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**Original Article**

**Same-Stage Total Knee Arthroplasty and Osteotomy for Osteoarthritis with Extra-Articular Deformity. Part II: Femoral Osteotomy, Prospective Study of 6 Cases**

Yves **Catonné**\* \*\*, Frédéric **Khiami**\*, Elhadi **Sariali**\*, Marc-Antoine **Ettori**\*, Olivier **Delattre**\*\*\*, Bruno **Tillie** \*\*\*\*\*

\*Hôpital Pitié-Salpêtrière, 47 boulevard de l'hôpital 75013 Paris; Université Pierre et Marie Curie (Paris VI); Paris, France

\*\* Clinique Jouvenet 6 square Jouvenet 75016 Paris, France

\*\*\*CHU de Fort de France 92000 Fort de France, Martinique, France

\*\*\*\*\* Clinique Bon Secours, 62000 Arras, France

**Corresponding author:** Yves Catonné, service de chirurgie orthopédique, Hôpital Pitié-Salpêtrière, 47 bd de l'hôpital 75013 Paris, France

[yves.catonne@gmail.com](mailto:yves.catonne@gmail.com)

## **ABSTRACT**

**Background:** Same-stage (1S) total knee arthroplasty (TKA) and femoral osteotomy (FO) may deserve consideration in patients with both knee osteoarthritis and severe extra-articular knee deformity (EKD). The objective of this study was to assess clinical and radiological outcomes and morbidity (complications and revisions) in 6 patients managed with 1S-TKA-FO.

**Hypothesis:** 1S-TKA-FO produces satisfactory outcomes and is not associated with higher morbidity rates compared to two-stage TKA-TO or TKA with intra-articular EKD correction, while also significantly shortening total treatment duration.

**Material and Methods:** A prospective study was performed in 6 patients managed with 1S-TKA-FO between 1999 and 2011; mean age was 64 years (range, 59-72 years) and mean body mass index was 29.5 (range, 26-35). The EKD was consistently greater than 10°. The cause was post-traumatic mal-union in 4 patients, constitutional EKD in 1 patient, and FO in 1 patient. In each patient, the clinical International Knee Society (IKS) score and the hip-knee-ankle angle (HKA), femoral mechanical angle (FMA) and tibial mechanical angle (TMA), were recorded prospectively before and after surgery.

**Results:** A long uncemented extension stem was used in all 6 patients and a posterior-stabilised implant in 5 patients. No hinged implants were used. In 4 patients, internal fixation of the FO was performed. Mean follow-up was 10 years (range, 4-15 years). From baseline to last follow-up, the mean IKS score increased from 46 to 161 and mean flexion from 95° (range, 70°-110°) to 107° (range, 90°-120°). The HKA measured radiographically was between 178° and 182° in all 6 patients. The complications consisted of deep vein thrombosis in 1 patient and knee stiffness requiring manipulation under general anaesthesia in 1 patient. No patient experienced mal-union or required revision surgery.

**Discussion:** Apart from a case-series study of 11 patients, very few data are available on 1S-TKA-FO. In our small population, no major complications were recorded. The encouraging long-term outcomes warrant a recommendation to perform 1S-TKA-FO in patients with knee osteoarthritis and an intra-femoral deformity greater than 10°.

**Level of evidence:** IV, prospective observational cohort study

**Key words:** Knee osteoarthritis. Extra-articular knee deformities. Same-stage total knee arthroplasty and proximal femoral osteotomy.



## **1. Introduction**

Advanced knee osteoarthritis can occur as a complication of an extra-articular knee deformity (EKD) located in the tibia or femur. The EKD may be post-traumatic, constitutional, or related to an osteotomy. When total knee arthroplasty (TKA) is indicated, the EKD must be taken into account to achieve satisfactory ligament balance. Although releasing the concave side of the joint may suffice to correct a small intra-osseous deformity, an osteotomy may be required if the EKD is severe. The osteotomy can be performed either as a separate procedure before the TKA or during the same stage as the TKA. Whereas several studies have addressed combined TKA and tibial osteotomy (1), published data on TKA with femoral osteotomy (FO) are scarce.

In 1990, Wolff et al. reported the first case of same-stage TKA and FO (1S-TKA-FO) (2). The 2000 report of 11 cases by Lonner et al. (3) is the largest study to date, and only anecdotal case-reports have been published since: in 2009, Moyad and Estok (4) detailed the operative technique they used to perform TKA and both tibial and femoral osteotomies, and in 2006 Shao et al. described the use of computed navigation to perform 1S-TKA-FO (5).

The objective of this study was to assess clinical and radiological outcomes and morbidity (complications and revisions) in 6 patients managed with 1S-TKA-FO. The working hypothesis was that 1S-TKA-FO produces satisfactory outcomes and is not associated with higher morbidity rates compared to two-stage TKA-TO or TKA with intra-articular EKD correction, while also significantly shortening total treatment duration.

## **2. Material and Methods**

### **2.1 Material**

Between 1999 and 2014, 32 TKAs with same-stage tibial osteotomy or FO were performed. For this study, the 6 patients (6 knees) with FO and a follow-up longer than 5 years were selected (Table 1). The procedures were performed by a single surgeon, at two different centres. The EKDs were categorised using a variant of the Hungerford classification that covers both varus and valgus deformities (6): Type 1, deformity related solely to wear; Type 2, wear and ligament laxity on the convex side of the joint; Type 3, intra-osseous deformity without laxity (3F if the deformity is femoral and 3T if it is tibial); and Type 4, both intra-osseous deformity and ligament laxity. All 6 patients had 3F EKDs with an intra-osseous angulation greater than  $10^{\circ}$  (femoral mechanical axis  $\geq 100^{\circ}$  if valgus deformity and  $\leq 80^{\circ}$  if varus deformity) and no ligament laxity.

There were 4 females and 2 males with a mean age at surgery of 64 years (range, 59-72) and a mean body mass index of 29.5 (range, 26-35). The EKD was related to femoral fracture mal-union in 4 patients, constitutional in 1 patient, and secondary to femoral varus osteotomy with excessive varus correction in 1 patient. The EKD was in valgus in 2 patients, in varus in 1 patient, and rotational in 1 patient. Another patient had a deformity in all three planes combining  $32^{\circ}$  of varus,  $15^{\circ}$  of recurvatum, and  $20^{\circ}$  of fixed flexion. Finally, in a patient with a history of two TKA procedures, each followed by loosening,  $20^{\circ}$  of varus deformity was caused by diaphyseal mal-union and femoral implant malposition with an FMA of  $102^{\circ}$ , i.e., at a  $12^{\circ}$  angle from the femoral mechanical axis. In the 5 patients with at least a coronal plane deformity, the mean FMA was  $105^{\circ}$  when the deformity was in valgus and  $73^{\circ}$  when it was in varus. The tibial mechanical angle (TMA) was normal, between  $87^{\circ}$  and  $90^{\circ}$ , in all 6 patients.

The presence of previous scars and the type of osteotomy to be performed guided the selection of the surgical approach, which was medial in 3 patients and lateral in 3 patients. The same operative technique was used in all 6 patients, with implantation of the tibial component first, followed by the FO then by implantation of a long-stemmed femoral

component after reaming using a rigid reamer to allow a femoral cut at 6° from the FMA. The stem was 10-20 cm in length and was straight in 4 cases and offset in 2 cases. Fixation of the osteotomy was performed in 4 patients, using a lateral diaphyseal plate (n=2), a medial metaphyseal plate (n=1), or a lateral metaphyseal plate (n=1). In the remaining 2 patients, the implant stem was sufficient to ensure stability.

The type of FO varied with the type of deformity. In the 2 patients with femoral valgus deformity, a medial closing-wedge FO was performed. The patient with metaphyseal femoral varus deformity was managed using a lateral closing-wedge osteotomy followed by screw-plate fixation. In the patient with a complex intra-osseous deformity at the distal third of the femur combining varus, fixed flexion, and recurvatum (Figure 1), the FO was performed in an oblique plane then stabilised by a 20 cm-long stem and a diaphyseal plate. For the patient who had a lateral rotational deformity due to mal-union after intra-medullary nailing of a diaphyseal femoral fracture, a posterior-stabilised long-stemmed implant was chosen and a derotational FO was performed in the metaphyseal area and stabilised using a medial plate (Figure 2). Finally, in the patient with a history of recurrent TKA loosening and femoral diaphyseal mal-union with 20° of angulation, a diaphyseal FO with fixation by a lateral plate was performed, followed by implantation of a stemmed posterior-stabilised prosthesis.

Regarding the constraint choices, posterior-stabilised implants were used in 5 patients. In the remaining patient, a decision was made intra-operatively to implant a CCK prosthesis with a long cam. Cementation to the stem junction was performed in all 6 patients. The extension stem was not cemented in any of the patients. No patient received a hinged implant.

Post-operative care involved early full weight bearing and early joint mobilisation. An extension splint was worn during walking for the first 60 days.

## **2.2 Methods**

All pre-operative and post-operative data were recorded prospectively. The clinical parameters collected for the study included the body mass index, range of motion, and the International Knee Society (IKS) knee and function scores. Each patient was tested for laxity in varus and valgus. Radiographs obtained before and after surgery consisted of antero-posterior and lateral single-leg weight-bearing views, an antero-posterior schuss view, a 30° skyline view, and a long-leg weight-bearing view. In addition, computed tomography (CT) was performed in the 4 patients with rotational deformities and/or post-traumatic mal-union. The following radiological parameters were measured: hip-knee-ankle angle (HKA), classified as normal if between 180° and 184°; femoral mechanical angle (FMA) on the medial side of the intersection between the mechanical axis of the femur and the bicondylar line, to assess the femoral intra-osseous EKD; and TMA, to determine whether a tibial intra-osseous deformity was present.

Intra-operative, immediate post-operative, and delayed post-operative complications were recorded, as well as any revision procedures.

## **3. Results**

Mean follow-up was 10 years, with a range of 5-15 years.

### **3.1 Clinical outcomes (Table 2)**

Improvements after surgery compared to baseline were 46 (range, 9-80) to 161 (range, 138-184) for the mean total IKS score, 21 (range, 9-35) to 77.5 (range, 64-90) for the IKS knee score, and 25 (range, 0-45) to 83 (range, 70-100) for the IKS function score. Mean range

of knee flexion increased from 95° (range, 70°-110°) to 107° (range, 90-120°). No patient exhibited knee laxity after surgery.

### **3.2 Radiological outcomes (Table 2)**

Primary healing of the osteotomy was achieved in all 6 patients. The mean HKA angle before surgery was 155° (range, 148°-162°) in the patients with varus deformity and 205° (range, 200°-211°) in those with valgus deformity; after surgery, the HKA angle was between 178° and 182° in all 6 patients. The mean FMA was 75° in the patients with varus deformity and 105° in those with valgus deformity; after surgery, the FMA was consistently between 89° and 93°. The TMA ranged from 87° to 90° before surgery and from 89° and 91° after surgery. Finally, no radiolucent lines or signs of implant mobility were noted.

### **3.4 Complications**

After surgery, 1 patient experienced deep vein thrombosis. In another patient, stiffness, with knee flexion restricted to 70°, prompted manipulation under general anaesthesia 6 weeks after surgery; at last follow-up, knee flexion in this patient was 110°, i.e., identical to the value measured pre-operatively.

### **3.5 Revision procedures**

Apart from manipulation under general anaesthesia in 1 patient, no revision procedures were required during follow-up. Two female patients died, of causes unrelated to the knee surgery, at 79 years of age and 14 years after surgery and at 87 years of age and 15 years after surgery, respectively.

## **4. Discussion**

## **4.1 Results**

All 6 patients had satisfactory clinical outcomes with marked IKS score improvements (total mean IKS score, 46 at baseline and 161 after surgery). The improvement in the IKS knee score (21 to 77.5) was comparable to that in the IKS function score (25 to 83).

The mean gain in knee flexion after 1S-TKA-FO was 12° (from 95° to 107°). As reported after TKA with TO, flexion was more severely restricted before surgery compared to studies of standard TKA. This fact explains the relatively limited range of post-operative flexion (107°; range, 90°-120°), which was comparable to those reported after TKA in patients with severe deformities (7) or with post-traumatic osteoarthritis (8). The good overall alignment (FMA and TMA) may be related to the use of long-stemmed implants that necessarily induce alignment on the reaming guide then on the stem after the FO. In our small population, no cases of non-union were recorded, even in the 2 patients managed without internal fixation. The clinical and radiological outcomes were satisfactory overall, confirming our working hypothesis.

## **4.2 Comparison with earlier data**

### **4.2.1 1S-TKA-FO**

Few data are available on combined TKA and FO. Hungerford et al. were the first to consider combining TKA and FO, in 1984 (9), and in 1991 they reported the outcome of 1S-TKA-FO in a patient with severe femoral varus angulation due to rickets (2). In 2000, Lonner et al. described their experience with 1S-TKA-FO in 11 patients (3), including 10 with post-traumatic mal-union as the cause of the EKD. Anterior tibial tuberosity elevation was performed in 7 of the 11 patients. Good clinical and radiological outcomes were achieved. Non-union developed in 1 patient, supporting the need for plate or locking nail fixation. In 2

patients, Incavo et al. combined TKA and FO with retrograde nail fixation (10). A good outcome was also obtained in the patient managed by Shao et al. using computer navigation (5).

#### 4.2.2 Other treatment options

The challenges raised by intra-osseous femoral deformities differ from those encountered with tibial deformities, as the flexion and extension gaps are mismatched after the bone cuts are made, requiring an asymmetrical cut in flexion. When TKA is performed alone, an asymmetrical posterior cut can be performed. However, in patients with femoral varus deformity, this option can cause internal rotation of the femoral implant, which may produce excessive medial constraint with a patello-femoral imbalance. This option of TKA alone with ligament balancing is often used when the EKD is moderate (11). Available studies of TKA with intra-articular correction of the EKD did not provide information about post-operative laxity. Two-stage surgery with an osteotomy followed by TKA has been advocated (2). However, the need to delay the TKA until the osteotomy is healed and, in some cases, to remove the fixation material is often poorly accepted by the patients. We believe this option deserves preference in patients with rotational diaphyseal mal-union, which requires an osteotomy at a distance from the knee.

1S-TKA-FO also has a number of drawbacks. As with osteotomy alone, the coronal deformity is corrected in extension but not in flexion. An advantage of 1S-TKA-FO in our opinion is the good femoral alignment along the long femoral stem. On balance, no option is perfect, and the best compromise must be sought.

In very elderly patients with severe osteoporosis suggesting a risk of osteotomy non-union, a constrained rotating-hinge prosthesis can be implanted after performing perpendicular cuts. This option can also be used in patients who have type 4 EKDs with ligament laxity (7).

## **Conclusion**

Combined FO and TKA may deserve consideration in selected patients with post-traumatic mal-union or major constitutional EKDs, in whom ligament balancing is likely to be difficult to achieve using TKA alone. Combined FO and TKA produces good clinical outcomes without increasing morbidity rates compared to TKA alone. A good indication is coronal intra-osseous angulation greater than 10° without ligament laxity.

Nonetheless, the use of combined TKA and FO for only about 0.1% of all TKA procedures performed in our department indicates that this procedure is appropriate in only a small minority of patients. The most widely used treatment in patients with moderate EKDs is TKA alone with ligament balancing. Furthermore, early FO remains the treatment of choice in patients with EKDs due to mal-union.

## **Disclosure of interest**

YC: royalties from Biomet

ESA: royalties from Symbios

FK: no conflicts of interest

MA: no conflicts of interest

OD: no conflicts of interest

BT: consultant for B Braun

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None



**Contributions of each author**

YC: performed the surgical procedures, provided patient follow-up, and drafted the manuscript

ESA: provided patient follow-up

FK: created the tables

MAE: provided patient follow-up

OD: provided patient follow-up

BT: contributed to draft the discussion section

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## FIGURE LEGENDS

### **Figure 1:** 62-year-old male

**a:** Knee osteoarthritis complicating femoral mal-union after a fracture at 20 years of age; knee stiffness and complex deformity with 32° of varus, 15° of recurvatum, and 30° of external rotation

**b:** Antero-posterior and lateral radiographs 12 years after posterior-stabilised total knee arthroplasty with a 20 cm-long stem, screw-plate fixation, and grafting of the removed bone into the osteotomy site: complete healing was achieved within 4 months

### **Figure 2**

**a:** Pre-operative appearance of a diaphyseal femoral mal-union with rotational deformity

**b:** Radiographs after surgery

**Table 1:** Main features in the study population, including the cause of the deformity and previous treatments of the same knee

Patient #	Cause	Sex	Age op.	Side	BMI	Year op.	Previous treatments	Deformity
1	Trauma	F	65	L	35	1999	blade plate	20° valgus
2	Constitutional	F	72	L	32	2000	none	31° valgus
3	Trauma	M	65	L	29	2004	femoral nail	40° internal rotation
4	Trauma	M	62	L	28	2007	conservative treatment	32° varus 15° recurvatum 10° internal rotation
5	Trauma	F	60	L	26	2008	2 TKAs	20° intra-osseous varus
6	Varus FO	F	59	R	27	2011	Varus FO	18° varus

Age op., age at surgery, in years; BMI, body mass index; Year op., year surgery was performed; FO, femoral osteotomy; F, female; M, male; L, left; R, right; TKA, total knee arthroplasty

**Table 2:** Type of total knee implant and pre-operative and post-operative data

Patient #	Type of TKA	HKA pre-op.	HKA post-op.	TMA	FMA pre-op.	FMA post-op.	ROM pre-op.	ROM post-op.	IKS pre-op.	IKS post-op.	Complications	Revision	Last FU	FU, y
1	CCK stem 15	200°	181°	90°	102°	92°	0/0/70°	0/0/90°	9	143	None	no	died 2013	14
2	PS stem 15	211°	182°	89°	109°	91°	0/0/110°	0/0/120°	29	144	None	no	died 2015	15
3	PS stem 20	181°	182°	90°	91°	93°	0/0/110°	0/0/110°	80	180	None	manip. GA	2015	11
4	PS stem 20	148°	178°	87°	68°	88°	0/20/80°	0/0/100°	32	184	None	no	2017	10
5	PS stem 20	181°	182°	89°	100°	92°	0/10/90°	0/0/100°	57	138	DVT	no	2015	7
6	PS stem 15	162°	179°	90°	78°	89°	0/0/110°	0/0/120°	70	176	None	no	2017	4

TKA, total knee arthroplasty; HKA, hip-knee-ankle angle; pre-op., pre-operatively; post-op., post-operatively; TMA, tibial mechanical angle; FMA, femoral mechanical angle; ROM, range of motion; IKS, International Knee Society score; FU, follow-up; CCK, Constrained Condylar Knee; PS, posterior-stabilised; DVT, deep vein thrombosis; manip. GA, manipulation under general anaesthesia









