or mortality within 1 year. One hundred eighty patients met study inclusion [111 total hip arthroplasties (THAs), 69 TKAs]. Average age was 79.2 years and 72.2% were female. The average time from admission to definitive fixation was 96.5 h with 31.1% of patients having surgery within 48 h after presenting to hospital. Postoperative length of stay and mortality were not affected by time to definitive fixation greater than 48 h for either of the periprosthetic TKA or THA patient groups. Postoperative mortality within 1 year was 5.5% for all patients (6.3% THA, 4.3% TKA) [13].

17.4 Periprosthetic Tibial Fractures

Fractures of the tibia are less frequent than fractures in the femur but are more likely to happen intraoperatively [14]. The classification system of Felix et al. works on similar principles to the main classification systems for femoral fractures, classifying fractures by their location, and the grade of involvement of the prosthesis [15] (Fig. 17.5). Type I fractures are splits or depressions in the tibial plateau; type II fractures are adjacent to the tibial stem; and type III fractures are distal to the stem of the prosthesis. Fractures of the tibial tuberosity are called type IV. In each case, the prosthesis can be classed as stable (A) or unstable (B); as with the femur, fractures adjacent to stable prostheses are best managed with fixation while if the implant is loose, revision is recommended. Fractures occurring during implantation are given the suffix C; in these cases, on-table revision to a stemmed prosthesis is advised.

In 2017 Kim et al. analyzed 16 patients with periprosthetic tibial fracture after TKA. There were 6 type II and 10 type III fractures according to the Felix classification [16]. Ten patients had fractures in the proximal metaphysis, and 6 in the diaphysis. MIPO using locking plates was performed on the medial side in four cases, the lateral side in two cases, and both in ten cases. Fourteen of sixteen fractures achieved union at 17.1 weeks (range, 14–24) postoperatively. There were two failures that required a secondary procedure. Except one for one case with varus malunion, all had acceptable alignment. Mean range of motion (ROM) at the final follow-up was 108.8°, and 15 patients recovered pre-injury knee joint activity. Mean knee and function scores were 88.9 and 83.3, respectively. Knees with fewer than eight cortices giving purchase to screws in the proximal segment showed higher failure rates. The conclusion was that MIPO with locking plates can achieve satisfactory results for periprosthetic tibial fractures after TKA. Rigid fixation of the proximal segment may be necessary for successful outcome [16].

According to Schreiner et al., periprosthetic tibial fractures predominantly affect elderly patients with a reduced bone quality and reveal a high complication rate [17]. Careful operative planning with individual solutions respecting the individual patient condition is crucial. If open reduction and internal fixation (ORIF) with a plate is considered, restoration of the correct alignment and careful soft tissue management including minimal invasive procedures

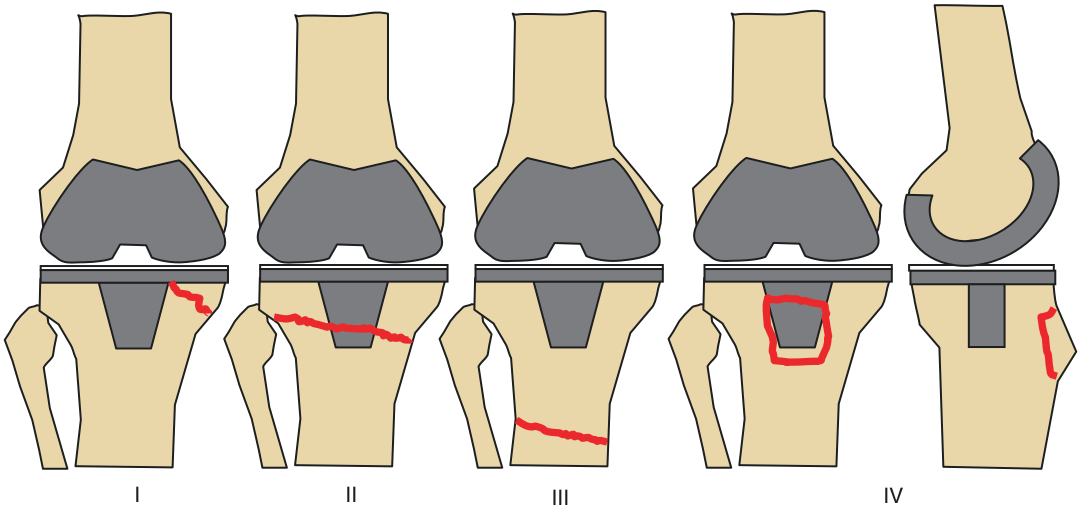

Fig. 17.5 Felix classification of periprosthetic tibial fractures [15]. Type I: fracture of the tibial head with involvement of the prosthesis-implant interface; type II: fracture of the meta-/diaphyseal transition; type III: fracture distal to the tibial component; type IV: fractures of the tibial tuberosity (subtype A, stable prosthesis; subtype B, loose prosthesis; subtype C, intraoperative fracture)

seem important factors for the postoperative outcome. From a total of 50 periprosthetic TKA fractures, 9 cases (7 female, 2 male; 2 cruciate retaining, 7 constrained TKAs) involving the tibial side were identified. The mean age in this group was 77 years with a follow-up rate of 67% after a mean of 22 months. The Felix classification showed type IB ($n=1$), type IIB ($n = 2$), type IIIA ($n = 4$), and type IIIB ($n = 2$) and surgical intervention included ORIF ($n = 6$), revision arthroplasty ($n = 1$), arthrodesis ($n = 1$), and amputation ($n = 1$). The rate of adverse events and revision was 55.6% including impaired wound healing, infection and re-fracture, respectively. Main revision surgery included soft tissue surgery, arthrodesis, amputation, and re-osteosynthesis. The clinical outcome showed a mean Oxford Knee Score (OKS) of 29 points and a functional/ Knee Society Score (KSS) of 53/41 points. Radiological analyses showed 4 cases of malalignment after reduction and plate fixation [17].

In 2019 Morwood et al. stated that periprosthetic tibia fractures were difficult to treat and had a high risk of nonunion and reoperation even with modern plating techniques [18]. Most patients can be treated to union with operative fixation and do not require revision arthroplasty, if the components are stable initially. They recommended dual plating for fractures in the proximal third, and either single plating or nailing for fractures in the middle and distal thirds depending on bone quality, implant positioning, and fracture morphology. They analyzed 38 patients with an average follow-up of 15.3 months. Eleven (28.9%) fractures were in the proximal tibia (four with extension into the plateau (Felix 1A) and seven adjacent to the tibial stem (Felix 2A)), six (15.8%) in the mid-shaft/diaphysis (Felix 3A), and 21 (55.3%) in the distal 1/3rd (metaphysis, Felix 3A). 76.3% (29/38) of fractures united by 6 months following the index procedure, leaving nine nonunions. The overall reoperation rate was 31.6% (12/38). There were no significant differences in rates of union, reoperation, superficial infection, or deep infection in patients treated with single versus dual plating [18].

17.5 Periprosthetic Patellar Fractures

The most commonly used classification system for periprosthetic patellar fractures is that of Ortiguera and Berry [19] (Fig. 17.6). Types I and II have a stable prosthesis and are classified according to the state of the extensor mechanism. Type I fractures have an intact extensor mechanism and may be treated nonoperatively. In type II fractures, the extensor mechanism is disrupted, and the authors advise operative fixation or patellectomy. In type III fractures, the implant is loose. If the bone stock is good (type IIIa), fixation and implant revision can be attempted; if the bone stock is poor (type IIIb), the authors advice removal of the patellar component and patelloplasty or complete patellectomy.

As with the tibia, a large proportion of periprosthetic patellar factures may be managed nonoperatively. In cases with a stable implant and no disruption to the extensor mechanism, nonoperative management, with a short period of immobilization, produces acceptable results in the majority of cases [20]. In cases with disruption of the extensor mechanism, reconstruction of the extensor mechanism with partial patellectomy (if necessary) is recommended above cerclage or tension band wiring, which has a high rate of treatment failure [21]. In such cases, suture anchors may provide a useful method of fixation [22]. In cases with a loose implant, there is a high complication rate. If there is suitable bone stock, revision maybe performed; if not, resection arthroplasty or patellectomy may be considered [21].

17.6 Outcome of Osteosynthesis for Periprosthetic Fractures After TKA

In 2018 Nagwadia and Joshi analyzed the outcome of osteosynthesis for periprosthetic fractures with stable implants in 43 patients (mean age 66 years) having 45 fractures (29 femoral, 11 tibial, 5 patellar) [23]. Anterior femoral cortex notching was found in 13 patients with femoral fractures. Different implants were used according to the need of the fractures. After TKA, the mean Hospital for Special Surgery (HSS) score was 84.2, which reduced to mean 76 at 9 months following osteosynthesis. Three patients had nonunion, one had delayed union and one had implant failure. The main conclusion was that osteosynthesis for periprosthetic fractures around knee with locked compression plate gave promising results. Fractures involving patella were associated with inferior functional outcome. Understanding the fracture pattern and bone stock available for fixation with correct choice of implant and correct surgical technique gave promising outcomes in periprosthetic fractures around knee [23].

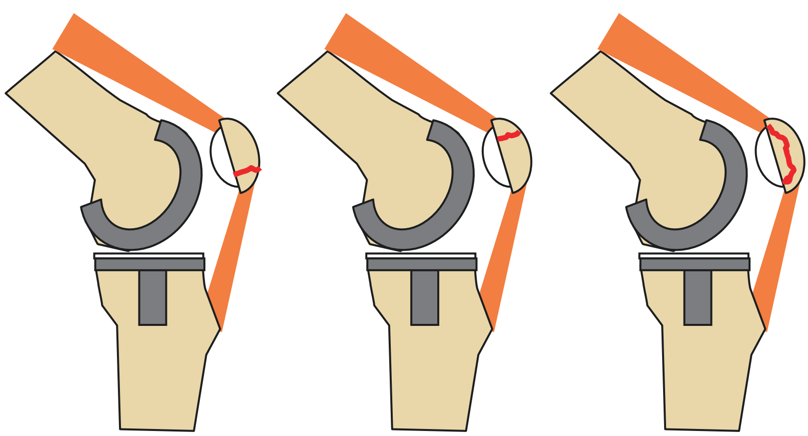

Fig. 17.6 Ortiguera and Berry classification of patellar periprosthetic fractures [19]. Type I: nondisplaced displaced fracture adjacent to a well-fixed prosthesis; type II: displaced fracture adjacent to a well-fixed prosthesis; type III: loose component

17.7 The Universal Classification System

The Universal Classification System (UCS) is a classification system intended to apply to any periprosthetic fracture in any bone [24]. Similar to the Vancouver classification of periprosthetic fractures about the hip, the UCS classifies fractures into types A–C based on position within the bone, with the addition of types D, E, and F (Fig. 17.7). It is straightforward and intuitive and has the advantage of accounting for fractures (such as inter-prosthetic fractures) not classifiable using the other systems discussed here. Unlike the other classification systems, it has been examined for intra- and interobserver reliability in both experts and trainees [25]. Interobserver reliability was substantial in both groups, and intraobserver reliability was near perfect.

17.8 Conclusion

Lewis and Rorabeck classified periprosthetic femoral fractures into three types: types I and II are nondisplaced and displaced fractures, respectively, adjacent to a well-fixed prosthesis; type III is any fracture adjacent to a loose prosthesis. The authors advised that type I fractures be managed nonoperatively, type II fractures be treated with fixation (IM nail or plate osteosynthesis), and type III fractures be managed with revision surgery.

Concerning periprosthetic tibial fractures, dual plating for fractures in the proximal third, and either single plating or nailing for fractures in the middle and distal thirds depending on bone quality, implant positioning, and fracture morphology, is recommended.

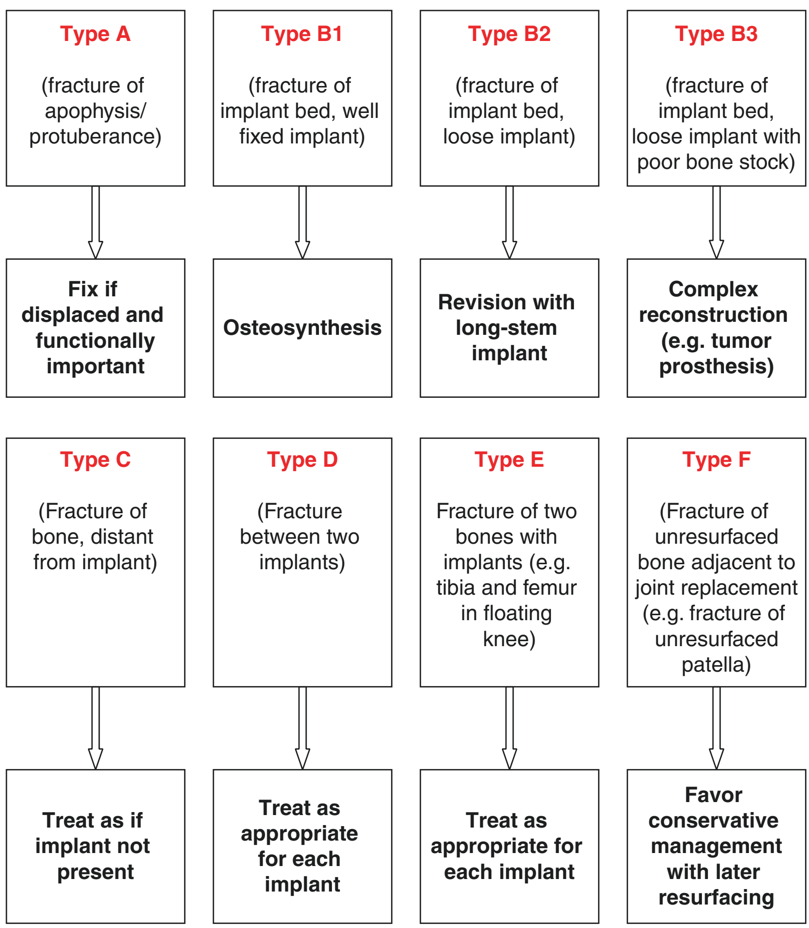

Fig. 17.7 The Universal Classification System (UCS) for periprosthetic fractures [24]

Regarding patellar periprosthetic fractures, Ortiguera's type I fractures may be treated non-operatively. In Ortiguera's type II fractures, operative fixation or patellectomy is advised. In Ortiguera's type III fractures, the implant is loose. If the bone stock is good (type IIIa), fixation and implant revision can be attempted; if the bone stock is poor (type IIIb), removal of the patellar component and patelloplasty or complete patellectomy is recommended.

Mortality rate is around 25%. Union is achieved in about 78% 6 months after bone fixation. The union rate including following procedures is around 95%. However, many patients after surgery are not self-reliant mobile or on orthopedic aids.

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