12 Management of the Complications Following Fractures Around the Knee (Post-traumatic Bi- or Tricompartmental Arthritis)

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Abstract

The relationship between periarticular fractures and development of knee arthritis is well known. However, considering the lack of the literature, it is difficult to precisely estimate the incidence of post-traumatic arthritis of the knee, ranging from 20 % at 5 years to 50 % at 15 years after the fracture. A treatment option for most of the patients could be total knee arthroplasty (TKA). In these patients, the strategy should be accurately planned preoperatively, because of different problems: presence of hardware, multiple surgical scars, bony defects, malalignment, stiffness, instability, malunions, previous infections, and ligamentous deficiency. TKA after proximal tibial or distal femoral fractures can be challenging, most of all for bone loss and instability. The results of post-traumatic TKA are good, but more similar to revision TKA than to standard primary TKA. Post-traumatic TKA patients have a higher risk of complications compared to the general population undergoing TKA for primary osteoarthritis. It is still unclear whether post-traumatic TKAs have a higher risk of infection compared to standard TKAs, but a higher risk of infection in TKAs after infected periarticular fractures has been reported.

Keywords

Knee arthroplasty • Post-traumatic arthritis • Complex knee • Complication

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12.1 Epidemiology

Different authors reported that articular incongruity and instability can lead to post-traumatic arthritis [7, 16, 31].

There are few long-term studies on arthritis after proximal tibial or distal femoral fractures, and the incidence is not clearly defined. Honkonen et al. in 1995 reported an incidence of 44 % for post-traumatic arthritis in 131 cases, at 7.6 years after surgically treated fractures around the knee. The authors reported young age, combined meniscectomy, medial tilt, articular cartilage damage, inadequate fixation, residual malalignment, and poor reduction as risk factors for developing post-traumatic osteoarthritis [7, 14]. Conversely, Wasserstein et al. observed a 5.3 times increased risk of total knee arthroplasty (TKA) in patients affected by a proximal tibial plateau fracture 10 years before compared to standard population, with a further increased risk correlated to old age (hazard risk, HR, 1.03 per year over the age of 48), bicondylar fracture (HR 1.53), and major comorbidities (HR 2.17) [45]. Other authors reported an incidence of arthritis ranging between 20 % at 5 years and 50 % at 15 years after a proximal tibial fracture [21, 34]. A similar incidence of post-traumatic arthritis was estimated after treatment of comminuted, intra-articular fractures of the distal femur [30, 39].

However, different authors reported that the development of end-stage knee post-traumatic osteoarthritis occurs at a mean of 7 years after the fracture, ranging from 2 to 11 years [20, 21] (Fig. 12.1).

12.2 Clinical Examination

When approaching a TKA in a patient with previous surgery, the strategy should take into account different problems: the presence of hardware, multiple surgical scars, bony defects, malalignment, stiffness, instability, malunions, and previous infections [3]. For these reasons, delayed TKA in patients with previous periarticular knee fractures can be challenging, with a 26 % rate of complication and 21 % of reoperation [47].

Clinical examination should include the evaluation of location and type of pain, degree and type of instability, gait disturbance, or malalignment. Preoperative range of motion (ROM) evaluation is mandatory: post-traumatic arthritis can be associated with limitation of flexion or extension [27, 28]. The patients should be informed on the realistic expectation for postoperative ROM because this is correlated with the preoperative movement [17]. Previous scars, the need for a skin graft, or other cutaneous problems should be carefully evaluated, because of the higher risk of cutaneous complication in these patients. In case of complex previous surgeries, with multiple skin incision, the plastic surgeon should be consulted [3].

Furthermore, post-traumatic arthritis can be associated with extensor mechanism abnormalities, i.e., patella baja, due to fibrous tissue formation and consequent stiffness [3] (Fig. 12.2).

12.3 Imaging and Preoperative Workup

The first step is to obtain a complete radiographic study including anteroposterior (AP), lateral, Merchant, and long-leg weight-bearing views. On the x-rays, the surgeon should evaluate bone stock, patellar height, osteolysis, hardware position, limb alignment, and significant bony deformities below or above the joint [35]. Some authors described the tilt of the tibial plateau in the AP and lateral views as an important aspect, reporting patients with a medial tilt having a higher risk of developing post-traumatic arthritis [14]. In our experience, a computed tomography (CT) scan is fundamental to evaluate bone quality, bony defects, and hardware position. In patients with a history of open fracture or previous septic joint, considering the high suspicion of infection, a blood count with differential, erythrocyte sedimentation rate (ESR), C-reactive protein level (CRP), and joint aspiration should be performed to rule out active infections [3, 4].

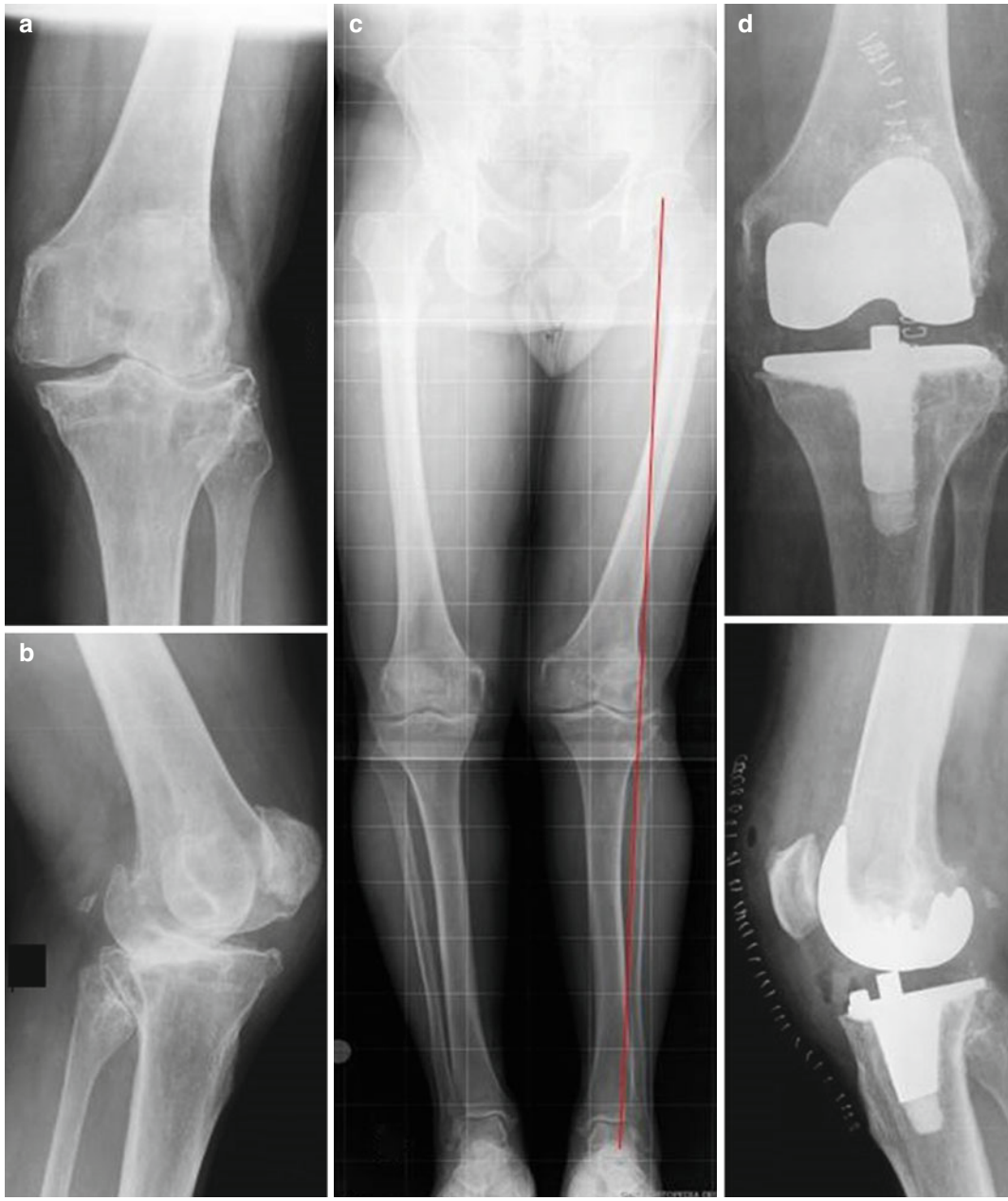

Fig. 12.1 Clinical case: 54-year-old man with post-traumatic left knee arthritis after previous lateral plateau fracture. (**a**) Preoperative anteroposterior (AP) x-ray; (**b**) lateral preoperative view; (**c**) preoperative long-leg view showing the valgus malalignment; (**d**) postoperative x-rays

12.4 Indications

Proximal tibial plateau fractures are common in patients younger than 50 years old [9]. Consequently a considerable number of patients affected by post-traumatic arthritis can be younger than 60 years, and this complicates the treatment choice. In patients younger than 60 years, with uni-compartimental post-traumatic arthritis, osteotomies around the knee may

Fig. 12.2 Clinical case: 75-year-old man with post-traumatic right knee arthritis after previous distal femoral and patellar fracture. (**a**) Preoperative anteroposterior (AP) x-ray showing the retained hardware; (**b**) lateral preoperative view showing a patella baja; (**c**) preoperative patellar view; (**d**) preoperative long-leg view; (**e**) postoperative x-rays

decrease pain and slow down the progression to arthritis, delaying the time for a total knee arthroplasty [1, 12].

However, in all patients affected by bi- or tricompartmental post-traumatic arthritis, a TKA should be considered. There is still a debate on the best approach for hardware removal, which is often necessary because of its interference with the implant or the instrumentation. When extensive hardware removal is required, especially in cases with poor skin quality, a two-step surgery is recommended: first step of hardware removal, followed by TKA after soft tissue recovery. The same approach should be considered in the cases with suspected infection [3, 48].

12.5 Implant Selection

Similarly to primary TKA, different joint arthroplasty designs can be considered in post-traumatic bi- or tricompartmental arthritis. The implant with the least constraint necessary to provide symmetric, well-balanced flexion and extension gaps should be preferred [3].

Posterior cruciate ligament (PCL) retaining (cruciate retaining, CR) implants can be used in selected cases with minimal deformities, no flexion contractures, and no instabilities. However, in the vast majority of the cases, a posterior-stabilized (PS) implant allows for deformity correction and accurate ligament balancing [3, 7]. In patients affected by

arthrofibrosis or flexion deformity, a PS implant should be preferred [4].

When ligamentous deficiencies or poor bone quality is present, a more constrained implant may be required in association with femoral or tibial extensions. In cases with poor bone quality, but good ligamentous balance, a standard PS design can be used, in association with stem extensions and bone fillers, e.g., wedges and sleeves [4]. Hinged implants should be reserved to patients with low activity level, severe instability, or major bone loss [40].

12.6 Surgical Technique

When performing a TKA after a tibial plateau fracture, different problems should be considered: prior incisions, hardware removal, alignment, instability, and bony defects. In this section, the differences between TKA in post-traumatic arthritis and standard TKA will be discussed.

12.6.1 Prior Incisions

The presence of prior incisions should be carefully evaluated in the preoperative planning. Considering the vascular supply of the anterior knee skin, the most recent or most lateral incision should be chosen, avoiding the elevation of large subcutaneous flaps [3, 15, 29]. Old transverse skin scars should not be transected creating acute angle $\leq 60°$ because triangular skin flaps have a high risk of necrosis. When a new incision is required, the surgeon should create a skin bridge of at least 6 cm [3, 15].

12.6.2 Exposure

Post-traumatic arthritis can be associated with a stiff knee. In these cases, the general principles for stiff knee exposure should be followed, including the following: (1) protection of patellar tendon; (2) sequential release of scarring in the suprapatellar space, gutters, and peritendinous tissue; and (3) avoiding vigorous retraction or forceful flexion of the knee [3]. The so-called Tarabichi maneuver can be useful to remove the adhesions of the quadriceps muscle [43]. When the quadriceps is severely contracted, a V-Y turndown or tibial tubercle osteotomy can be highly effective to gain adequate exposure. If a V-Y quadriceps turndown is chosen, the surgeon should pay attention to the superior lateral geniculate artery, to reduce the risk of devascularization of the patellar and patellar tendon. On the other hand, when performing a tibial tubercle osteotomy, the fragment should be approximately 2 cm wide and 8–10 mm thick, and care should be taken to preserve the lateral soft tissue hinge [10, 27].

12.6.3 Malalignment

Intra-articular deformity correction should follow the general principles of TKA. It is mandatory to obtain a well-aligned lower limb: many authors demonstrated an increased risk of mechanical failure and aseptic loosening when components or mechanical axis shows malalignment postoperatively [21].

Conversely, large deformities may require an extra-articular correction through an osteotomy, which can be performed in a staged or simultaneous procedure [23]. Rotational deformity is not rare in post-traumatic arthritis, and it should be carefully evaluated and corrected before or at the time of surgery [41]. Malalignment due to ligament incongruence can be managed as well as in revision TKA or in valgus-varus TKA. In these cases, a constrained implant may be required [4].

12.6.4 TKA in Nonunion

There is little data in literature regarding TKA after proximal tibial fracture nonunion. Some authors suggested to bypass the nonunion with longer stem in association with bone grafts. Small fragments can be excised, and the bone

defect can be treated following the revision TKA principles [2, 18, 22, 50].

In some cases, intramedullary guides can be difficult to use, so extramedullary, navigation, or personalized instrumentations can be useful. Tumor prostheses can be used in elderly patients with large defects, nonunion, and bone fragments [25].

12.6.5 Bone Loss

Bone losses are frequent in post-traumatic arthritis and should be managed according to the principles of revision surgery [3]. Furthermore, metaphyseal bone is often compromised in post-traumatic arthritis, so the bone ingrowth in the cementless implants may be inadequate, and longer stems can be useful [21].

Contained small defects, less than 5 mm, can be filled with cement, while bigger defects can be managed using metallic augments, bone grafts, or tantalum cones [13, 33] (Fig. 12.3). Large cavitary metaphyseal deficiencies can be managed with tantalum cones, sleeves, or impaction graft techniques [3]. Many authors prefer metallic augments over bone allograft because of the better primary stability, earlier mobilization, and immediate weight bearing. Bone losses can also affect the joint line, causing impairment of the extensor mechanism function and gap imbalance of the implant. In these cases, metal augments can be very useful in restoring the correct joint line, using the landmarks as described in revision TKA [4].

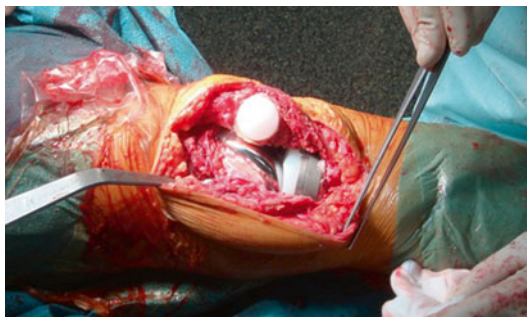

Fig. 12.3 Intraoperative picture showing a tibial wedge

Some authors suggested that tibial metal augments may not be adequate to fill defects greater than 20 mm, particularly in young patients [5]. Due to this reason and to the lack of versatility of metallic augments, some authors in these cases prefer the use of fresh allograft. The advantages of bone allograft are easy remodeling, ability to fill cavitary or segmental defects, excellent biocompatibility, and potential for ligamentous reattachment. On the contrary, the main concerns regarding bone allograft include late resorption and risk of infectious disease transmission [44].

Considering the poor bone quality and the presence of bone loss, additional (longer) stems are often required in post-traumatic TKA. Brooks et al. demonstrated a reduction of 23–38 % of the axial loads on the tibial component using a 70 mm cemented tibial stem [6]. For this reason, if an augment is necessary, a tibial stem should be used, as well as in cases in which a stronger hinge is necessary because of poor bone or ligamentous quality. The use of stems reduces the axial load to the implant and the bone-cement-implant interface. In the cases where a long diaphyseal bypass is necessary, e.g., in the presence of malunion, a metaphyseal cementation can be performed, in association with long cementless stems [11]. In many cases, there is a lack of congruence between the center of the tibial plateau and the center of the tibial diaphysis: in these cases, most of the authors suggest to use offsetted stems, in order to allow a correct restoration of the tibial surface [3].

12.7 Postoperative Management

The postoperative protocols should not differ from those used in standard TKA. Weight bearing should be calibrated in relation to the primary stability of the implant and can be (rarely) delayed depending on bone grafting and bone reconstruction. If V-Y quadriceps turndown or tibial tubercle osteotomy is used, a more careful

rehabilitation is recommended, to reduce the stresses on the extensor apparatus. In these cases, a hinged brace can be used, allowing passive gentle progressive ROM exercises during non-weight-bearing phases [4].

12.8 Complications

The risk factors for complication in TKA for post-traumatic arthritis include (1) severe stiffness, (2) multiple prior surgeries, (3) prior infection, and (4) poor skin conditions. One of the most serious complications is the avulsion of the patellar tendon; in cases of stiff knee, a more careful exposure, maybe using a tibial tubercle osteotomy, is recommended.

Also skin necrosis is a severe complication and can be correlated with implant exposure and infection. Patients with multiple scars are at high risk of cutaneous necrosis and need to be evaluated by the plastic surgeon preoperatively [27].

There is some concern about the higher risk of peri-prosthetic joint infection in TKA following prior fracture compared to standard TKA. Larson et al. hypothesized that TKAs performed after infected tibial plateau fractures would have a higher complication rate when compared with noninfected tibial plateau fractures. In this case-control study, the authors concluded that previously infected knees had a 4.1-fold increased risk of requiring additional procedures [19]. Recently other authors reported similar results in their case series [24]. In addition, Suzuki et al. evaluated 2022 primary TKA and, using logistic regression analysis, identified having a previous fracture and remnants of internal fixation as a major risk factor for infection [42].

12.9 Results

There are few reports describing the outcomes of TKA in post-traumatic arthritis, with small case series and only short- to medium-term follow-up.

In 1979 Marmor et al. described the results of 18 patients affected by post-traumatic arthritis treated with a modular unicondylar arthroplasty. In 15 cases both the medial and lateral compartments were resurfaced. The authors reported 78 % of satisfactory results 2 years after surgery [26]. Roffi et al. in 1990 described the outcomes of 17 cases of TKA in post-traumatic arthritis, with only 8 successful results. The authors concluded that the results of TKA in these patients may resemble revision rather than primary TKA [35]. However, most authors agree that TKAs after periarticular knee fractures achieve good clinical outcomes, but the procedure can be technically demanding and is associated with a higher failure and complication rate compared to standard TKA [4, 8, 21, 36, 37, 46, 47, 49]. Lizaur-Utrilla et al., in a prospective matched cohort study, evaluated the results of 29 patients affected by post-traumatic arthritis and 58 patients who underwent routine TKA, at 6.7 years of follow-up. The authors concluded that there were no differences in clinical outcomes, but the group affected by post-traumatic arthritis had a significant higher incidence of complications [20]. The results are even less satisfactory in cases of previous malunion or nonunion [32]. There is also a general agreement in affirming that patients affected by isolated intra-articular deformities obtain the better outcomes than more complex cases [38].

Similar results were reported for TKA after prior distal femoral fracture. Papadopoulos et al. reported the results of 47 cemented condylar TKAs in patients affected by previous distal femoral fracture, at an average follow-up of 6.2 years. In three cases, a distal femoral osteotomy in conjunction with longer cemented femoral stem was required because of malunion. The authors reported good clinical outcomes and improved Knee Society pain score and postoperative ROM, but six knee required revision surgery because of arthrofibrosis or aseptic loosening [30].

Considering the problems encountered in patients with prior hardware, such as difficulties in using intramedullary guides, some authors advocated using computer-assisted navigation to perform TKA in post-traumatic arthritis [25].

Table 12.1 shows a summary of the literature on results of TKA after post-traumatic arthritis.

Table 12.1 Summary of the literature regarding TKA in post-traumatic arthritis (ROM = range of motion)

Authors	Year	Number	Diagnosis	Mean follow-up	Outcomes
Marmor [26]	1979	18 knees	Post-traumatic arthritis	2 years	78 % of satisfactory results with modular unicondylar arthroplasty (15 cases of medial and lateral replacement)
Roffi [35]	1990	17 knees	Post-traumatic arthritis	27 months	62 % of patients met the criteria for successful outcome (Hospital for Special Surgery). Five major intraoperative or postoperative complications
Lonner [21]	1999	31 knees	Post-traumatic arthritis	46 months	58 % of good-excellent functional scores and 71 % of good-excellent knee scores. 57 % of complications
Saleh [36]	2001	15 knees	Previous tibial plateau fracture	6.2 years	12 knees scored as good or excellent according to average Hospital for Special Surgery knee score. There was a high rate of infection (3 patients), patellar tendon disruption (2 patients), and postoperative secondary procedures (3 patients required closed manipulation)
Papadopoulos [30]	2002	47 knees	Previous distal femoral fracture	6.2 years	Improved Knee Society pain score and postoperative ROM. Four cases of stiffness treated with Manipulation Under Anesthesia, two aseptic loosening, three deep infections
Weiss [46, 47]	2003	62 knees	Previous tibial plateau fracture	4.7 years	Good results at the knee score. 12 reoperations. 10 % of intraoperative and 26 % of postoperative complication rates
Wu [49]	2005	15 knees	Post-traumatic arthritis	35 months	Good results in terms of the knee score. The mean ROM was 94° at the last follow-up. 4 postoperative stiff knees requiring manipulation under anesthesia
Larson [19]	2009	19 knee	Previous infected tibial plateau fracture	6.4 years	53 % of complications and 26 % of recurrent infection
Civinini [8]	2009	29 knees	Post-traumatic arthritis	92 months	8 % of implant failure
Parratte [32]	2011	74 knees	Post-traumatic arthritis	4 years	Good clinical outcomes. 26 % of complications, most of all with severe consequence on functional outcomes (three extensor system avulsions, four infections, five cases of stiffness, and one of instability)
Shearer [38]	2013	47 knees	Post-traumatic arthritis	52 months	Significant improvement in Knee Society pain score. Better results in patients affected by isolated articular deformities Soft tissue defects requiring flap coverage were associated with worsening of the pain score ($p = 0.027$)

Authors	Year	Number	Diagnosis	Mean follow-up	Outcomes
Lunebourg [24]	2014	33 knees	Post-traumatic arthritis	11 years	Greater improvement in the control group of elective TKAs ($p<0.001$), with associated greater improvement in ROM ($p=0.001$). The survival rate of TKA at 10 years was better in the elective TKAs group (99 %, CI: 98–100 vs. 79 %, CI: 69–89; $p<0.001$)
Benazzo [4]	2014	44 knees	Post-traumatic arthritis	6 years	22 posterior-stabilized (PS) implants, 22 condylar constrained (CCK) implants. Good functional outcomes at the final follow-up. No differences between PS and CCK
Manzotti [25]	2014	16 knees	Post-traumatic after distal femoral fracture and retained hardware	Not reported	Group I: post-traumatic arthritis with navigated TKA. Group II: arthritis with navigated TKA (matched paired). No significant differences in surgical time, hospital staying, or intraoperative and postoperative complications between the two study groups
Lizaur-Utrilla [20]	2015	29 knee (matched with 58 standard TKA)	Post-traumatic arthritis	6.7 years	Comparable clinical results in the two groups. In post-traumatic arthritis higher incidence of minor complications
Scott [37]	2015	31 knees	Post-traumatic arthritis	>60 months	Higher complication rates compared to a match-paired group of standard TKA (13 % vs. 1 %)

Conclusion

The incidence of post-traumatic arthritis is reported in literature ranging between 20 % at 5 years and 50 % at 15 years after a proximal tibial fracture. TKA after proximal tibia or distal femoral fracture is a more demanding procedure compared to standard TKA. When approaching a knee replacement in a patient with previous surgery, the strategy should be accurately planned because of different problems: hardware presence, multiple surgical scars, stiffness, bony defects, malalignment, instability, malunion, and previous infections. A comprehensive preoperative planning is mandatory in these patients, in order to choose the correct implant and to better evaluate bone loss. There are few reports in the literature regarding TKA in post-traumatic arthritis, but most of those papers conclude that the outcomes are more similar to revision than to primary TKA. In addition, due to the previous surgery, more difficult exposure, and surgical technique, the incidence of complications after TKA in post-traumatic arthritis is higher than standard TKA.

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