Technical Note

One-Stage Total Knee Arthroplasty Plus Corrective Osteotomy for Osteoarthritis Associated With Severe Extra-articular Deformity

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Abstract: The mainstay for treatment of articular deformity caused by advanced tricompartmental osteoarthritis of the knee is total knee arthroplasty. When this is also associated with an extra-articular deformity, this also must be compensated or corrected. In this scenario, it is essential to achieve an optimal mechanical situation by restoring the anatomical and mechanical limb axes and an adequate soft-tissue balance. These premises are necessary to relieve pain and achieve satisfactory functionality and implant survival over time. A reconstructive single-stage technique is proposed for patients with knee osteoarthritis amenable to arthroplasty and a severe extra-articular deformity, aiming at addressing both problems simultaneously.

Total knee arthroplasty (TKA) is one of the most frequent surgical procedures in orthopaedic daily practice. It is the mainstay of treatment for advanced knee osteoarthritis, whether or not deformities are associated. The importance of an optimal mechanical situation and the restoration of the mechanical axes of the lower limb, associated with a correct ligament and soft-tissue balance, is undoubtedly necessary for achieving satisfactory functional performance and implant survival over time.[1] Many authors have suggested that misalignment and alteration of the axes in TKA are important risk factors related to aseptic loosening of the components and early implant replacement.[2-4]

Most frequently, gonarthrosis is associated with intra-articular deformity, in which case both conditions may be addressed with TKA. Conversely, there are seldom cases in which gonarthrosis is associated with an extra-articular deformity (EAD) and cannot be solved using an isolated TKA. These cases are, thus, meant to be treated separately.[5]

The most common cause of EADs around a degenerative knee is malunions after femoral and/or tibial fractures.[6] Other causes of EADs include congenital malformations, metabolic changes, previous osteotomy procedures, or other sorts of surgeries.[1] Any of these can cause an alteration of the lower-limb alignment which, in turn, can cause premature osteoarthritis of the knee, requiring joint replacement at an early age (Fig 1).[7] This suggests that prompt correction of the EAD could prevent development of knee osteoarthritis and therefore, joint replacement.[8]

When knee osteoarthritis is associated with a mild-to-moderate EAD and/or it is close to the joint, both problems can be solved separately by means of a TKA.[9] However, when knee osteoarthritis is associated with severe EAD or an EAD that is far from the joint, a simple TKA could be insufficient to address both problems and ensure a functional and durable survival of the implant.[5,10] Currently, there are 3 options available for addressing this clinical situation: 2-staged surgical treatment (corrective osteotomy followed by TKA), 1-stage surgical treatment (simultaneous osteotomy and TKA), or a computer-assisted navigation TKA trying to avoid an extra-articular osteotomy to the TKA.[11,12]

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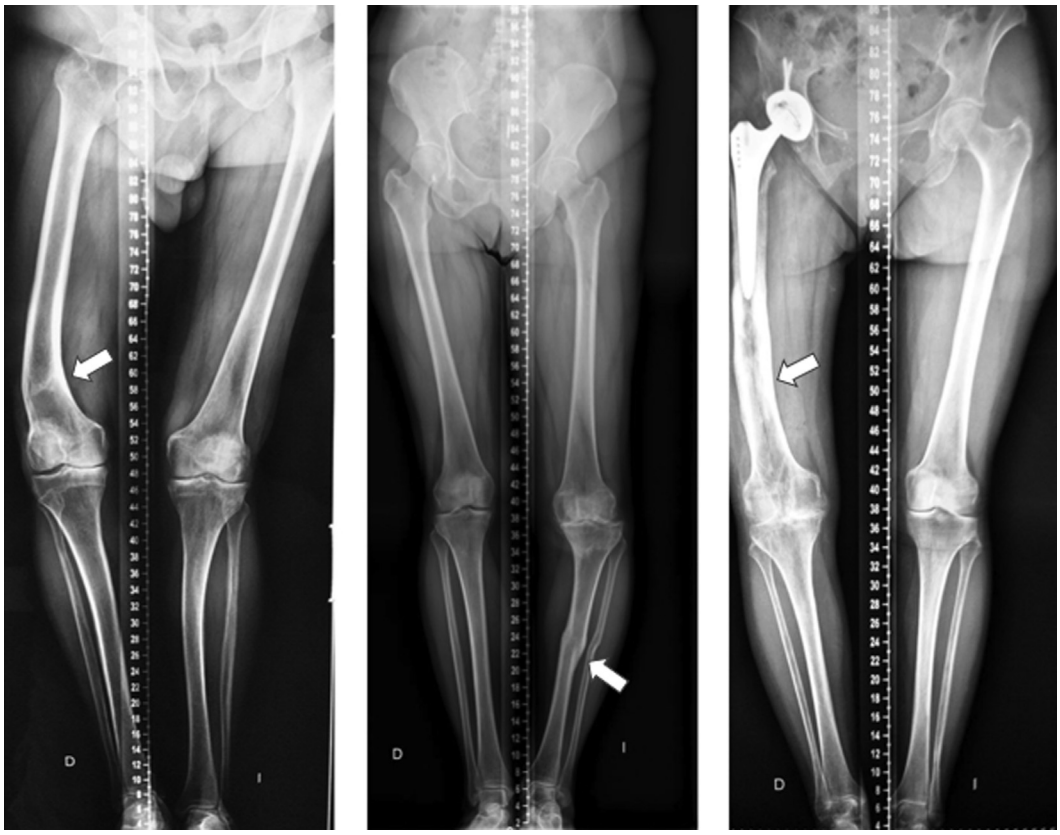


Fig 1. Several cases of knee osteoarthritis associated with extra-articular deformity. Anteroposterior X-rays of the whole lower limbs in the standing position (teleradiography). Arrows point to the extra-articular deformity, right femur in the right and left images and left tibia in the central image.

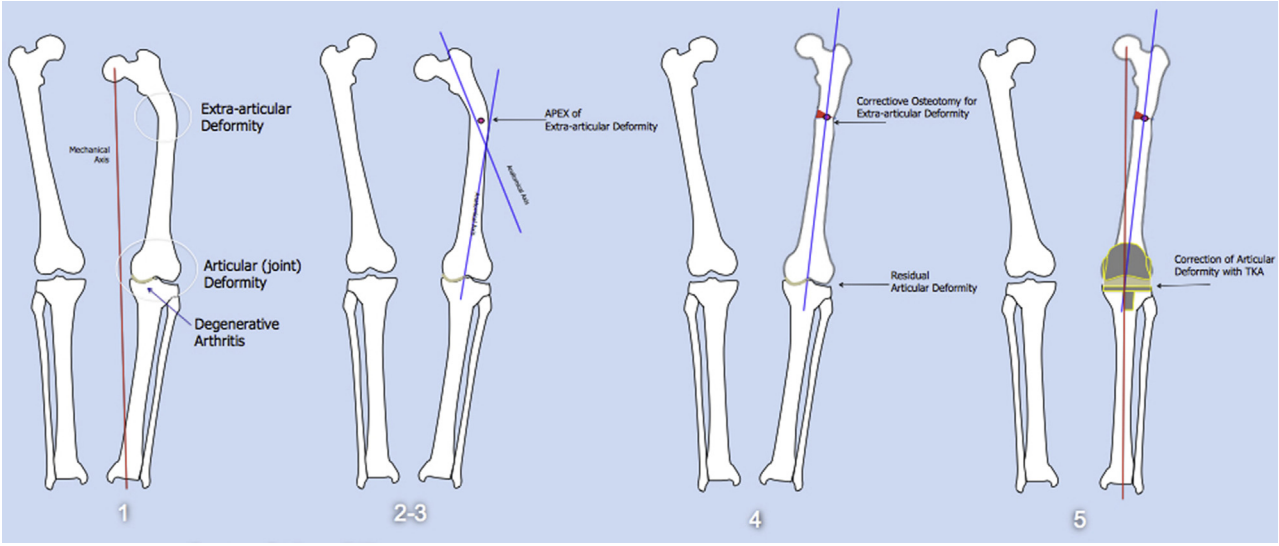


Fig 2. Analysis and planning carried out in a case of knee osteoarthritis with articular deformity associated with femoral extra-articular deformity. (1) The coronal mechanical axis of the left lower limb is drawn (red line) and the extra-articular femoral deformity is localized (upper circle). (2) The 2-bone segment axis of the femur (blue lines) intersect defining the apex of the deformity. (3) Decision making: an addition osteotomy at the apex (red wedge) is performed to restore the femoral axis independently from the total knee arthroplasty (TKA) when deformity is severe and far from joint. (4) Simulate osteotomy for extra-articular correction. (5) Simulated TKA to correct the remaining articular deformity.

Fig 3. A right knee is shown with the patient placed in the supine position on a radio-transparent surgical table. Sterile surgical drapes are used according to standard technique for total knee arthroplasty, placing a positioning boot underneath to hold the leg in the desired knee flexion at any given time. A non-pneumatic narrow disposable silicone ring tourniquet (HemaClear) was used.

The main aim of this paper is to describe a 1-stage surgical technique of corrective osteotomy and TKA for cases of knee osteoarthritis associated with a severe and/or away-from-the-joint EAD. It also aims to discuss their indications, advantages, and limitations in comparison with other treatment options.

Surgical Technique

Preoperative Planning and Analysis

The individualized preoperative study is the first step required (Video 1). For this purpose, radiographs (anteroposterior and lateral) including the whole limb leg in the standing position (teleradiography) are necessary. Using these radiographs, the anatomical and mechanical axes of each segment and the joint deformity angles are determined. The anatomical axes of the deformed section are then drawn, thereby the apex of the EAD (the point at which both axes intersect), and the angle of deformity are determined. This apex will be the desirable point to perform the osteotomy. It is essential to carry out the study on both coronal and sagittal planes (Fig 2).

If we consider that the EAD is mild-to-moderate (<15°) and/or it is close to the joint (<10 cm), we recommend correction using only TKA. In contrast, if the EAD is greater than 15° and/or is further away from the joint, we prefer to associate an osteotomy at the apex of the EAD with the TKA.

It is advisable to simulate the planned corrections before surgery, to estimate the final mechanical position after correction. For this purpose, simple printed cut-outs of the radiographs or even computer systems of varying complexity can be used, some of which include 3-dimensional reconstructions and printing of the limb.

Positioning of the Patient

The surgery is performed with the patient under epidural or general anesthesia, which can be associated or not with femoral block. The patient is placed in the supine position on a radio-transparent surgical table with a proximal tourniquet or by restricting blood flow through a non-pneumatic narrow disposable silicone ring tourniquet (HemaClear; OHK Medical Devices, Haifa, Israel). The sterile surgical drapes are placed according to standard technique for TKA, placing a positioning boot underneath to maintain the required degree of knee flexion at any given time (Fig 3).

Surgical Approach

Von Langenbeck's medial parapatellar approach is used. The approach can be extended proximally or distally to reach the apex of the EAD (Fig 4). However, a medial or lateral approach must be associated in the femur or tibia if the apex is further away from the joint.

Arthrolysis and Removal of Osteosynthesis Hardware

Depending on the osteoarthritis and the EAD etiology, it is sometimes necessary to perform a knee arthrolysis to release scar tissue and/or remove periarticular osteosynthesis hardware from previous surgeries, if it is expected that this may interfere during surgery (Fig 5 A and B).

Osteotomy

The deformity apex, which is determined during the preoperative planning, is located using intraoperative radioscopy and it is marked (Fig 6A). The decision on the osteotomy type, opening-wedge or closing-wedge, is made depending, basically, on the operated limb

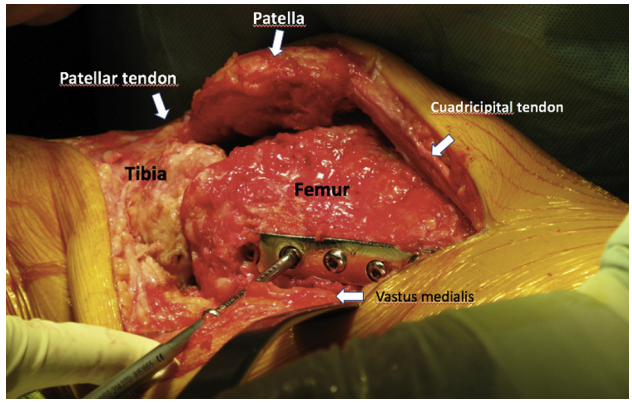


Fig 4. A Von Langenbeck's medial parapatellar approach of a right knee. The patella is dislocated externally during the procedure. The approach can be extended to reach the apex of the extra-articular deformity.

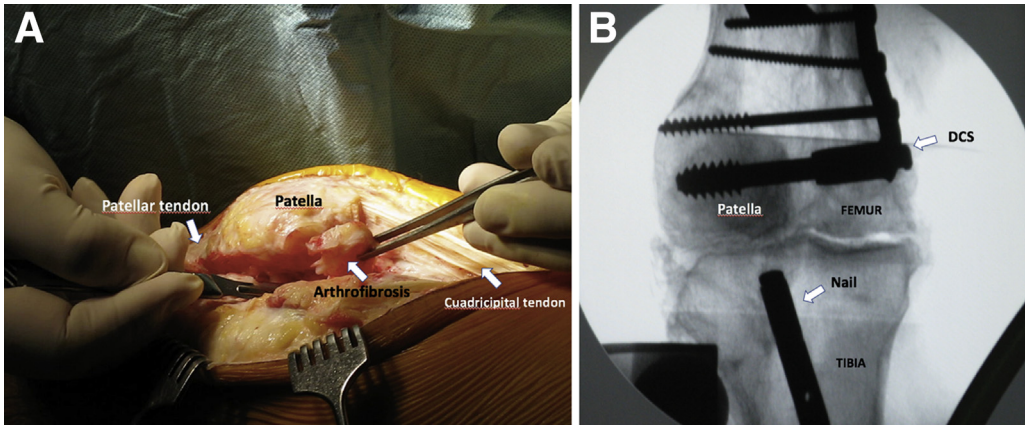


Fig 5. Right knee, medial view. (A) Knee arthrolysis to release intraarticular scar tissue. (B) Intraoperative fluoroscopy showing peri-articular osteosynthesis hardware (tibial intra-medular nail and distal femur DCS [Dynamic Condylar Screw System, Synthes]).

shortening. In the former one, the osteotomy begins by using a surgical saw at the level of the apex that should be completed using osteoclasia (Fig 6 B and C). In the latter, a predetermined sized wedge is removed from the convex side of the bone (Fig 6 D and E). Once the deformity is corrected by aligning the anatomical axes of the proximal and distal segments in both coronal and sagittal planes, a small plate is placed with unicortical screws to temporarily maintain the correction (Fig 7). However, the plate may be used definitively if satisfactory stability of the segments is not achieved using only the implant stems itself. If there is an associated rotational deformity component, it also can be corrected at that time by derotating the segments of the osteotomy.

Total Knee Arthroplasty

Once the anatomical axis and the EAD are corrected, tibia and femur joint surfaces are shaped to fit the TKA, also correcting the intra-articular deformity when necessary. The TKA is carried out on a conventional technique fashion, using intramedullary guides and cemented components on the surface. The stem sizes, which are not cemented, are chosen intraoperatively, so that a solid fixation of the osteotomy can be ensured. It is recommended reaming of medullary canals to achieve an optimal press-fit of the stems, providing an adequate stability for the osteotomy (Figs 8 and 9). If this is not the case, an additional internal fixation can be applied or even the provisional plate could be kept definitively, as mentioned previously(Fig 10 A and B).

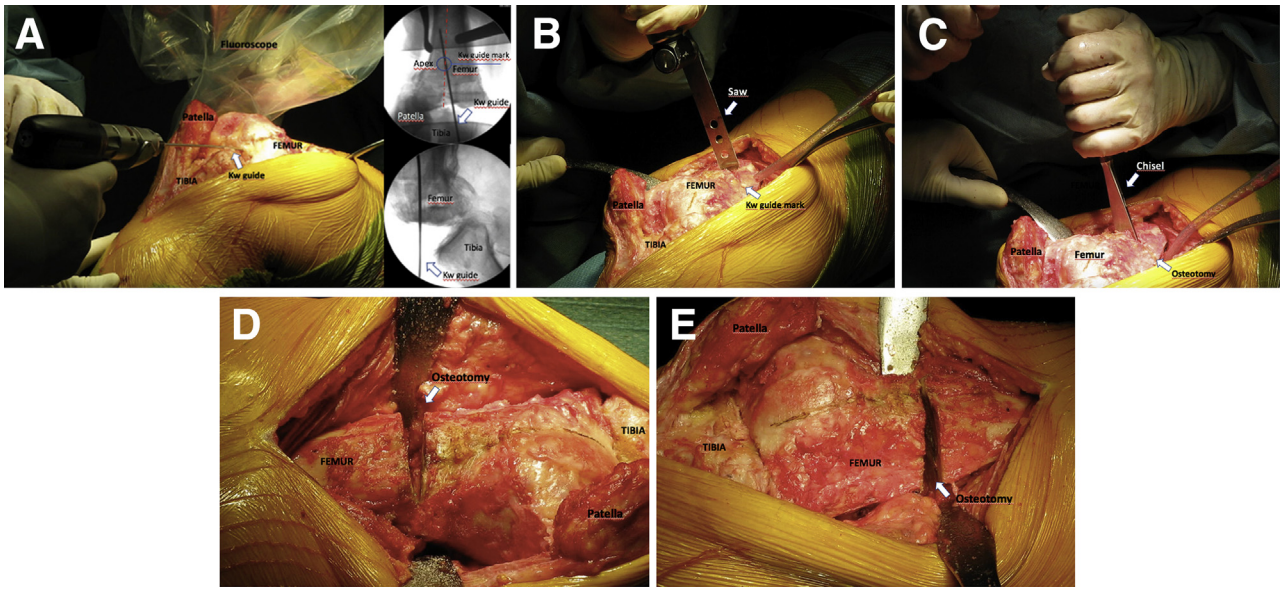


Fig 6. Right knee, medial view. The apex (blue circle) of the deformity is located with a K wire controlled by fluoroscope (anteroposterior view [up] and lateral view [down]) and marked (blue line) (A) (Femoral axis red discontinuous line). The osteotomy is performed with the saw (B) and completed with the chisel doing an osteoclasia (C). Superior (D) and medial (E) views to show the anteroposterior and lateral projection of the osteotomy respectively.

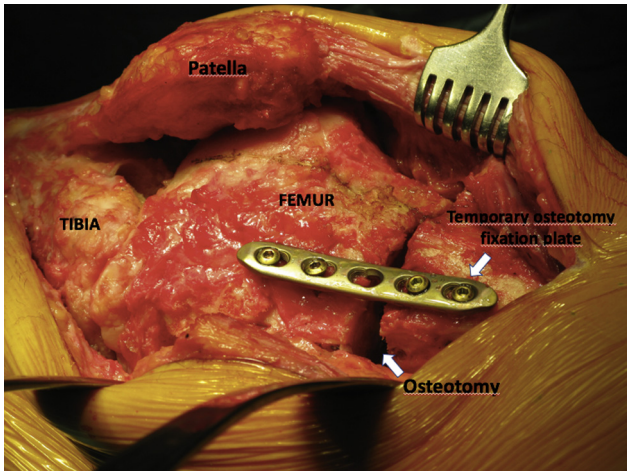


Fig 7. Right knee, medial view. Intraoperative image showing a temporary stabilization of the osteotomy using a plate and screws at the deformity apex level. In this case, an opening and extension osteotomy is shown.

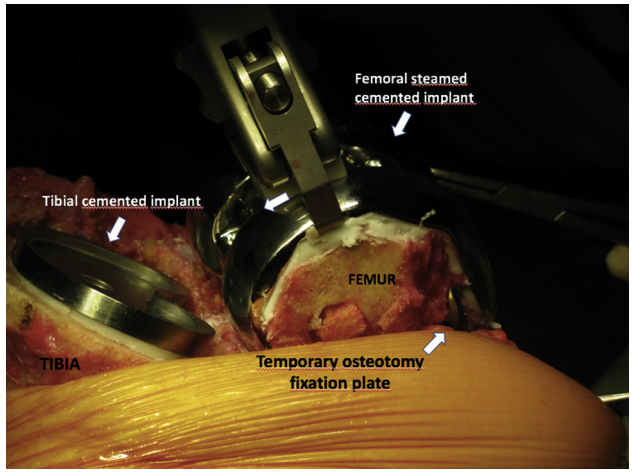


Fig 9. Right knee, medial view. Tibial and femoral implants after definitive implantation. Both components are cemented on the back of the implant, leaving the stems cementless and are press-fitted in the femoral canal in this case.

Other Considerations

Preoperatively, 2 g of cefazolin is administered for antibiotic prophylaxis and maintained for 24 hours, administering 1 g every 8 hours. Vancomycin is used in patients who are allergic to β-lactam antibiotics. At 30 minutes before wound closure, a dose of 500 mg of intravenous tranexamic acid is administered. Careful hemostasis is carried out and washed with saline, and layer-wise closure is performed leaving an articular drain for 48 hours.

Guide to Postsurgical Treatment

From first day postoperatively, cryotherapy is applied and the patient is allowed to perform controlled active mobility exercises. Partial load is allowed using crutches after removal of the drains. From the first

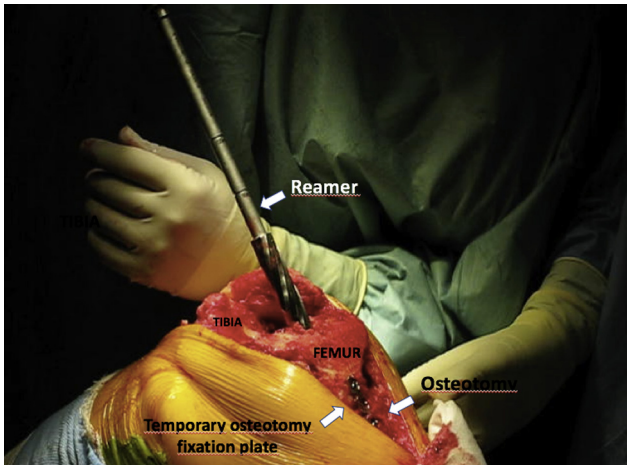


Fig 8. Right knee, medial view. With the knee in the flexed position the femoral medullary canal is reamed to achieve an optimal press-fit of the stemmed implants.

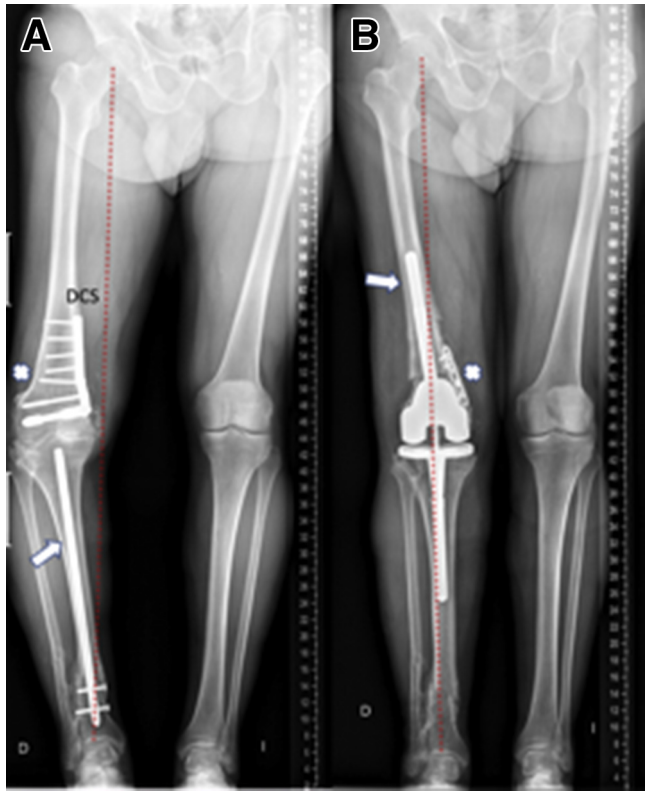
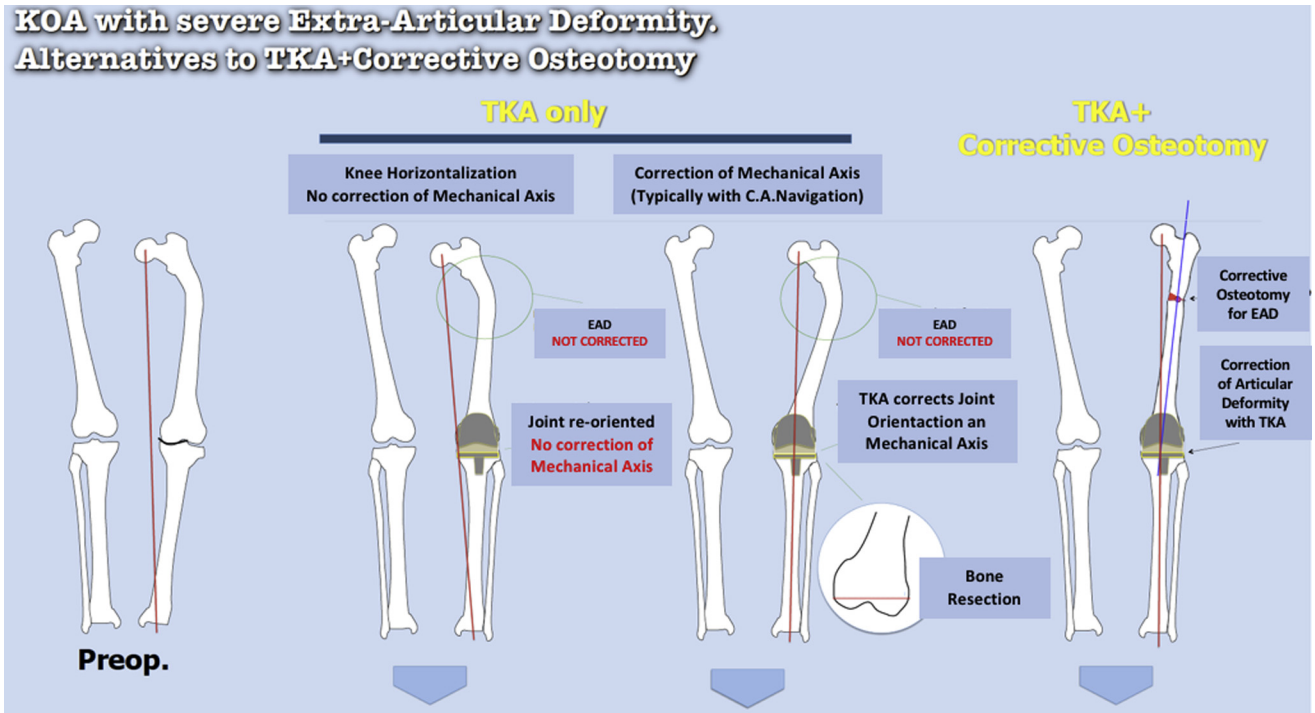


Fig 10. Teleradiography of both lower limbs preoperative (A) and postoperative (B). Right lower limb mechanical axis are identified (red discontinued line). (A) Preoperative right limb with severe knee osteoarthritis with extra-articular deformity (cross), varus deformity (red discontinued line), and previous surgeries hardware: DCS (Dynamic Condilar Screw System) and nail (arrow). (B) Postoperative right limb with knee constrained prosthesis with corrected limb mechanical axis (red discontinued line). Press-fit femoral component stem (arrow) and temporary plate (cross) that was finally definitive in this case.



Main goal	Joint Horizontalization	Mechanical Correction	Mechanical &Anatomical Correction
Mechanical Axis	Uncorrected	Corrected	Corrected
Anatomical Axis	Uncorrected	Uncorrected	Corrected
Joint Orientation	Horizontal	Horizontal	Horizontal
Technical Complexity	+	++	+++
IM Fixation	Difficult	Difficult	Possible
IM Guide	Difficult	Difficult	Possible
Bone Resection	++	+++	+
LB Difficulty	++	+++	+
Improvement in LLD	+	++	+++ (opening wedge)
Authors' Recommendation	No	Optional(close to joint)	Yes

IM: Intramedullary, LB: Ligament Balancing, LLD: Limb Length Discrepancy

Fig 11. Algorithm showing the alternatives in knee osteoarthritis management associated with extra-articular deformities depending on the apex level and grade of deformity.

day, an assisted knee mobility system is used for 30 minutes twice per day until 90° of flexion is reached. On the second day, a guided physical therapy program is started for 5 to 9 days to decrease swelling, increase range of motion, and enhance muscle control and strength with the goal of functional independence. No further rehabilitation is carried out if flexion is beyond 90° at discharge from the hospital and, if necessary, the treatment will be carried out on an outpatient basis.

Discussion

Advanced osteoarthritis of the knee associated with an EAD entails a challenging situation for the orthopaedic surgeon. The search of a favorable mechanical position is critical for adequate implant survival of TKA and hence to achieve good clinical and functional results.[1] For this reason, in this complicated situation, we advocate for the correction of the mechanical limb axes, whether using only the TKA or simultaneously combining the TKA with an osteotomy upon the deformity apex.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Preoperative surgical planning is the key for a successful surgical result.	Preoperative planning errors can lead to postoperative complications.
Analysis of extra-articular deformities must include all the deformities and planes.	
Preoperative selection of the implant is crucial to obtain good results.	

One of the key points in these cases of knee osteoarthritis that is associated with an EAD is the magnitude and distance of the deformity to the joint.[5,13,14] Wolff et al.[13] proposed that the amount of deformity and distance to the joint line determine the extension of bone resection and the optimal balance of the soft tissues to achieve a successful arthroplasty. The larger the deformity[12] and the closer it is to the joint,[13] the greater impact (stress) on the knee joint. The need to associate a corrective osteotomy to the TKA depends, in our opinion, on 2 factors: the magnitude of deformity and the distance of its apex to the joint line. Mild extra-articular deformities (<5°) and some moderate deformities (5-15°) located near the knee joint (<5-10 cm) can be handled by placing a correctly oriented TKA without the need to associate a corrective osteotomy.[13,15] This attitude clearly implies accepting as good results mild misalignment of the anatomical axis in the deformed segment and, sometimes, slight deviations of the mechanical limb axis. It is reduced, however, technical difficulty, since it is an extra-articular osteotomy is avoided.[16] The limits to an isolated TKA would be deviations from the mechanical axis up to 15 mm, deviations from the anatomical axis up to 10°, translation up to 10 mm, and an articular angulation up to 5° from the horizontal plane. As a matter of fact, for this procedure, it is essential that the articular line that runs perpendicular to the mechanical axis of the femur or tibia does not intersect with the osseous insertion of collateral ligaments of the knee. This would imply the need to sacrifice them during surgery, destabilizing the joint, which is unacceptable.[5,12]

Computer navigation is a very useful tool not only for cases of mild EAD but also for cases with periarticular osteosynthesis hardware and stem implants from a hip prosthesis.[14,17-19] There are several advantages of this computer-guided procedure: no additional incisions for the osteotomy, possibility of early rehabilitation, and it avoids complications that arise from the osteotomy such as delayed consolidation, internal fixation failure, and infection at osteotomy level (Fig 11).[5,20,21] Tani et al.[22] had better clinical outcomes in cases in which navigation was used compared with non-navigated TKA associated with EAD in a small size study. However, its long-term survival is nowadays controversial.[17] Furthermore, when the deformity apex is located far from the joint or the collateral ligaments insertions are compromised by the osteotomies, a unique TKA is not enough to achieve a satisfactory mechanical result and therefore for these cases an associated corrective osteotomy is necessary.[5]

When the EAD is moderate or severe (>10-15°),[10,23] the insertion of the collateral ligaments is compromised by the femoral or tibial cuts[5] or, particularly, when the deformity is far from the knee joint[1] (>10 cm), the deformity must be corrected through an extra-articular osteotomy conducted simultaneously to the placement of the TKA. This 1-stage surgery is technically demanding[24] but it is highly advantageous for the long-term survival of the implants.[23] The main advantage is a single surgical session including both mechanical and anatomical limb axis correction. Moreover, there is less need of bone resection, lower risk of complications,[1] easier ligament and soft-tissue balance management, and intramedullary stabilization of the osteotomy.[10] Interestingly, it is feasible to correct limb length discrepancies in the same surgery. In addition, Moyad and Estok[23] stated that avoiding 2 anesthesias reduces risks, decreases the recovery time, and diminishes the total cost of the procedure (Table 1).

Various osteotomies and fixing methods may be used to stabilize the osteotomies.[10] In our technique, we prefer to perform the osteotomy in first place before the arthroplasty, in contrast to other authors, who recommend to correct the deformity after inserting the TKA.[25] We recommend opening-wedge osteotomies for limb lengthening in those patients with dysmetria. When this is not the case, either opening or closing wedge, may be valid. Intramedullary fixation with stemmed components is preferable to other fixing methods such as staples or plates, since they simplify the technique

Table 2. Advantages and Limitations

Advantages	Limitations
A single surgical intervention that address both problems: knee osteoarthritis and the extra-articular deformity.	Technically very demanding surgery.
A single anesthesia event.	Increased risk of complications associated with the osteotomy.
Lower costs and lower risk of complications.	Need for intraoperative fluoroscopic control.
Reduced bone resection (when?)	Stemmed implants cannot be used with a very distal deformity.
Correction of slight length discrepancies of the limbs is possible in the same procedure.	

and allow greater rotational control of the fragments and early weight bearing.[10,23] However, stemmed implants cannot always be used, as in cases of a very distal deformity (Table 2).[26]

In conclusion, knee osteoarthritis associated with EAD is an unusual but challenging situation in which preoperative mechanical and surgical planning are of paramount importance. We present a 1-stage technique for moderate or severe deformities located far away from the joint line. Although further investigation and longer series are needed to prove its advantages over other conventional methods, we encourage other groups to develop this technique and to share their results.

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