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Knee replacement in chronic post-traumatic cases

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- Post-traumatic knee arthritis is a challenging condition. Prosthetic surgery is demanding and the risk of complications is relatively high.
- Planning is an essential element of this surgery; correct diagnosis (to exclude latent infection) and adequate considerations regarding approach, axis, bone loss, choice of implant and level of constraint are indispensable.
- There are two main categories of post-traumatic arthritis: extra-articular deformities and articular deformities.
- Use of an algorithms can support the surgeon's choice of implant.
- Correct implant positioning and limb alignment restoration is associated with very good results, similar to those achieved with standard total knee arthroplasty.

Keywords: post-traumatic arthritis; extra-articular and articular deformities; decision algorithm in post-traumatic TKA; bone defects; level of constraint

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Post-traumatic arthritis of the knee is the third most common cause of total knee replacement after primary arthritis and rheumatoid arthritis. The number of operations for post-traumatic conditions has increased only slightly[1] Distal femoral and proximal tibial fractures are relatively common in young patients as a result of high-energy trauma, and in older patients as a result of low-energy trauma. These fractures may lead to malunion or nonunion, bone defects, limb malalignment, latent infection and soft tissue envelope compromise.[2] Trauma can cause acute cartilage damage with necrosis of cartilage cells[3] and chronic damage following alteration of the normal limb axis. Another cause of articular degeneration can be a meta-diaphyseal or diaphyseal tibial or femoral fracture healing with a limb deformity, which leads to chronic abnormal stress on articular surfaces and subsequent cartilage degeneration. Post-traumatic arthritis is a relatively common problem for the surgeon. It is nonetheless demanding and exposes the patient and surgeon to the risk of lower functional results. The aim of this paper is to give an overview of the various associated problems, and the surgical options available for dealing with this type of articular degeneration.

Planning

Planning is of utmost importance when approaching this challenging surgery. Clinical and radiological evaluations must address a number of issues: diagnosis (to exclude latent infection), approach, axis, bone loss, choice of implant and level of constraint. During clinical examination, the surgeon must evaluate skin temperature, redness, swelling, deformity both at rest and during weight-bearing, peripheral pulses, range of motion (particularly stiffness[4]), ligament balancing and presence of previous scarring. The pre-operative range of motion often correlates with post-operative range of motion and influences the surgical approach as, in the case of severe stiffness, the surgeon has to perform a tibial tubercle osteotomy to expose the knee. The ligaments must be tested and it is important to differentiate between real instability, secondary to ligament damage, and pseudo-instability caused by bone defects. Finally, scarring influences the choice of surgical approach. If appropriate for adequate exposure, the most recent scar should be used.[5] Opting for the most lateral scar lowers the risk of skin necrosis, as the oxygen vascularisation of the medial flap is preserved in so doing.[5] Prior transverse incisions may be crossed with a longitudinal incision at a right angle.[5]

Radiological planning involves three main radiographs:

1. Long-standing weight-bearing radiographs provide information on limb axis and deformity, allowing, in particular, the differentiation between extra-articular deformities and intra-articular deformities. These enable the surgeon to choose the right stem type (straight or off-set) and entry point of the reamer for the femoral and tibial canal in question.
2. Lateral view radiographs indicate patellar height (low patella in stiff knee), tibial slope and entry point of the reamer in antero-posterior position.
3. Patellar axial view shows patellar tracking and any dislocation/ tilt.

Pre-operative planning is often completed by CT scan to define bone quality and possible defects. Evaluation of the vessels (by angiography or angio-CT) is only required in cases of severe deformity. Though usually unnecessary, MRI can provide information on bone oedema or vitality.

Serological examination is necessary to exclude latent infection: white blood cell count, erythrocyte sedimentation rate and C-reactive protein. In the case of swelling, joint aspiration and culture of the aspirate should be carried out.

Finally, it is important in the planning phase to identify the implants which need removing while bearing in mind the following:

- Implants have often been in place for many years, so removal can be difficult;
- Only the necessary implant is to be removed in order to limit difficult and dangerous surgical intervention.

Algorithm proposal

A few examples are available in the literature, though no specific algorithm is available for this type of surgery.

Based on our experience of 44 chronic post-traumatic knees with a mean follow-up of six years,[2] we propose two algorithms, one for each deformity location:

- Extra-articular deformities (Fig. 1)
- Articular deformities (Fig. 2).

Extra-articular deformities

This type of deformity is usually the consequence of a meta-diaphyseal or diaphyseal tibial or femoral fracture healing with residual deformity, influencing the axis. According to the extent of deformity, it is necessary to evaluate possible correction implant (Fig. 3 a, b), corrective osteotomy and/or total knee arthroplasty (TKA) (one or two steps). Deschamps et al[6] showed that global deformities of up to 22° varus (22° for tibia and 20° for femur) and up to 15° valgus (6° for femur and 15° for tibia) can be corrected by asymmetric bone resection and ligament release without osteotomy. Major deformities are to be treated with osteotomy and TKA.

Articular deformities

In the case of deformity with possible associated bone loss, it is necessary to evaluate ligament competence and degree of bone loss in order to identify the best implant or combination of implants for the specific case in question. In the case of complex joint fractures, the solution may be TKA and, in most cases, implant revision may prove useful. It is necessary to choose between metal augment (titanium or trabecular metal), bone graft (morcellised allograft, autograft from bone resection, structured allograft), trabecular metal cone or sleeves. The Anderson Orthopaedic Research Institute (AORI) classification of bone defects, based on pre-operative imaging and confirmed intra-operatively, is intrinsic to treatment choice: an implant supported by poor quality bone can lead to early failure.

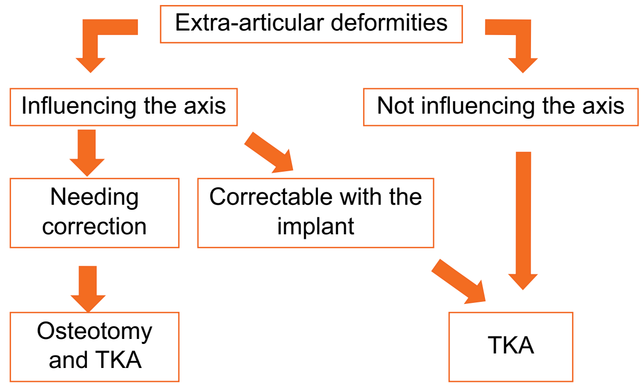


Fig. 1 Algorithm proposal for extra-articular deformities.

An alternative solution is the use of stems which help share the load of the methaphyseal bone and transfer it to the diaphyseal bone, thus reducing stress on the interface between the damaged bone and the implant. They add stability and stiffness to the construct, protect bone defect reconstruction and, if canal filling, they help re-instate joint alignment and component position.

The evaluation of ligament competence, especially in cases of bone loss, is essential when deciding upon the level of constraint. For ligament competence and good bone stock we can perform a cruciate-retaining (CR) or posterior stabilised (PS) implant, while for isolated ligament incompetence we have to use a constrained condylar knee (CCK) implant with CCK liner to increase the level of constraint. However, in cases of bone defect and good ligament competence we can perform a CCK implant, with the possible addition of an augment and stem for bone reconstruction, with a PS liner to reduce stress at the bone-implant interface. Finally, in cases of severe bone loss, ligament incompetence or extensor mechanism disruption, we have to consider upgrading the constraint to a rotating hinge knee (RHK) implant.

Based on implant combination, there are five main possible solutions:

- Unicondylar knee arthroplasty (UKA)
- TKA – Augment – CCK
- TKA – Bone grafting – CCK
- TKA – Cone – CCK
- Segmental TKA

UKA

UKA can be performed in post-traumatic cases (Fig. 4), but only one compartment must be involved; the deformity must be correctable and the ligament competent. This

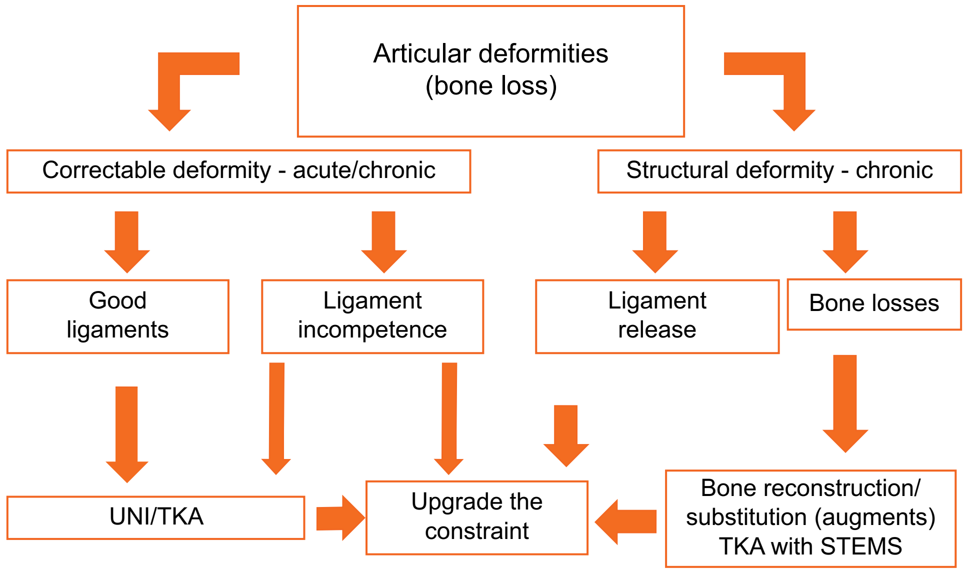


Fig. 2 Algorithm proposal for intra-articular deformities.

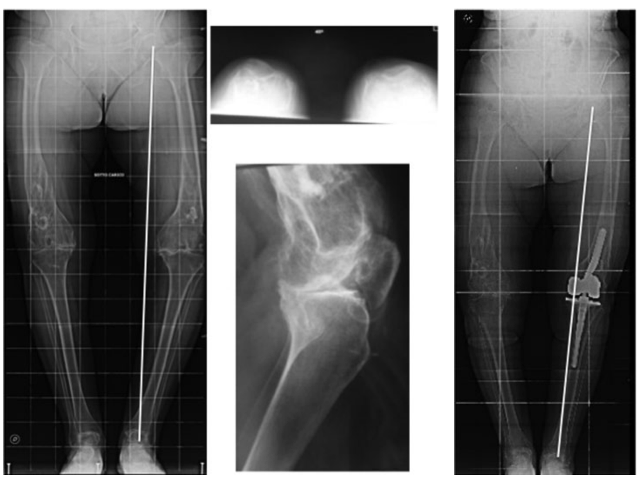


Fig. 3 a) Extra-articular deformity: pre-operative condition.
b) Post-distal femoral fracture and follow-up at 3 years after CCK implant. Radiographs show good restoration of limb alignment.

solution is contra-indicated in cases of articular comminution or severe deformity.

TKA – Augment – CCK
This solution is adapted for defect types 1, 2 and 3 according to the AORI classification. The surgeon has to fill the bone loss (uncontained), support component alignment (frontal, sagittal and rotational), and position and re-tension the ligaments (Fig. 5).

TKA – Bone grafting – CCK
Morcellised bone graft is indicated for contained bone defects type 1 (Fig. 6), while in cases of massive bone loss, we have to use a structural allograft.

TKA – Cone – CCK
Trabecular metal cones can fill the defect and enhance metaphyseal fixation and reconstruction stability. These are indicated for type 3 defects (Fig. 7).

Segmental TKA
Segmental TKA can be used in cases of bicondylar defects, severe bone loss and severe collateral ligament incompetence (Fig. 8).

Surgical tips and tricks

In post-traumatic cases, there are different tips and tricks for each of the different steps of surgery.

Pre-operative planning

In most cases, radiographs are sufficient for planning. However, they may sometimes underestimate the amount of bone loss. In post-traumatic cases, especially in intra-articular deformities, a CT scan should be performed for a more precise assessment of bone loss so that one can plan the materials needed for correct revision (cones or sleeves, stems and augments, etc).

Surgical approach

Post-traumatic deformities often present with hardware in situ and joint stiffness. The choice of approach is sometimes related to approaches previously performed, following the ‘most lateral incision’ rule. A Keblish approach is sometimes necessary if there is lateral hardware or if a lateral approach was previously performed. Choosing the right approach can sometimes be complicated if a double approach was previously performed for a tibial plateau fracture. In such cases, a median incision can be performed, but it has to follow one of the two previous scars

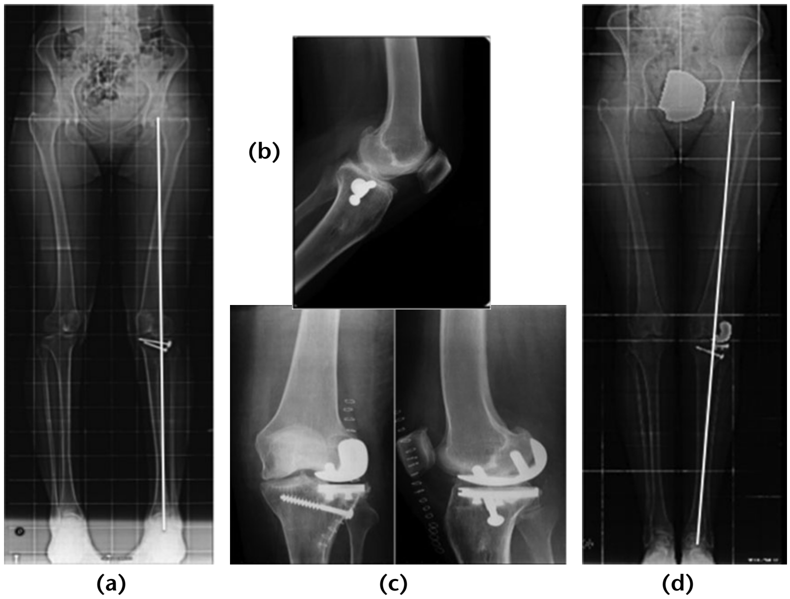


Fig. 4 a) Articular deformity; b) lateral post-traumatic arthritis following tibial plateau fracture, treated with lateral UKA implant fracture; c) the removal of only one screw; d) follow-up at two years shows good restoration of limb alignment.

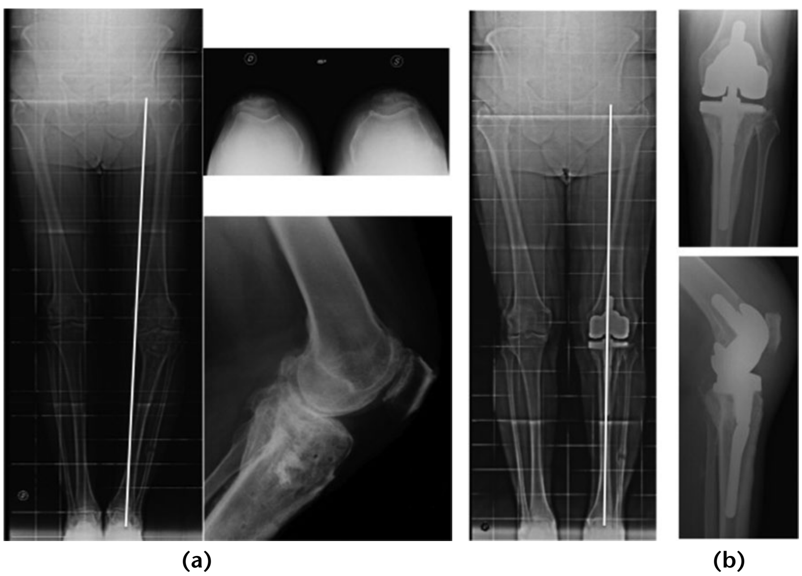


Fig. 5 Articular deformity. a) Post-traumatic varus knee treated with CCK implant and b) medial titanium augment to restore limb alignment. Tibial off-set stem protects the bone reconstruction.

distally. Concerning exposure, an extended approach may be needed in cases of stiff knee. The authors' preferred extended approach is a tibial tubercle (TT) osteotomy as it permits good exposure and the risk of complications is lower than with other extended approaches.

Joint reconstruction and choice of implant constraint

We face pseudo-instability of the joint in most cases of post-traumatic deformities: correct bone loss reconstruction leads to correct ligament competence. The main issue is to redefine the right joint line. As mentioned before, in the case of intra-articular deformities, a pre-operative CT scan can be useful to evaluate the amount of bone loss and to define the correct position of the joint line. However, landmarks such as epicondyles, meniscal scars, fibular head, tibial tuberosity and patellar height are evaluated intra-operatively.

Once the correct joint line has been defined and trial implants are in place, a posterior stabilised (PS) liner is used to evaluate gaps, joint balance and stability. The knee should be balanced regardless of the choice of constraint and a PS liner can also be used with a CCK implant if the balance is optimal. A CCK implant is sufficient in the vast majority of post-traumatic cases. The use of a hinged

(a)

(b)

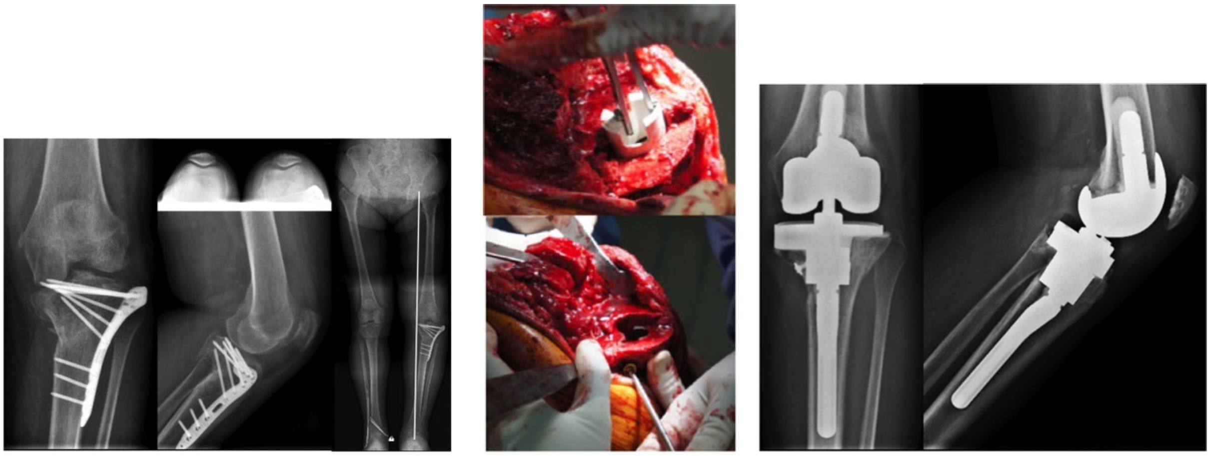
(c)

Fig. 6 Articular deformity. a) Post-traumatic varus knee in a young patient; b) treated with posterior stabilised design, morcellised bone graft and tibial tuberosity osteotomy (post-operative radiographs); c) at one year, radiographs show consolidation of the tibial tuberosity osteotomy and correct limb alignment.

implant should be limited to the rare cases of complete ligament incompetence despite correct bone loss reconstruction.

Discussion

Fracture and subsequent haemarthrosis, and often surgical treatment, lead to fibrosis, stiffness of the knee and also cartilage damage; insufficient reduction induces limb malalignment. These three consequences of trauma lead to the development of osteoarthritis.[7] Following a tibial plateau fracture, the incidence of arthritis is higher[8,9] than with distal femoral fracture.[5,10] Literature reports show poorer results with TKA in post-traumatic arthritis than with primary arthritis. However, such studies are few and involve a very limited number of patients. In 1990, Roffi and Merrit[11] presented 17 cases of post-traumatic arthritis following knee fracture. Eight patients had clinically successful results. In 1999, Lonner et al[4] studied 30 patients with arthritis after intra-articular or metaphyseal fractures. At a mean follow-up of 46 months, a 6° improvement in range of motion and an improvement of Knee Society Score (from a pre-operative mean of 36 points to a post-operative mean of 78 points) were reported. Knee scores were considered excellent or good in 71% of cases. Overall there were complications in 57% of cases (aseptic failure 26%, septic failure 10% and other complications 20%). Tibial loosening occurred mainly in cases where no stems were used or in cases with cementless tibial components. The authors therefore recommended the use of stems in cases of compromised metaphyseal bone stock. In 2003, Weiss et al[12] presented a series of 48 TKA in patients with previous distal femoral fracture, and 62 TKA in patients with previous fracture of the tibial plateau. In the first group, limb alignment restoration, correction of the deformity and ideal component position reported for 25 knees (52%). In the second group, limb alignment restoration, correction of the deformity and ideal component position reported in 48 knees (77%). The most common problems in patients with previous tibial plateau fracture were related to soft-tissue healing, post-operative stiffness and intra-operative extensor mechanism disruption. The authors showed that in patients for whom the goal is ideal limb and implant alignment, the results were similar to those of routine primary TKA. They also identified the single most important factor influencing outcome to be initial fracture treatment (correct incision, minimal periosteal stripping, anatomical reduction, use of bone graft). Shearer et al[13] also sought to identify the factors influencing outcome predictors in post-traumatic arthritis. They described a cohort of 47 patients divided into four categories: intra-articular, metaphyseal, diaphyseal, and combined femoral and tibial deformities. They found that intra-articular and metaphyseal deformities had worse pre-operative scores, but that changes in scores were similar to diaphyseal deformities; combined deformities were worse than isolated deformities,



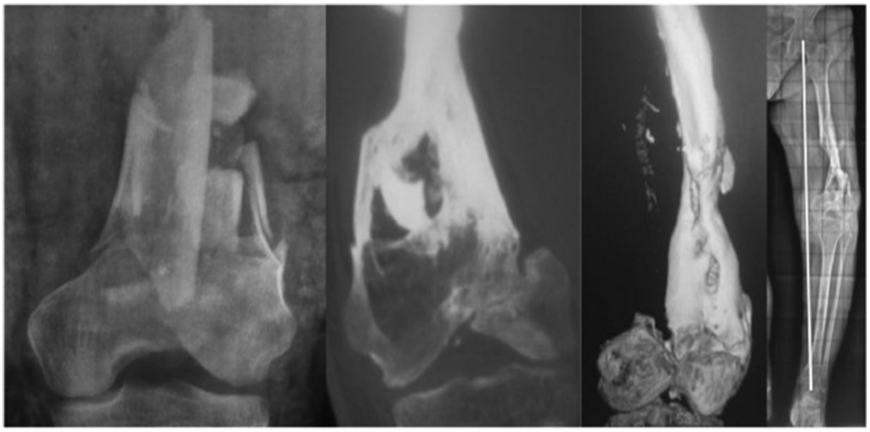
(a) (b) (c)

Fig. 7 Articular deformity. a) Failure of tibial plateau synthesis; b) treated with trabecular metal cone and one screw to support bone reconstruction (intra-operative findings); c) radiographs show good results at six months follow-up.

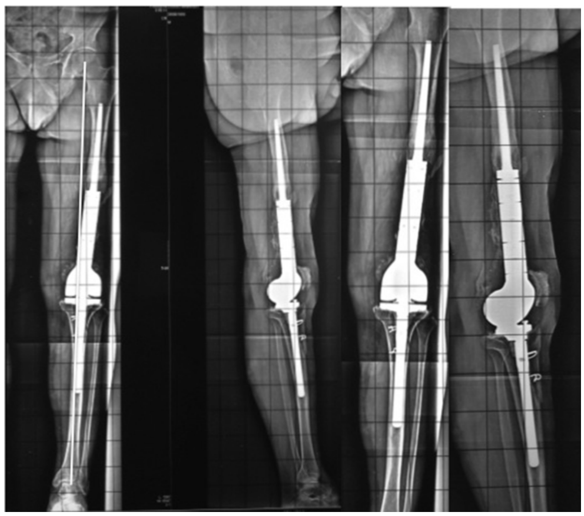
especially function. Finally, soft-tissue defects requiring flap coverage were associated with a worsening of pain score. Parratte et al[7] presented a retrospective multi-centre study of 74 patients with a mean follow-up of four years. They reported that knee score improved from a pre-operative mean of 25 points to 85 points at follow-up. The improvement in knee score was significantly greater than that of functional scores. However, complications occurred in 19 patients (26%), involving six cases of stiffness and three of extensor system avulsion. In our previously published study,[2] we presented a series of 44 chronic post-traumatic knees in 43 patients, treated with a PS design in 22 cases and CCK design in 22 cases. At a mean follow-up of six years, clinical KSS improved from a pre-operative mean of 33 points to 88 points, and 93% of patients had an excellent or good score; the functional KSS improved from a pre-operative mean of 56 to 84 points at follow-up, and was excellent or good in 86.5% of patients. Complications occurred in nine cases (four cases with incomplete knee extension), but re-operations were performed in only three cases (aseptic loosening, persistent pain and infection). Finally, the results of patients with PS design were compared to those of CCK design; we showed that patients with PS design had a higher mean value, especially for functional KSS, but the pre-operative state of those treated with the CCK design was poorer.

Regarding extra-articular deformity, Deschamps et al[6] presented a continuous multi-centre retrospective study of 78 patients treated with TKA including 18 cases with associated osteotomy. The bone deformity was corrected in isolated TKA by way of an asymmetrical cut of corresponding bone and the resulting resection laxity was balanced by releasing the convexity collateral ligament. The arthroplasty and osteotomy procedures were simultaneous in 16 cases. At a mean follow-up of four years, the mean pain score had significantly improved: knee function score was excellent in 52 cases and good in 14. Complications occurred in 12 cases. The authors concluded that osteotomy with TKA does not compromise mobility recuperation, but the gain in functional results seems lower than with isolated TKA. Metaphyseal osteotomy and perfect contact between the bone surfaces (without cement interposition) reduced the risk of nonunion. A recent study by Abdel et al[14] determined the long-term outcome (15 years) of 62 TKA procedures in patients with previous tibial plateau fracture. The authors showed that survival free of revision for aseptic loosening was 96%, while survival free of any revision was lower (82%), mainly due to polyethylene wear. They therefore concluded that the long-term survival of TKA in post-traumatic arthritis is similar to that of routine TKA.

Post-traumatic arthritis is particularly demanding for the surgeon and could be considered as a revision knee surgery. Planning is essential as latent infection (especially in cases of device in situ) must be excluded. Complete pre-operative radiological imaging allows us to distinguish between extra-articular and articular deformity. Different combinations of implants (depending on bone defect and ligament competence) can be used to correct the bone defect and re-create adequate bone stock to support the implant. Limb alignment must be achieved for better results. The level of constraint must be decided upon according to pre-operative tests and ligament competence. However, as for standard TKA, one must employ the constraint possible. However, it is important to remember that revision implants (for example CCK designs) offer various advantages such as the possible addition of stem, augment and cone to increase fixation and transfer the load to the diaphysis and permit a lower level of constraint to a PS liner. The choice of the approach is another essential step as soft-tissue defects represent a relatively frequent complication in this surgery and are associated with a worsening of the results. We have to remove only the devices that interact with the prosthesis implant. The use of reproducible



(a)



(b)

Fig. 8 Articular deformity. a) Severe articular and metaphyseal comminuted fracture, resulting in varus knee with bone defect and treated with segmental implant; b) Radiographs at six years follow-up which show good restoration of limb alignment and good implant osteo-integration.

algorithms increases the likelihood of successful surgery, as correct implant positioning and limb alignment ensure very good results, as observed with standard TKA.

Conclusions

Post-traumatic arthritis is a relatively common complication following knee fracture. It is challenging for the surgeon, and can be considered akin to revision surgery. Pre-operative clinical examination and planning are essential for success. The use of reproducible algorithms enables the assessment of deformity site, bone loss, ligament competence and level of constraint. The surgeon is then able to choose the best implant combination for each individual case. Despite the scarcity of studies in literature and the differing experiences of authors, the risk of complications is high. Correct technical execution, based on pre-operative considerations and intra-operative findings, is the key to good, long-term results.

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CONFLICT OF INTEREST

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