44 How to Handle Complications During TKA?

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Keynotes

1. To avoid critical perfusion, the skin incision should be anterior and longitudinal.
2. If there are multiple scars due to previous surgeries, use the most lateral scar.
3. Make sure that there is a sufficient exposure of the knee joint. In contract or stiff knees, think about, for example, a rectus snip or an osteotomy of the tibial tubercle to avoid damage to the extensor mechanism.
4. Use retractor for better exposure and preparation as well as for protection of the ligaments and popliteal vessels while sawing.
5. Severe valgus deformity (≥15°) in total knee arthroplasty (TKA) often goes along with lateral soft tissue release and is a risk factor for the development of peroneal nerve palsy. If it occurs, immediately therapy is considered.
6. In case of intraoperative ligament injury, use a prosthesis with higher condylar constraint.
7. The risk of a periprosthetic fracture is especially high if the cut surfaces have not been cleanly prepared, there is a severe sclerosis or during preparation of the PS box.
8. A relevant arteriosclerosis or peripheral arterial occlusive disease must be ruled out before tourniquet use.

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44.1 Introduction

Various complications can occur during total knee arthroplasty, considering the skin, capsule, ligaments and bone (TKA). Even though serious complications such as vascular injuries are rare, they require prompt and careful treatment. Damage of the popliteal artery requires interdisciplinary collaboration with vascular surgeons, angiologist or interventional radiologists. In addition, nerve injuries can present a major challenge for the surgeon as most of them are detected only post-operatively. In contrast, ligamentous injuries are more common. They need to be detected early and require adequate treatment to avoid subsequent instability.

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In this chapter, the main intraoperative complications occurring during TKA are described and management strategies are presented.

44.2 Intraoperative Complications

44.2.1 Surgical Approach

The vascular supply of the anterior skin and capsular structures of the knee are primarily provided by arteries from the medial aspect of the joint, coming from branches of the femoral artery [1]. A medial approach to the knee joint can result in malperfusion of the skin lateral to the incision. In addition, a very medial skin incision creates a large skin flap laterally, which is often stretched during exposure and can be damaged by this mechanical stress [2]. The consequences range from wound-healing problems to a full skin necrosis (Fig. 44.1). To avoid critical perfusion, the skin incision should be anterior and longitudinally. If there are multiple scars due to previous surgeries, the most lateral scar should always be used. If crossing an existing scar is unavoidable, the angle of incision should be greater than 60° to reduce the risk of skin necrosis and wound-healing problems.

Side Summary
Main blood supply of the anterior soft tissue of the knee is provided from medially.

In case of very complex scar formations, Wyles et al. reported on intraoperative laser-assisted indocyanine green angiography (LA-ICGA) visualising the actual perfusion [3]. This may help choosing the optimal approach in complex soft tissue situations and helps to prevent wound-healing problems.

The risk of skin complications during primary surgery is low and has to be distinguished from deep wound infection (incidence 0.6–3%) [4–6]. Wound complications during surgery are very rare. Extreme tension on skin especially during

Fig. 44.1 A complete skin necrosis after total knee arthroplasty. The surgeon used an untypical approach due to the pre-existing scars after open resection of the medial meniscus 1973. The necrosis was treated by using a gastrocnemius flap

minimal invasive surgery may cause skin damage. If so, early debridement of the skin should be performed.

During preparation of the subcutaneous tissue, the joint capsule and the aponeurosis of the quadriceps femoris muscle should be sufficiently exposed to achieve a good exposure to the knee. This might be difficult in contract and stiff knees.

The most commonly used approach in TKA is the medial parapatellar approach. It allows a good exposure of the knee joint but could lead to injury or malperfusion of the extensor mechanism. The blood supply to the extensor mecha-

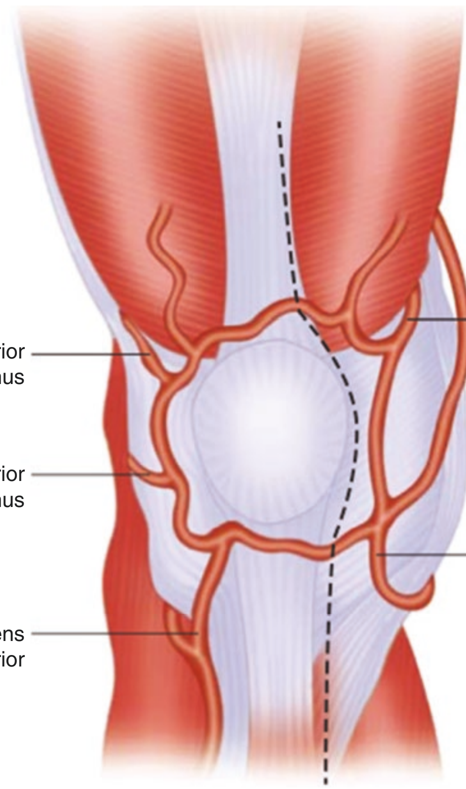

Fig. 44.2 The blood supply to the extensor mechanism comes from the descending genicular artery, medially and laterally from the superior and inferior genicular arteries, and also from the anterior tibial recurrent artery

nism arises from the descending genicular artery, medially and laterally from the superior and inferior genicular arteries, and also from the anterior tibial recurrent artery (Fig. 44.2). A medial parapatellar approach impairs the medial blood supply of the skin and also to the extensor mechanism or even cut it off completely, depending on the especially proximal extension [6–9]. Clearly, this might increase the risk for a post-operative rupture of the extensor mechanism.

The proximal medial blood supply might be preserved using a minimally invasive subvastus or midvastus approach as especially the subvastus approach seems to less affect the bloody supply of the superomedial genicular artery. Up to now, there is no evidence for this assumption. However, both approaches come along with a more limited exposure of the knee joint and are more difficult to extend. Hence, they should only be used in non-obese patients with mobile soft tissues. Previous scars, obesity or severe deformities are relative contraindications [10].

Side Summary
The minimal invasive subvastus or midvastus approach may protect the superomedial genicular artery. However, both approaches may give limited exposure to the knee.

With a subvastus approach, the medial perforating vessels are in danger. This might lead to a severe haematoma. The midvastus approach might result in an atrophy of the distal part of the vastus medialis muscle, if the motoric nerve is injured during the approach [11].

In stiff knees, there is a considerable risk of a rupture of the patella tendon. Careful detachment of the patellar tendon proximally and medially to the tibial tubercle is described for such situations [12]. However, the detachment can weaken the mechanical properties of the extensor mechanism, increasing the risk of post-operative rupture. A ‘rectus-snip’ might help to avoid such devastating complication when dealing with a very stiff knee or patella baja. It is easy to perform, and there is no need for modifying the post-operative rehabilitation procedure. In case of an additional patella baja, an osteotomy of the tibial tubercle might be an option for extension of the approach. The osteotomy should have a length of at least 7–8 cm and a thickness of 1 cm for prevention of a fracture of the flap [13, 14]. In order to avoid secondary displacement of the flap, at least two screws should be used for refixation. As the tibial stem may impede a correct position of the screws, there is the possibility to use cerclage wires as they are easier to place and provide solid static fixation [15].

44.2.2 Exposure of the Knee Joint

The patella tendon is at risk not only during the arthrotomy but also during the entire surgical procedure. The lateral dislocation of the patella during the exposure might result in an injury of the patellar tendon. In an attempt to gain more exposure, for example, by inserting lateral retractors, the patellar tendon might be avulsed from the tibia. Ruptures of the quadriceps or patellar tendon are rare (1–12% incidence). However, these represent a serious complication in TKA. If untreated, these result in loss of extensor function [16].

A complete excision of the infrapatellar fat pad facilitates the exposure and preparation of the tibia, but might also compromise the blood supply to the patellar tendon due to cutting of the anterior tibial recurrent artery. In addition, it might represent a direct injury to the patellar tendon itself. Caution is required if there has been a previous lateral meniscus resection. In such cases, the previous lateral approach might lead to a malperfusion of the extensor mechanism as the lateral inferior genicular artery had been injured. An excessive lateral release might also reduce the blood supply of the extensor mechanism through the lateral superior genicular artery [16].

Depending on the site of injury and quality of the tissue, a suturing attempt or reconstruction of the patellar tendon may be possible. If a suture is performed, it should be supported by performing a McLaughlin cerclage using a cable wire, FibreWire or PDS suture (Fig. 44.3). The augmentation of a patellar tendon using autologous hamstring grafts provides higher primary stability than suture repair alone and allows an early post-operative mobilisation [17]. However, if tendon quality is poor, a suturing attempt is rarely successful [18]. Various techniques using autograft, allograft or synthetic material have been published, with mixed results [19]. Reconstruction using a polypropylene mesh appears to be promising, especially in cases of pre-existing chronic injuries and extensor mechanism insufficiency, and shows good results in short- and mid-term follow-up for both ruptures of the patellar and quadriceps tendon [16, 20].

Side Summary
In case of patellar ligament rupture, primary repair and cerclage might be sufficient. In case of poor ligament quality, augmentation with autograft or allograft should be considered.

44.3 Femoral and Tibial Preparation

44.3.1 Vascular Injuries

Even though very rare, an injury to the popliteal artery is a serious complication in TKA. The reported incidence is 0.11–0.17% [21, 22]. The main cause is a direct injury to the popliteal artery with a saw, a chisel or retractors (61%). Indirect injuries can be caused by excessive hyperflexion, hyperextension or twisting of the knee joint (17%), in particular in patients with arteriosclerosis [23].

The use of a retractor can protect the popliteal structures from direct trauma during sawing and furthermore facilitates exposure and preparation of the tibia. It is crucial to place the retractor centro-medial, close to the posterior margin of

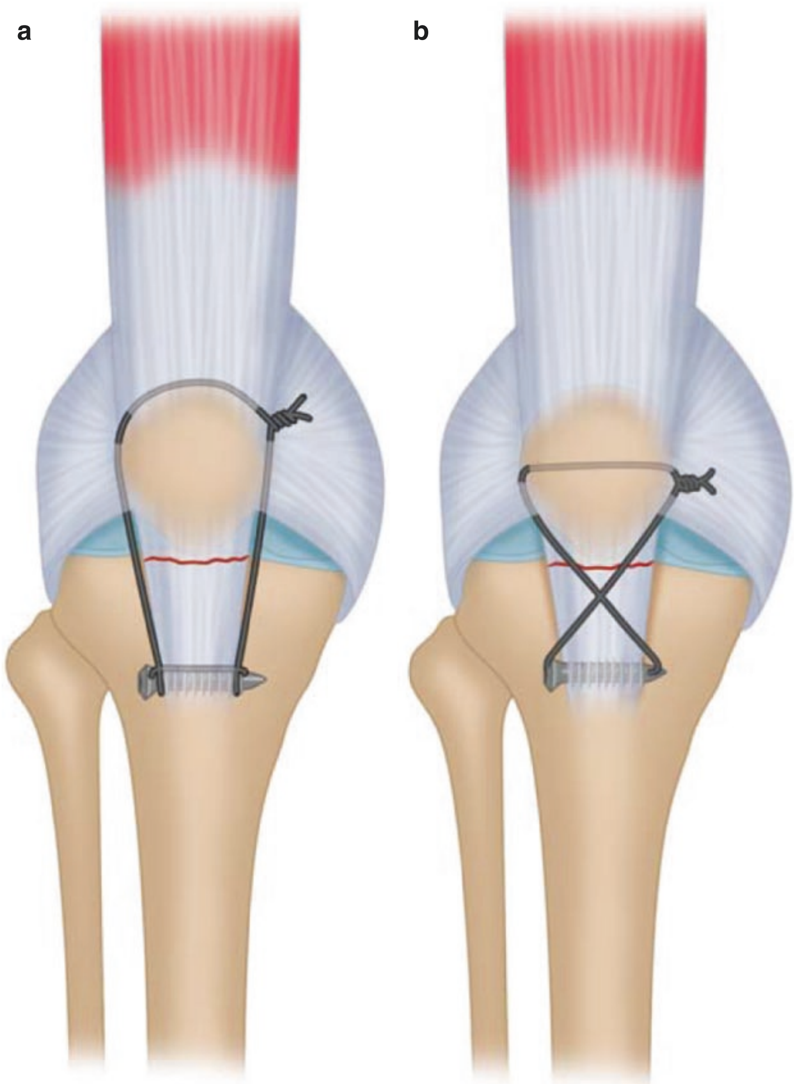

Fig. 44.3 Scheme of McLaughlin Technique Type 0 (**a**) and 8 (**b**) to support the patella tendon suture

the tibia, next to the posterior cruciate ligament (PCL) insertion in order to avoid injury of the popliteal artery. In flexion, the artery can be identified 1 cm posteriorly and 1 cm laterally to the knee joint centre [24].

> **Side Summary**
> The popliteal artery runs 1 cm laterally and 1 cm posteriorly to the centre of the knee in 90° of flexion.

Another potential source of haemorrhage may be encountered during resection of the lateral meniscus for better exposure of the tibial plateau. Bleeding from the lateral inferior genicular artery may occur. During resection of the PCL, in preparation for a posterior-stabilised prosthesis, arterial bleeding may occur from terminal branches of the medial genicular artery.

If bleeding complications occur during surgery, the first step should be exploration and identification of the source of bleeding. Regarding the management of bleeding complications, a distinction must be made between injury to minor vessels and injury to the popliteal artery. Minor sources of bleeding can generally be treated by ligatures, sutures or cauterisation of the vessel. Injury to the popliteal artery accompanied by severe bleeding often requires an interdisciplinary approach. The anaesthetist should be informed first so that an imminent hypovolaemia can be avoided and, if necessary, transfusion of erythrocyte concentrates, coagulation factors and tranexamic acid can be initiated [25]. At the same time, the tourniquet should be used to avoid further blood loss. Depending on the pattern of injury, a vascular suture, patch or arterial bypass may be necessary. Alternatively, the vessel can be repaired using endovascular stenting with interventional radiology. Bleeding from minor vessels can be stopped by coagulation, coiling or endoluminal application of thrombin [22]. Of note, a radiological intervention can be frustrating or more difficult with a prosthesis in situ. There is currently no consensus on the superiority of one method. Both procedures are used, depending on the pattern of injury and the available infrastructure [22, 23, 26]. Once the vascular injury has been treated successfully, implantation of TKA can be completed. Besides the vascular complications described earlier, other complications may occur during femoral and tibial resection or preparation such as neuronal injuries.

44.3.2 Nerve Injuries

When talking about nerve injuries, one must differentiate between cutaneous nerves and mixed motoric or sensoric or purely motoric nerve injuries. Using the medial approach, the inferior ramus of the saphenous nerve is often injured, leading to hypaesthesia of the lateral skin from the proximal tibia down to the diaphysis of the lower leg. There is a risk of neuroma formation, which may cause persistent pain after surgery. Sometimes, revision surgery or removal of the neuroma is required [27]. Very few studies have investigated the incidence of this hypaesthesia. Black et al. observed an incidence of 27% when using the medial skin incision [28]. Therefore, it is important to discuss this common complication preoperatively with the patient.

Side Summary
Damage of the inferior branch of the saphenous nerve may occur during the standard medial approach and cause neuroma formation.

Severe nerve injuries during TKA are a serious but rare complication. The incidence reported in the literature ranges from 0% to 9.5% [29]. Risk factors include flexion contractures and severe valgus deformities with an extent of more than 15°. In particular, the peroneal nerve is prone to injury during a lateral release in case of severe valgus deformity [30]. The peroneal nerve contains fibres from lumbar segments L4-S2. The common peroneal nerve winds around the fibular head before dividing into the deep and superficial peroneal nerves, and, due to this exposed position, it is therefore susceptible to pressure. It often lies directly behind the tendon of the popliteus muscle, around 6–11 mm from the tibial margin [31]. Peroneal nerve injury can lead to loss of function of the tibialis anterior muscle, extensor digitorum muscle, extensor hallucis longus muscle and peroneus muscles. Consequently, the patient can no longer dorsiflex the foot postoperatively and complains of numbness on the lateral aspect of the foot. If the tibial nerve is affected, loss of function of the tibialis posterior muscle occurs, accompanied by limited plantar flexion of the foot. The hypaesthesia in this case is plantar. Correction of severe valgus alignment might increase tension on the lateral soft tissues and peroneal nerve. This might result in postoperative traction-related nerve injuries [32].

Side Summary
Correction of severe valgus deformity or lateral release may damage the peroneus nerve.

In most cases, an injury to nerve structures can hardly be evaluated during surgery and becomes only apparent post-operatively. Sensitivity and motor function should therefore be tested immediately after surgery, before connecting any pain catheters, to rule out a lesion of the abovementioned structures. A very rarely used possibility of evaluating nerve function especially in severe valgus deformation during surgery is neuromonitoring [33]. If paraesthesia or paresis occurs post-operatively after initially intact sensitivity and motor function, compartment syndrome must be excluded urgently and conservative treatment initiated. This involves placing the affected knee in approximately 45° flexion (Fig. 44.4), taking measures to reduce swelling and loosening circular bandages [29]. Further diagnostics should be also initiated. Besides conventional radiographs in two planes to rule out a mechanical conflict, sonography should be performed as a dynamic examination, accompanied by CT or MRI to detect nerve compression due to a haematoma. If a haematoma is identified as a cause of compression, it should be treated immediately. In theory, nerve compression can also be caused by a protruding tibial component. However, there is very little literature at present which discusses this phenomenon.

If no cause of the sensory disturbance or paralysis can be identified, conservative treatment should be initiated and a peroneal splint applied. According to a study by Park et al., up to 75% of patients with incomplete nerve palsy showed a complete recovery [34]. Another study recommends surgical decompression depending on the EMG findings if there is no improvement within the first three months [35]. This approach is contested in the literature, as other studies have shown that a complete recovery can take up to two years [34].

Fig. 44.4 Recommended position of knee in case of post-operative peroneal nerve palsy

44.3.3 Ligament Injuries During Preparation of Femur and Tibia

During tibial and femoral resection, there is also a risk of accidental injury to the collateral ligaments. The retractors should be placed so that the ligament structures are protected from the saw blade (Fig. 44.5). Overall, the preparation of femur and tibia holds the greatest potential for collateral ligament injury. The incidence is reported between 1.2% and 2.7% [36, 37].

The treatment of medial collateral ligament (MCL) injury during TKA remains a subject of controversy. The MCL is in contrast to the lateral collateral ligament well vascularised and shows a good intrinsic healing capability. In principle, there is the option of an intraoperative suture, reconstruction of the collateral ligaments or of using a more constrained prosthesis. However, higher constrained results in increased shear forces acting on the prosthesis-cement interface, which might lead to a reduced survival rate [38]. Bony avulsions of the ligament insertion can be reattached using bone anchors or screws. Alternatively, a reconstruction of the collateral

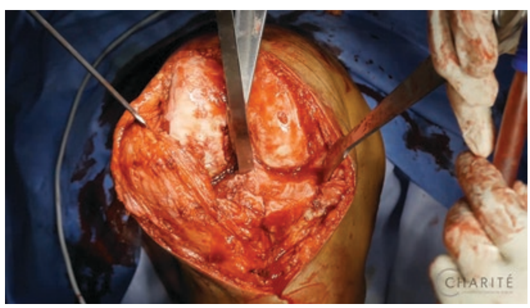

Fig. 44.5 Recommended position of the retractors to avoid intraoperative ligament injury while sawing, a chisel preserving the PCL from the saw blade

ligaments using the gracilis or semitendinosus tendon has been described [39]. In mid-term follow-up, reliable suture and reconstruction show no disadvantage compared with groups without MCL injury [36, 40]. In general, these reconstructions require more careful post-operative treatment, which includes wearing of a knee brace for about 6–8 weeks and partial weight bearing of the operated leg. This quite frequently results in a flexion deficit in short-term follow-up and therefore a longer and more intensive rehabilitation [36]. Especially in obese patients, the use of such a brace remains difficult as it is often only poorly fitted. In such cases, the surgeon might prefer using a prosthesis with higher condylar constraint. As discussed earlier, the increased degree of constraint results in higher shear forces on the prosthesis-cement interface, so these implants may have a comparatively inferior survival rates [38]. The choice of procedure should therefore be made dependent from the constitution, age and functional requirements of the patient.

During preparation of the tibial plateau, the patellar tendon must also be protected against accidental injury caused by the saw blade. In addition, a forced dislocation of the patella with inadequate exposure and preparation of the tibia can lead to a rupture of the patellar tendon. If there is a limited view of the surgical site, the exposure should be improved appropriately before continuing preparation of the tibia. During tibial resection, the PCL may be injured or the bony attachment may be accidentally cut. The latter can be avoided by inserting a chisel anterior to the bony attachment. In the event of PCL injury or insufficiency, a switch should be made to a posterior-stabilised prosthesis.

44.3.4 Periprosthetic Fractures

The reported rate of intraoperative periprosthetic fractures is 0.4% [41]. The incidence of intraoperative periprosthetic fractures of the femur is significantly higher for cementless prosthesis systems (5.4%) than for cemented components (0.1–1%) due to the greater impacting force required. Another risk factor for periprosthetic fractures is a severe sclerosis [42]. Depending on location, bone quality and fragment size, a periprosthetic fracture can be treated using screws or a plate osteosynthesis, or by a stemmed prosthesis [41].

Different classification systems exist for periprosthetic fractures of the knee joint. A widely used system is that developed by Rorabeck for the femoral site (Table 44.1) and by Felix for the tibial site (Figs. 44.6 and 44.7) [43, 44]. Since 2014, the Unified Classification System (UCS) according to Duncan and Haddad has been established (Table 44.2, Fig. 44.8), which has shown good inter-observer reliability [45, 46].

Periprosthetic fractures occur most commonly during exposure and preparation of the surgical site (39%).

A fracture of the medial femoral condyle can occur during preparation of the PS box in posterior-stabilised implants, especially in small and osteoporotic knees. This is because the size of the PS box is uniform in most prosthesis models and is often independent of the size of the femoral component. In small femoral components, the design leads to a relative increase of the dimensions of the PS box. In contrast to larger components, the femoral preparation of the PS box of small femoral components is substantially larger at the expense of the condyles, which increases the risk of fracture. However, sometimes poor preparation of the box leaving remnants of cortical bone at the posterior condyle may also cause fracture.

Side Summary
Periprosthetic fracture occurs most commonly during knee preparation at the femoral side.

Table 44.1 Classification of the periprosthetic fractures by Rorabeck et al. [43]

Class	Prosthesis	Fracture
Type 1	Fixed	Not dislocated
Type 2	Fixed	Dislocated
Type 3	Loose	Dislocated or not dislocated

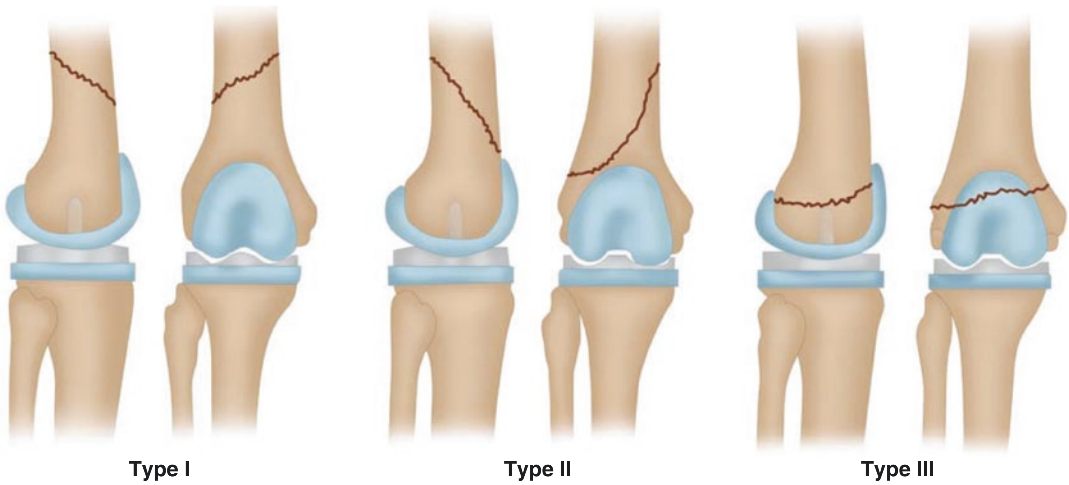

Fig. 44.6 Classification of femoral periprosthetic fractures by Rorabeck [43]

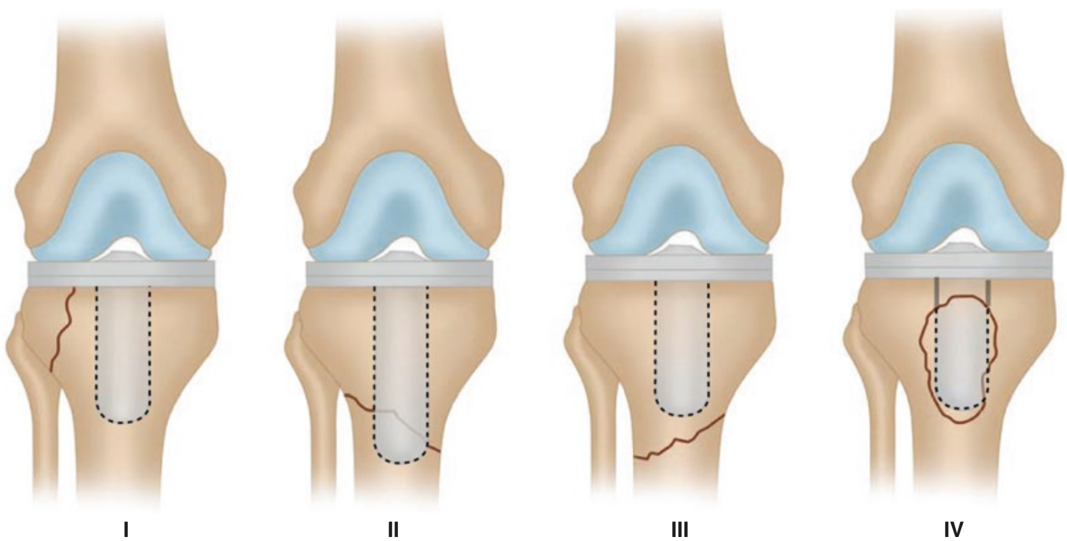

Fig. 44.7 Classification of tibial periprosthetic fractures by Felix [44]

The second-highest rate of periprosthetic fractures (33%) is found during insertion of trial components. Significantly fewer fractures (19%) occur during cementing of the final implants [41]. Trial components are often made of metal and are therefore extremely rigid. This can lead to periprosthetic fractures during placement of the metal trial component. Trial components made of plastic offer an advantage [47]. The cementing and insertion of the final implants also carries a risk of fracture (Fig. 44.9). However, the risk of a periprosthetic fracture is especially high if, as mentioned earlier, the cut surfaces have not been cleanly prepared or if there is a severe sclerosis.

Side Summary
Second-highest rate of periprosthetic fracture occurs during insertion of the tibial component.

Table 44.2 Unified classification system by Duncan and Haddad [45]

Class	Description		Prosthesis	Fracture
Type A	Fracture of an apophysis or protuberance of bone		Fixed	Dislocated or not dislocated
Type B	Fracture involves the bed supporting or adjacent to an implant	1	Fixed	
		2	Loose	
		3 (poor quality of bone)	Loose	
Type C	Fracture which is in the bone containing the implant, but distant from the bed of the implant		Fixed	Dislocated or not dislocated
Type D	Interprosthetic fracture—affecting one bone which supports two replacements		Fixed or loose	Dislocated or not dislocated
Type E	Fracture of two bones supporting one replacement		Fixed or loose	Dislocated or not dislocated
Type F	Fracture of a native surface articulating with a prosthesis		Fixed	

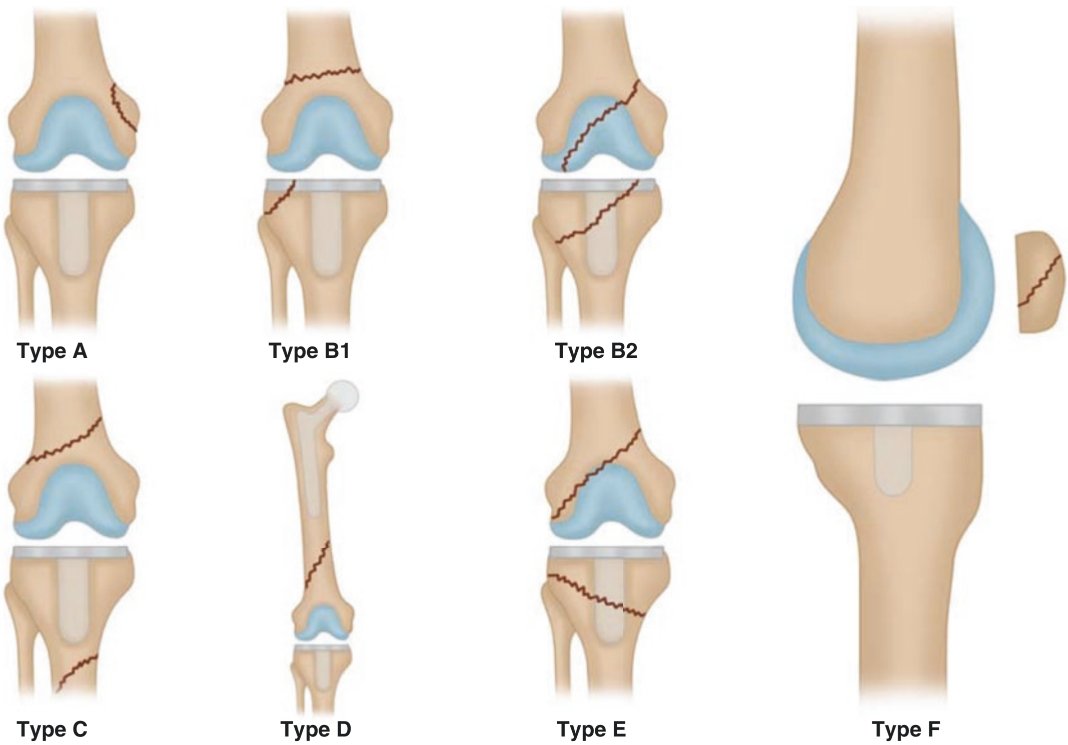

Fig. 44.8 UCS classification by Duncan and Haddad [45]

There are different ways of treating periprosthetic fractures. Treating a periprosthetic facture is always challenging and universal solution cannot be given. The treatment depends on the kind and localisation of the fracture and furthermore requires a critical judgement of the age, constitution and functional demand of the patient. A loose prosthesis should always be revised. If the implant is still well fixed, it can be treated by performing an additional osteosynthesis. However, there are some exceptions. If the fracture is located near the top of the stem or if the bone quality is very poor, there might be a revision of the fixed prosthesis necessary in order to improve the biomechanical requirements for the healing of the fracture. In rare

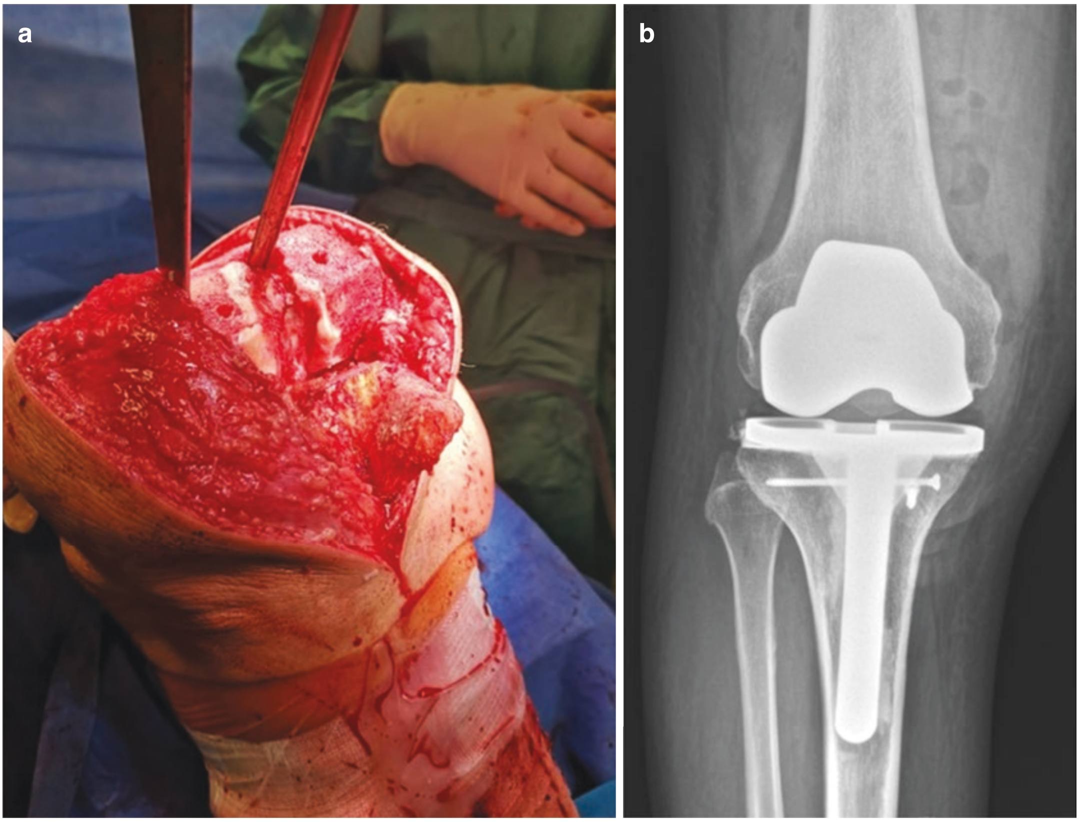

Fig. 44.9 Intraoperative fracture of the anterior tibia when impacting the tibial component (**a**), radiographic follow-up showing the refixation of the fragment by using a screw (**b**)

cases, an osteosynthesis with screws is impossible as the stem of the prosthesis fills the intramedullary canal, while a very thin cortical bone is present. If there are fractures on both sides or the patient is—for other physical or mental reasons—not able to realise a partial weight bearing, performing an osteosynthesis might also not be successful and a revision should be performed.

A further potential complication during preparation of the femur is the 'notching' of the anterior femoral cortex. Biomechanical studies have found this to be a risk factor for supracondylar femoral fractures [48, 49]. Biomechanical studies have shown that notching of over 3 mm is required before significant weakness of the bone should be considered [50]. However, these data have not yet been confirmed in clinical studies [51]. Irrespective of the clinical relevance, notching indicates that the prosthesis was inserted in too much extension or implanted too far posteriorly, which can alter the biomechanics of the prosthesis.

44.4 Insertion of Implants and Wound Closure

44.4.1 Cementing with Use of a Tourniquet

The insertion of the final implants can also produce complications. Tourniquet use improves the surgeon's view and should therefore allow a shorter operating time. In addition, the reduced blood circulation improves the adhesion of the cement, which should extend the prosthesis survival time [52]. For these reasons, some surgeons use a tourniquet for the entire course of the procedure. Whether this can significantly reduce the intraoperative and post-operative blood loss remains disputed. However, most studies have found delayed mobilisation and rehabilitation due to severe pain in the thigh [52]. Tourniquet use while cementation also improves cementing quality, reduces total blood loss and shows significantly faster rehabilitation immediately post-surgery due to the reduced pain symptoms [52, 53]. Very few studies have investigated the influence of tourniquet use on the occurrence of post-operative deep-vein thrombosis (DVT). In a meta-analysis, Yi et al. observed a higher incidence of DVT following tourniquet application (risk ratio 2.63), but there was no statistical significance [54]. Nevertheless, a relevant arteriosclerosis (Fig. 44.10) or peripheral arterial occlusive disease must be ruled out before tourniquet use; otherwise damage to the sclerotic vessels or embolic occlusions of the arteries may occur [55]. If a vascular bypass, a circulatory disorder or a severe arteriosclerosis is known, and a tourniquet should not be used. If necessary, an angiologist or vascular surgeon should be consulted before TKA.

Fig. 44.10 In case of marked vascular calcification on the preoperative radiograph, there might be a circulatory disorder of the lower limb. In such cases, an angiologist or vascular surgeon should be consulted before surgery and a tourniquet should not be used

44.4.2 The Final Steps

Before wound closure, a final critical examination of the flexion and extension gap is conducted and minor corrections are made if necessary by a medial or lateral release. However, it should be noted here that the tourniquet fixes the quadriceps and vastus lateralis muscles, which can give the impression of an insufficient balancing [56]. Therefore, the soft tissue balancing and the checking of patellar tracking should be carried out with trial components in situ before applying the tourniquet. Otherwise, the altered vastus lateralis compression may give the impression of poor patellar tracking, leading to an excessive lateral release [57, 58]. When the tourniquet is released, the lateral release can lead to instability and persistent pain.

Once the cement has hardened and the knee joint has been flushed, the layered wound closure takes place. Various studies have found that wound closure performed in flexion shows a significantly better range of motion and greatly reduced anterior knee pain in follow-up for up to three months post-operatively [59]. However, other studies have not confirmed this observation [60].

During wound closure, tranexamic acid can be applied intraarticular after capsule suturing to reduce blood loss. In addition, tranexamic acid is often administered intravenously in the context of anaesthesia. As the licensing of tranexamic acid differs from country to country, it is hard to give a general recommendation here. However, combined application (intravenous and intra-articular) showed significantly less post-operative bleeding compared to the control group, a correspondingly lower drop in haemoglobin level, and hence a lower rate of post-operative blood transfusion [61]. This is of major importance, as blood loss in primary TKA can be up to 1.8 L, possibly requiring a blood transfusion [62]. Some studies have shown that the administration of allogenic blood is associated with an increased risk of periprosthetic infection [63]. However, it remains debatable whether the higher infection rate can be attributed solely to the allogenic blood transfusion. In general, it is patients with pre-existing cardiac conditions and multiple comorbidities who require a post-operative transfusion. Increased body mass index, diabetes mellitus and immunosuppression associated with rheumatoid arthritis are also regarded as risk factors for a periprosthetic infection [63].

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