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# Knee arthroplasty for acute fractures around the knee

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- Results of open reduction and internal fixation for complex articular fractures around the knee are poor, particularly in elderly osteoporotic patients.
- Open reduction and internal fixation may lead to an extended hospital stay and non-weight-bearing period.
- This may lead to occurrence of complications related to decubitus such as thrombo-embolic events, pneumonia and disorientation.
- Primary arthroplasty can be a valuable option in a case-based and patient-specific approach. It may reduce the number of procedures and allow early full weight-bearing, avoiding the above-mentioned complications.
- There are four main indications:
  - 1) Elderly (osteoporotic) patients with pre-existing (symptomatic) end-stage osteoarthritis.
  - 2) Elderly (osteoporotic) patients with severe articular and metaphyseal destruction.
  - 3) Pathological fractures of the distal femur and/or tibia.
  - 4) Young patients with complete destruction of the distal femur and/or tibia.
- The principles of knee (revision) arthroplasty should be applied; choice of implant and level of constraint should be considered depending on the type of fracture and involvement of stabilizing ligaments. The aim of treatment is to obtain a stable and functional joint.
- Long-term data remain scarce in the literature due to limited indications.

**Keywords:** elderly; fracture; knee; osteoporosis; total knee arthroplasty

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## Introduction

Complex epiphyseal knee fractures are rare. In contrast to the high incidence of femoral neck and proximal humerus fractures, epiphyseal knee fractures account only for up to 1% of annual emergency admissions. Furthermore, the sub-type of fracture appears to be gender related, with a male predominance for proximal tibia fractures (overall incidence 13.3/100,000 adults) whereas distal femoral fractures are more frequently seen in women (overall incidence 4.5/100,000 adults).<sup>1-3</sup> Treatment of complex epiphyseal fractures is multifaceted and challenging. Today, especially in young patients, the first choice of treatment remains open reduction and internal fixation. Management of these fractures in the osteoporotic elderly is more demanding as metaphyseal bone loss often limits options for anatomical reconstruction and fixation. Current surgical treatment options, including intramedullary nailing, internal and external fixation, are often complicated by an extended non-weight-bearing period, malunion or non-union.<sup>2,3</sup> Due to the presence of multiple risk factors such as old age, concomitant diseases and osteoporosis, in combination with severe comminution and initial displacement, loss of reduction is described in up to 30–79% of cases, implying loss of function and sometimes a need for subsequent surgery (Fig. 1). To avoid these complications and to shorten the recovery phase, primary total knee arthroplasty (TKA) has been proposed as a first intention solution based on the model of primary hip or elbow arthroplasties for fracture. It is often used as a last resort in the treatment of failed fixation of complex knee fractures.<sup>4,5</sup> The main advantages of primary arthroplasty are the ability to preserve joint function and to allow patients to resume full weight-bearing immediately, while prolonged weight-bearing restriction is often implemented after internal fixation. Due to cognitive and/or physical impairment, older



**Fig. 1** Full-length X-ray of a 93-year-old female patient showing non-union of a distal femoral fracture with secondary displacement, cut-out and failure and collapse of bone.

patients are often not able to follow detailed weight-bearing instructions and arthroplasty may be of value in the fragile elderly to prevent occurrence of decubitus-related co-morbidities. Furthermore, faster discharge from the hospital can help to limit the disorientation often observed in this elderly population.<sup>6–17</sup> The goal of this literature review is to give an overview of current indications, treatment strategies, surgical pitfalls, post-operative management and results to be expected.

## Indications

There are four main indications for primary arthroplasty for complex fractures around the knee (Table 1). The first and best indications are intra-articular fractures in elderly

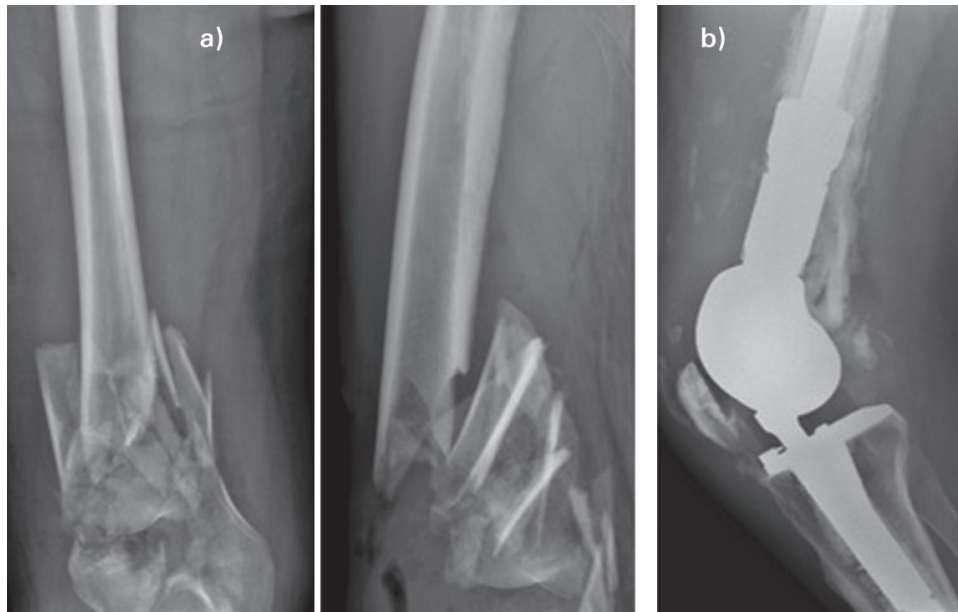
**Table 1.** Indications for first-line total knee arthroplasty

- |   |  |
|---|--|
| 1 | Elderly (osteoporotic) patients with pre-existing (symptomatic) end-stage osteoarthritis |
| 2 | Elderly (osteoporotic) patients with severe articular and metaphyseal destruction        |
| 3 | Pathological fractures of the distal femur and/or tibia                                  |
| 4 | Young patients with complete destruction of the distal femur and/or tibia                |



**Fig. 2** X-ray and computed tomography scan of an 83-year-old female patient with a distal comminuted supracondylar femoral fracture with severe osteoporotic bone.

osteoporotic patients with pre-existing symptomatic end-stage osteoarthritis. Secondly, arthroplasty might be the first choice in the treatment of complex tibial plateau or distal femoral fractures in elderly osteoporotic patients where articular and metaphyseal destruction makes reconstruction and internal fixation hazardous (Femur: AO/33C3 and selected 33C2 cases. Tibia: AO/41C3) (Fig. 2). Metaphyseal comminution complicates the reconstruction of the native alignment and a solid fixation is extremely difficult to obtain and consequently often leads to malunion and/or non-union. There is a major risk of inadequate reduction of the articular step-off, secondary loss of reduction and material cut-out.<sup>2–17</sup> Thirdly, use of TKA might be indicated for pathological fractures of the distal femur



**Fig. 3** Complete destruction of the distal femur in young patients suffering from a road accident are rare (A). In some cases, there is a good indication for TKA (B).

Source. Courtesy of Prof. Francesco Benazzo.

and/or tibia in cases with poor bone stock or profound condylar destruction.<sup>18</sup> Lastly, in very rare cases, arthroplasty might be a last-resort solution in young patients with complete destruction of the distal femur and/or the proximal tibia. This indication is the most debatable and remains a case-by-case decision. These patients can be considered as having exceptional indications and the case should be discussed prior to any decision with a group of surgeons including senior trauma and reconstruction surgeons. These patients often present with a complete destruction of 10 cm to 15 cm of the distal femur or 10 cm of the proximal tibia. It might be an option in the treatment of extremely complex high-energy fractures due to road traffic accidents, falls from heights or sports accidents with major bone loss where there is not even enough bone left for a potential knee arthrodesis. Most of these patients are initially managed with external fixation during the initial damage control procedure. Therefore, this is not an emergency situation and there is no need to rush the procedure. The indication should be very well discussed in the team and with the patient and the family. Of course, open reduction and internal fixation remains the first choice of treatment in younger patients with the aim to save as much bone stock as possible and to facilitate arthroplasty in the future if needed. TKA might be indicated in very rare cases of major bone loss and articular destruction as a salvage procedure when nothing else is possible. Arthroplasty can, however, be technically challenging in younger patients with previous (tibial plateau) fractures in whom debilitating post-traumatic arthritis has

developed. Old wounds, retained metalwork, bony deficiency and instability can lead to poorer outcomes and higher complication rates than in primary knee arthroplasty for the same indication, and that might be the justification for a first-intention arthroplasty (Fig. 3).<sup>19</sup>

## Treatment

### *Pre-operative evaluation*

In the elderly, particular attention should be paid to a review of the medical history with rigorous ortho-geriatric assessment as these patients often have associated medical conditions. Pre-operative assessment with blood management, as well as cardiac and pulmonary evaluation are mandatory. It is of importance to know if patients have had previous orthopaedic surgery, as this can impede joint replacement. In these patients, skin is often fragile with post-traumatic haematoma which requires strict pre-/per- and post-operative follow-up. Vascular status should be checked as aberrant arterial or venous blood supply might contra-indicate surgery. Arthroplasty is contra-indicated if there is any doubt concerning adequate skin healing due to poor vascular condition (Fig. 4).<sup>20</sup>

Most of the young patients needing arthroplasty for an acute fracture around the knee are seen in a poly-trauma setting. For these patients, initial damage control, stabilization and treatment of life-threatening conditions are prioritized. A temporary stabilization of the complex knee fracture with traction or a spanning external fixator and the management of potential skin problems should be





**Fig. 4** Poor skin condition around the knee and leg.

done initially, based on validated damage-control protocols. Any doubt on per-operative skin coverage contraindicates arthroplasty. It is important to avoid pin placement close to the joint as this might compromise future arthroplasty with higher risk of infection. Attention should be paid to vascular and neurological evaluation of the involved limb with precise description in the medical record. Arthroplasty can be planned once the patient is in a stable condition, has been discharged from the intensive care unit (ICU) and is fit for surgery.

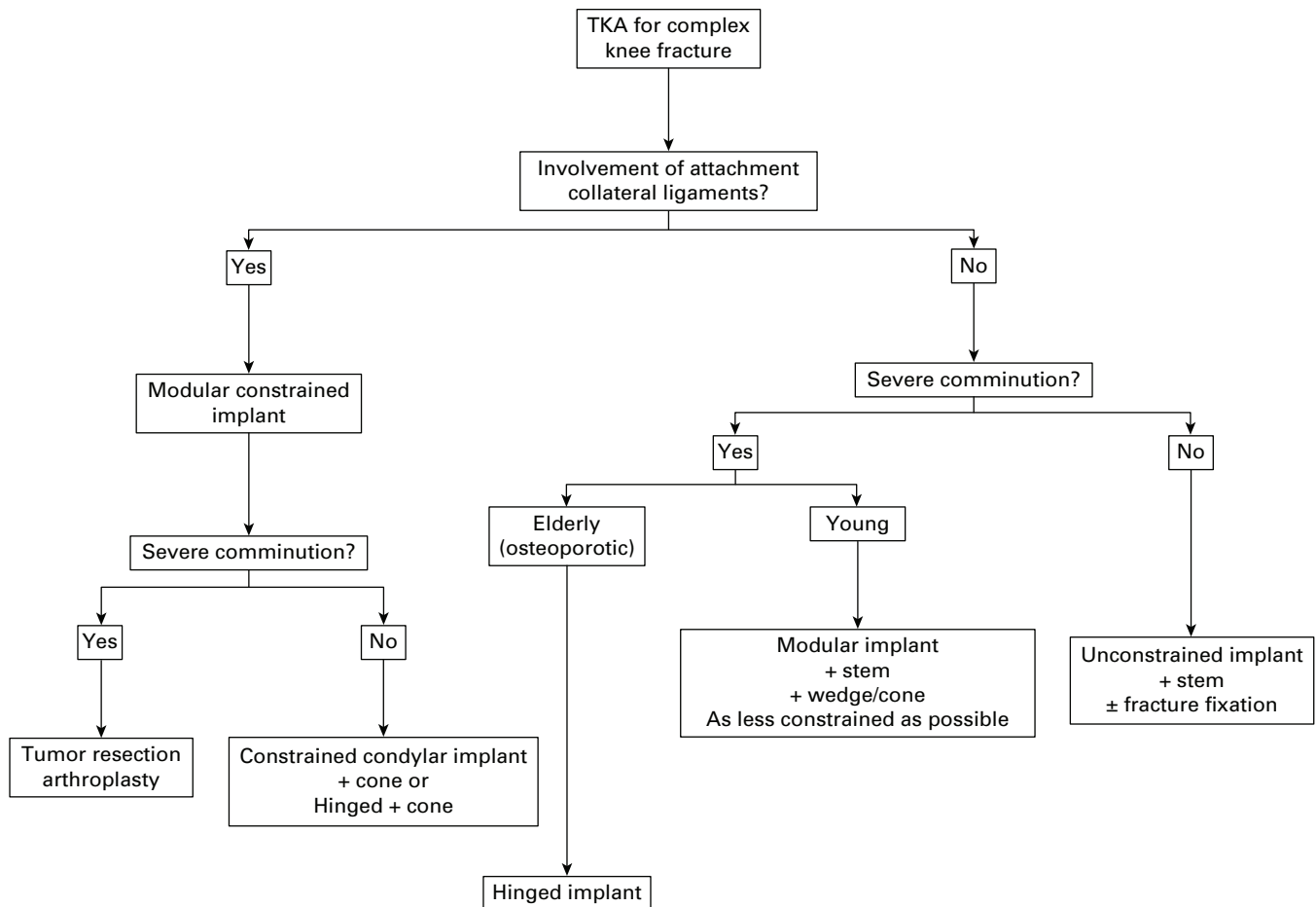
### *Surgical considerations*

#### *Choice of implant*

Concise pre-operative analysis of X-rays and often three-dimensional computed tomography (3-D CT) are required to estimate the exact implants needed. Arthroplasty for complex knee fractures requires thorough knowledge of the basic rules of revision surgery. Choice of constraint, joint-line restoration and component rotation, bone defect filling and implant fixation follow the same principles as in

TKA revision or as in segmental TKA reconstruction for tumour. Implant type and level of constraint are related to the type and the level of the fracture and the degree of metaphyseal destruction. The goal of surgery is to provide a stable, mobile knee allowing immediate full weight-bearing. Any fracture involving the collateral ligament insertions should be very carefully evaluated as reconstruction might require the use of a rotating-hinge implant (Figs 5 and 6). In cases with severe metaphyseal destruction up to the diaphysis, use of a segmental megaprosthesis should be considered, particularly on the femoral side. Surgery should be performed by senior orthopaedic/trauma surgeons with good access to a full range of implants. Need for stems, cones, augments, tumoral reconstruction type or hinged implants should be well thought out and ordered beforehand, as most hospitals only have primary implants on the shelf. In case of (metal) allergies, hypo-allergenic implants should be provided (Fig. 7).<sup>21,22</sup>

Furthermore, during pre-operative planning, particular attention should be paid to a thorough assessment of



**Fig. 5** Flowchart for decision-making type of implant in case of arthroplasty for complex knee fractures.

Note. TKA, total knee arthroplasty.

extensor mechanism integrity. At the time of the arthroplasty, anterior tibial tuberosity fixation (with screws or tension-band wiring), patellar tendon repair, or augmentation or extensor mechanism allograft transplantation might be required. Anterior tibial tubercle avulsion has been described as a relative contra-indication for TKA but is still possible if there is no major fragmentation.<sup>2-5</sup>

#### *Intra-operative guidelines*

**Patient positioning and approach.** Patient positioning is standard as for primary arthroplasty or revision, according to the surgeon's preference. An electric knee support might be of value as it is, due to the fracture, often difficult to use fixed supports to obtain a stable knee position. A tourniquet can be used, but prolonged inflation should be avoided. Tourniquets might compromise release of the extensor system, especially in the case of mega-prosthesis implantation. Working without a tourniquet allows immediate management of adequate haemostasis, in combination with regular administration of tranexamic acid.<sup>23</sup>

There is no superiority of one approach over another, so surgeons must use their standard TKA revision approach. The senior author (SP) prefers the extended sub-vastus approach as it is quadriceps sparing with the possibility to extend proximally. In this context, a tibial tubercle osteotomy or a quadriceps snip is very rarely needed.<sup>5,24</sup>

**Principles of joint arthroplasty.** In revision arthroplasty as in tumour reconstruction arthroplasty, joint-line restoration and respecting rotation are key to restore knee function. The classic 'three-steps' Kelly–Vince technique for reconstruction must be used with, first, the reconstruction of the tibial base plate, second, the flexion space, and third and lastly, reconstruction of the extension space (Fig. 8).<sup>25</sup>

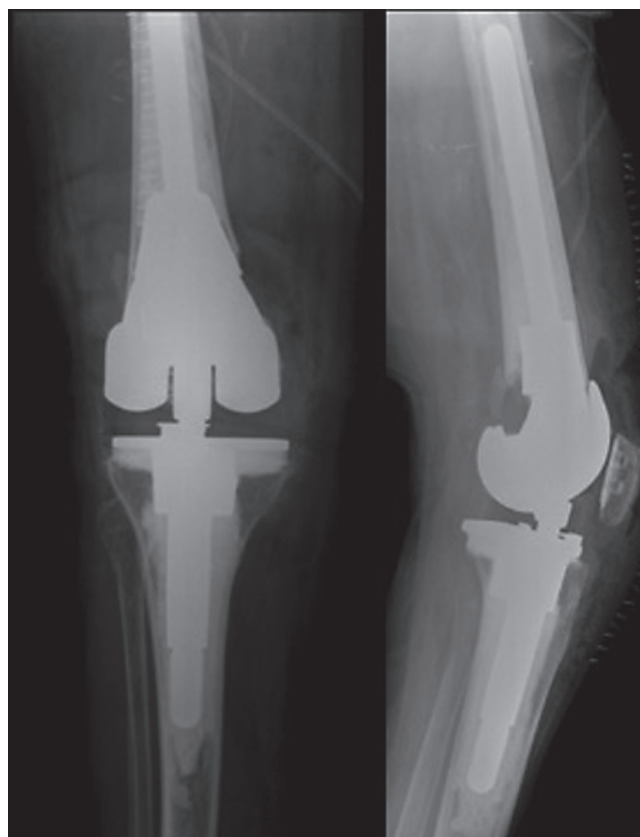
In the treatment of complex knee fractures with severe (femoral) comminution, it is often difficult to find the landmarks usually used for the restoration of these two parameters. To be able to deal with this complex situation, 'primary temporary reduction' is helpful. The idea is to perform a temporary reduction of the fracture using



**Fig. 6** Schematically, when the fracture involves the tibial or femoral collateral ligament insertions, a rotating-hinge implant should be used.

classical bone clamps. Then, the distance between a specific point on the intact femur and the joint-line is measured. The original femoral rotation is also marked in order to align the final component respecting the patient's anatomy (Fig. 9). It is known that the joint-line is found approximately 25 mm distal to the medial epicondyle and/or 10 mm proximal to the head of the fibula.<sup>21</sup> The distance from the adductor tubercle to the joint-line divided by the femoral width, recently described as the adductor ratio, may help to get the joint-line at the correct position when temporary reduction is not possible.<sup>26</sup> Furthermore, the meniscus or the residual meniscal rim can serve as a reference for joint-line height.

When temporary reduction cannot be used, rotation can be hard to determine. In case there are no clear anatomical structures to guide the surgeon in severe comminuted knees, the senior author (SP) recommends determination of the native femoral rotation based on temporary primary reduction with marking of the femoral shaft axis and epiphyseal–metaphyseal rotation. These references can serve as a guidance for joint-line level and rotation during trial and definitive implantation. Coronal alignment of the tibial component should be referred to the axis of the tibia using the classic intramedullary rod.



**Fig. 7** The 83-year-old osteoporotic patient shown in Fig. 2 was treated using a fully cemented hinged-type implant with a femoral and tibial stem and addition of tantalum cone and sleeve.

Tibial rotation can be set using the tibial tubercle, while ensuring congruence with the femoral component in extension.<sup>2–5</sup>

*Filling defects, component sizing and implant fixation.* Bone defects can be addressed with structural reconstruction for segmental defects, whereas cavitary defects can be reconstructed using bone cavity filling methods. Autografts and allografts can be used, and synthetic bone fillers can be an option for small defects. However, to manage large defects, porous tantalum cones or equivalent systems can be useful, particularly in osteoporotic bone, to provide a reliable metaphyseal support. In case of complete metaphyseal and epiphyseal destruction, a segmental tumour-reconstruction-type prosthesis with either segmental femoral and/or tibial components may be needed (Figs 3 and 7).

Due to loss of metaphyseal/epiphyseal congruence and distal femoral landmarks it can be hard to determine femoral component size. Correct size could be estimated by relying on measurement of one of the condyles with a calliper, as it is done in bipolar hip arthroplasty for hip fractures. Adequate sizing of the femoral component is



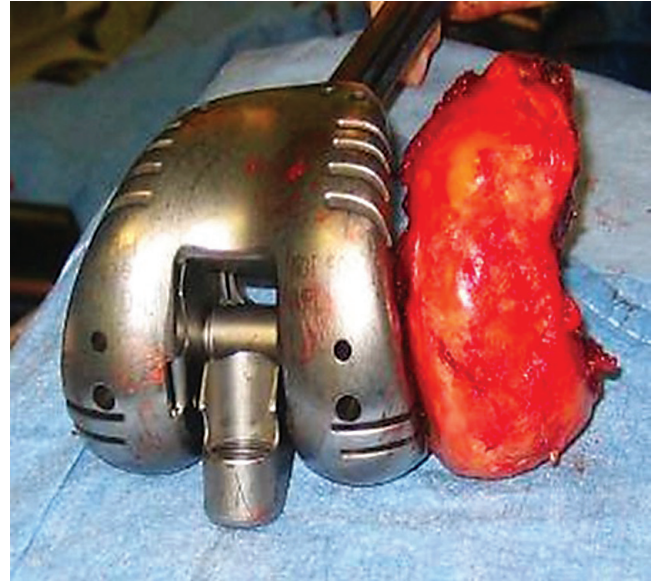


**Fig. 8** As in joint (revision) arthroplasty and tumour resection arthroplasty, joint-line restoration is key. In a first step, a solid tibial base should be constructed. In this image a trial insert is placed to build and balance the flexion and extension gap.



**Fig. 9** Principle operative primary temporary reduction.

essential to manage properly restoration of the flexion space, to avoid soft tissue impingement and to avoid anterior overstuffing, and it should restore native condylar



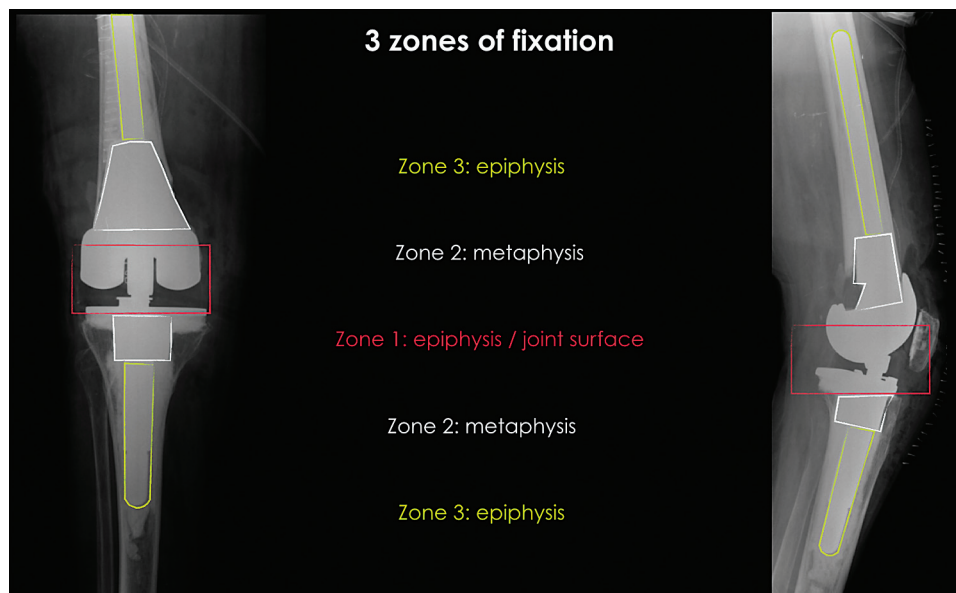
**Fig. 10** In complex knee fractures, femoral sizing may not be feasible due to joint comminution. The native condyle can be measured with a calliper and used to determine femoral sizing.

offset (Fig. 10). Following the Morgan-Jones rules for revision TKA, reliable implant fixation can be realized when a good fixation for at least two out of three zones (epiphyseal – metaphyseal – diaphyseal) is achieved (Fig. 11).<sup>22</sup> This can be done by usage of stems, cones and sleeves to maximize bone–implant interface. Based on the literature, there is no proven superiority between a long uncemented stem with diaphyseal engagement and a shorter cemented stem for prosthetic revision. The current trend favours usage of short fully cemented stems associated with metaphyseal reconstruction using a cone or a sleeve, to optimize control of rotational stresses and to avoid stem tip impingement. In cases using a tumour prosthesis, it is recommended to use long and fully cemented stems, to optimize stability. As mentioned above, previous orthopaedic procedures, such as ipsilateral total hip arthroplasty (THA) might increase the risk of a post-operative inter-prosthetic fracture due to occurrence of a stress raiser in between both stem tips. Therefore, it is recommended to bridge the area between the TKA and THA for a length at least twice the diameter of the diaphysis (Fig. 12).<sup>21,27</sup>

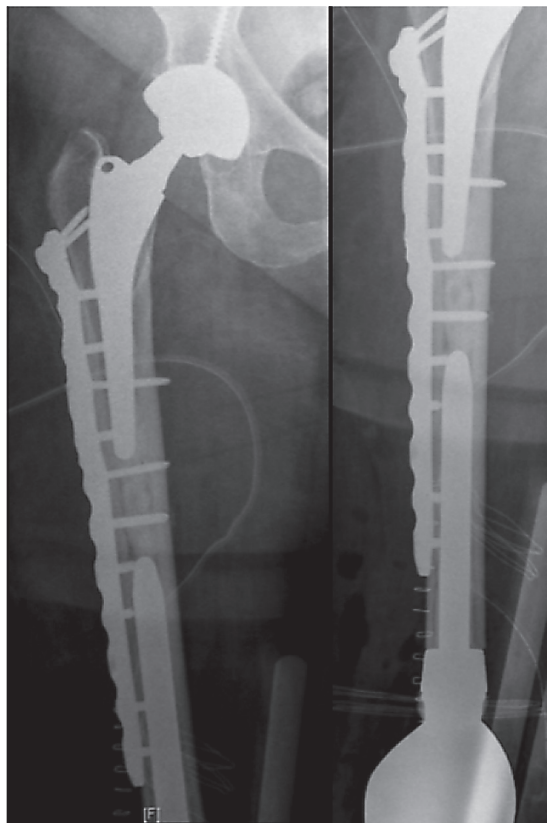
#### *Post-operative management*

Adequate ortho-geriatric management is mandatory in the post-operative setting with good pain control. The main goal of arthroplasty is immediate resumption of full weight-bearing and ambulation (as in hip fracture management) to prevent thrombo-embolic and decubitus-related complications.<sup>16,28</sup>





**Fig. 11** The principles described by Morgan-Jones et al should be used as in prosthetic revision. Three zones of fixation: epiphyseal, metaphyseal, diaphyseal. To be reliable, fixation should involve at least two of the three zones.



**Fig. 12** An ipsilateral total hip arthroplasty increases the risk of an inter-prosthetic fracture due to occurrence of an important stress riser between both implants. Internal fixation using a bridging plate is recommended. The bridged length should be at least twice the diameter of the diaphysis.

## Results

Most studies are based on small retrospective series with short follow-up due to limited indications for arthroplasty in fracture care. An overview of available studies with clinical data is given in Table 2. Wolfgang was to our knowledge the first to report on the use of joint replacement for an epiphyseal fracture of the distal femur in a case of rheumatoid arthritis.<sup>29</sup> One of the first studies (2006) reporting on longitudinal data with 10-year results of knee arthroplasty as a primary treatment for distal femoral fractures showed a 42% incidence of mortality within the first post-operative year from associated cardiac and pulmonary co-morbidities.<sup>30</sup> In addition, they described four early inter-prosthetic fractures. Appleton's series, however, had a mean age of 82 years and highlights the importance of pre-operative planning, use of bridging plates in the presence of total hip replacement and good peri-operative orthogeriatric management.<sup>14,20,27</sup>

A holistic approach resulted in improved outcome data as shown by Ebied et al in 2018 with excellent results for patient satisfaction and function at mid-term follow-up in 27 patients after TKA for comminuted intra- and peri-articular knee fractures with pre-existing arthritis.<sup>16</sup> Wang et al described the use of TKA with a stemmed femoral implant as a reasonable method for elderly patients suffering from supracondylar femoral fractures and concomitant knee arthritis, based on a cohort of 24 patients with mean follow-up of 3.0–5.5 years.<sup>14</sup> One of the largest series was published by the French Hip and Knee Society, reporting on 26 patients (21 females, 5 males) with a

**Table 2.** Overview of the available studies of acute fracture treatment around the knee with detailed information on the number of included patients, the mean age at the time of surgery, indications, type of implant, duration of follow-up, survival, outcome and complications

Publication	Number of patients	Mean age at time of surgery	Indication	Type of implant	Follow-up	Survival	Outcome	Complications
Acute fractures								
Wolfgang, 1982 <sup>29</sup>	1	/	Intercondylar femoral fracture in patient with rheumatoid arthritis	Primary total knee arthroplasty	/	/	/	/
Appleton et al, 2006 <sup>30</sup>	52–54 cases	82y (55–98)	Distal femoral fracture AO 33-A3 (9) / 33C (45)	Hinged total knee replacement	2–19y	Cum. Mortality: 41% first year – up to 97.3% at 10y	Cumulative rate of reoperation 13.6% first year, up to 18.1% by 3y	- 1 ischaemic foot - 1 haematoma - 1 patellar tendon rupture at 15 m - 1 deep wound infection - 4 periprosthetic fractures in first 3 months
Ebied et al, 2018 <sup>16</sup>	27	63y (59–74)	Intra- and peri-articular distal femoral fracture (9) and tibial plateau fracture (18)	LCCK or rotating hinge for femoral fractures – primary TKA with tibial stem for tibial fractures. Insert dependent on ligamentous stability	6 years (range 3–8)	2 patients died, rest of patients 100% survival	- Full extension, flexion av. 110° - X-ray satisfactory - KSS 80 (75–89)	1 early post-op pulmonary infection
Wang et al, 2018 <sup>31</sup>	24	68, 8y	Complex supracondylar femoral fracture with knee arthritis. Two patients with previous ORIF distal femur	Primary TKA with femoral stem	38 months (range 18–60)	1 patient died, 100% survival	- Av. ROM 105.2° - Adequate stability - 17/24 satisfied - HSS 86.2	/
Parratte et al, 2011 <sup>5</sup>	26	80.5y (70–98)	- Distal femoral epiphysis (10 – Müller B(1)/C(9)) - proximal tibia (16 – Müller B(8)/C(8)) - 17 with pre-existing arthritis	- 21 primary TKA (PS) - 5 rotating hinge prostheses - 1 hinge prosthesis	16.2 months (4–36)	/	- flexion 99° (75–140) - act ext deficit 4.1° - IKS 82 - IKS function 54	23% complications - 1 CVA - 2 disorientation - 2 phlebitis - 4 wound complications - 1 common fibular nerve palsy - 1 tibial tubercle avulsion - 1 deep infection - revision rate 9.5% - 1 stiffness - 1 deep infection
Boureau et al, 2015 <sup>4</sup>	21	79y (68–96)	- 10 distal femoral fractures - 11 proximal tibial fractures	- 20 rotating hinge prostheses - 1 semi constrained implant	31 months (9–68)	1-year mortality 14% (6 deaths in total)	- Parker score 4.6 - IKS knee 78.4 - IKS function 38.2 - Oxford 36/60	/
Sarzaeem et al, 2017 <sup>32</sup>	30	67.6y ± 4.2	AO 41A – 41B – 41C fracture	- Primary TKA - 3 CCK	4.5y ± 1.1	100%	- ROM 106 ± 13° - Tegner 3.5 ± 1.3 - KSS Knee 90.7 - KSS function 69.6 - VAS satisfaction 8.1 - VAS pain 1.5 - all to previous act. - X-ray satisfactory	/
Pathologic fractures								
Johnson et al, 2020 <sup>18</sup>	15	62y ± 9	Pathological peri-art. distal femur (11) or proximal tibial (4) fracture	Tumour endoprosthesis (11) - Rotating hinged (4)	19 months	11 patients died, overall 5y survival 33%	87% had severe pain before surgery, 0% at moment of follow-up	- 13% re-operation for wound debridement (1) and amputation (1) for recurrence. - 2 (13%) VTE

Note. ORIF, Internal reduction and Internal Fixation; LCCK, Legacy Constrained Condylar Knee; TKA, Total Knee Arthroplasty; PS, Postero-stabilized; CCK, Constrained Condylar Knee; KSS, Knee Society Score; IKS, International Knee Society; ROM, Range of Motion; HSS, Hospital for Special Surgery; VAS, Visual analogic scale; CVA, Cardio Vascular Accident; VTE, Venous thrombo embolism.

mean age of 80.5 years. Functional results were satisfactory with good recovery of range of motion; however, Parker scores dropped by a mean of 1.7 points. In one patient a skin complication was observed, one patient had cardiac complications and three patients suffered from a deep venous thrombosis (of whom one developed a pulmonary embolism). In one patient an anterior tibial tubercle avulsion was seen. No implant revisions were needed. Complications should not be underestimated; these findings outline the need for peri-operative ortho-geriatric management, as for hip fractures, in the elderly complications are often more decubitus-related.<sup>5</sup>

These findings have been confirmed in later studies. In 2015, Boureau et al published their series of 21 TKAs (mean age 79 years), showing local complications in 9% of cases (one case of stiffness and one infection). Functional outcomes were comparable with the literature but showed a mean two-point decrease in Parker score. In this study the global one-year mortality rate was, however, 14%, going up to 30% in the femoral fracture group. As for hip fractures in the elderly, one should bear these relatively high numbers in mind and communication with the patient and family is essential.<sup>4</sup> Sarzaeem et al published their data on 30 patients receiving TKA for proximal tibial fractures with pre-existing OA or osteoporosis. At a mean follow-up of 4.6 years, they reported significant improvement in Tegner scores with restoration of full range of motion and 100% return to previous activities.<sup>31</sup> Based on data from the Danish Knee Arthroplasty Register published in 2017, 52,518 primary TKAs were reviewed, of which 3% were inserted for non-acute post-traumatic fracture arthritis (PTFA). During the first five years TKA for PTFA had an inferior survival rate with a higher risk of revision than osteoarthritis, with adjusted hazard ratio ranging from 1.5 to 2.4 between age categories. After five years, no significant differences in risk of revision were seen between the groups. Revision due to instability occurred more frequently in TKAs performed due to previous fractures.<sup>32</sup> Complication rates of TKA for fresh fractures range between 8% and 42%; revision rates are low and functional results are usually satisfactory. In cases with secondary post-traumatic TKA with failed osteosynthesis, complication rate ranges between 20% and 48% with need for implant revision in 8–20% of cases.<sup>2–5</sup> A single study, recently published by Johnson et al, on outcomes of knee arthroplasty for primary treatment of pathological peri-articular fractures, showed significant clinical improvement post surgery.<sup>18</sup>

## Conclusions

Results in first-line arthroplasty for complex knee fractures in elderly patients with prior osteoarthritis are encouraging, and better than in arthroplasty secondary to failure of

open reduction and internal fixation. Lower revision and complication rates are seen, with earlier resumption of weight-bearing and better functional results. Arthroplasty should be considered in the decision-making in the treatment of fractures around the knee as it might save the patient's life with early resumption of weight-bearing and limited co-morbidities. A case-based approach should be implemented, and first-line arthroplasty should be considered as an alternative for the treatment of complex knee fractures. Multidisciplinary management is key in elderly patients to limit post-operative complications. Principles of revision arthroplasty should be respected with emphasis on a meticulous pre-operative preparation and a refined surgical technique. Due to limited indications, published series are limited. Better definition of indications and surgical techniques should extend experience and further improve results.

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The other authors declare no conflict of interest relevant to this work.

## OA LICENCE TEXT

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