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Total knee arthroplasty and extra-articular deformity: Deformity correction with intra-articular bone resections. 10 years follow up

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ABSTRACT

Background: This study aimed to evaluate the feasibility and clinical results of one stage total knee arthroplasty for patients with knee osteoarthritis with extra-articular femoral or tibial deformity, treated with intra-articular bone resections and soft tissue balance for deformity correction.

Methods: 28 patients (29 knees) with osteoarthritis of the knee associated with extra-articular deformity >10° underwent one-stage total knee arthroplasty from 1997 to 2017. The deformity was corrected in all the patients by mean off the intra-articular bone resections and soft tissue release during the knee arthroplasty. 14 of them had tibial deformities, 15 had femoral deformities, and the etiology was post traumatic in 14 cases and post osteotomy in 15. The Knee Society Score was used to evaluate the patient outcome.

Results: One-stage total knee arthroplasty with intra-articular correction of the limbs extra-articular deformity and soft tissue releases to balance the knee in flexion and extension was performed in all the patients.

The average follow up was of 10.3 years. The average Knee Society Score was of 24.3 points preoperatively and 86 points at one year after surgery. The range of motion improved from 83.7° preoperatively to 107.1° (86°–125°) postoperatively. The average mechanical axis deviation was restored from 11.8° preoperatively to 0.9° postoperatively, and the postoperative average anatomical axis was 6.3°. Two prosthesis were revised, one due to deep infection and one because knee instability.

Conclusion: The correction of the extra-articular deformity by intra-articular bone resections performed at the time of a total knee arthroplasty is indicated if the resections do not affect the femoral or tibial insertions of the collateral ligaments of the knee, and is the treatment option to avoid performing an osteotomy to correct de limb axis. This method can be applied to angular deformities up to 20° in the femur and up to 30° in the tibia. Through this technique we have achieved good results, after more than 10 years of follow up, in 27 of the 29 patients treated.

This is a retrospective level 2 study.

1. Introduction

The long term results of a total knee arthroplasty (TKA) depends on the correct prosthesis placement, the restitution of the mechanical axis of the limb and the joint stability due to an appropriate balancing of the soft tissue.[1,2]

A deformity is considered as extra-articular when is located proximal to the femoral epicondyles or distal to the fibular neck.[3] In patients with knee osteoarthritis associated with extra-articular deformity, a thorough physical evaluation is mandatory, as well as the consideration of the different surgical techniques available when planning a TKA.[4]

Femoral and tibial deformities can result from fractures malunions, osteotomies, metabolic bone diseases, Paget's disease or congenital malformation, and can occur in the coronal, sagittal, axial planes, or combined.[4]

The discussion is open about the most appropriate surgical technique to correct the limbs axis, and the most accepted options are to perform an osteotomy at the deformity site or by mean of intra-articular bone resections (IBR) during the TKA.[2]

The IBR will result in a secondary translational deformity.[5] However, there is certain consensus about that if the femoral deformity exceeds 20° in the coronal or sagittal plane, or if the tibial deformity exceeds 30°, the correction should not be performed only by means of IBR and soft tissues release, since it may lead to a complex knee instability.[5]

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This study presents the level 2 retrospective analysis of a continuous group of patients operated of TKA with knee osteoarthritis associated to femoral or tibial extra-articular deformity >10°.

2. Methods

Between 1997 and 2017, 1197 TKA were operated at our institution, 29 of them (28 patients) associated to an extra-articular deformity > 10° (2.4%).

The inclusion criteria was a TKA with an angular extra-articular deformity greater than 10° in the middle or distal third of the femur or in the middle or proximal third of the tibia, with a minimum follow up of 3 years.

This series includes 19 women and 9 men, with an average age of 64.3 years (47–86 years). 16 patients were operated of the right knee. The average follow up was of 10.3 years (3–19 years).

The causes of the deformity were: **A-** Malunion in 14 patients (48%): Three of femoral shaft fractures, four of femoral supracondylar fractures, three of the proximal third of the tibia and four of the tibial shaft; **B-** Post-osteotomy in 14 patients: of the distal femur in eight patients (28%), of the proximal tibia in six patients (24%). **C-** One patient with a terminal fibular Hemimelia and a sequel of a tibial lengthening treatment.

We must point out that even if the majority of the valgus osteotomies of the proximal tibia create an extra-articular deformity, only those exceeding 10° have been included in this study.

The Knee Society Score[6,7] was used to perform a clinical and functional evaluation.

3. Results

There were 16 varus knees (average of intra-articular deformity of 9.2°) and 13 valgus knees (average of intra-articular deformity 16.6°). The extra-articular deformity was situated in the middle third of the femur in three patients (10%), in the distal third of the femur in 12 (41%), in the proximal third of the tibia in 10 (35%) and in the middle third of the tibia in 4 (14%).

Regarding the type of extra-articular deformity, all of the patients had a coronal deformity: 13 in varus (average 13.8°), 15 in valgus (average 12.4°) and one patient with a medial displacement of the distal femoral segment of 3 cm. (Fig. 1). In six patients the deformity was also in the sagittal plane, three in flexion and three in extension, with an

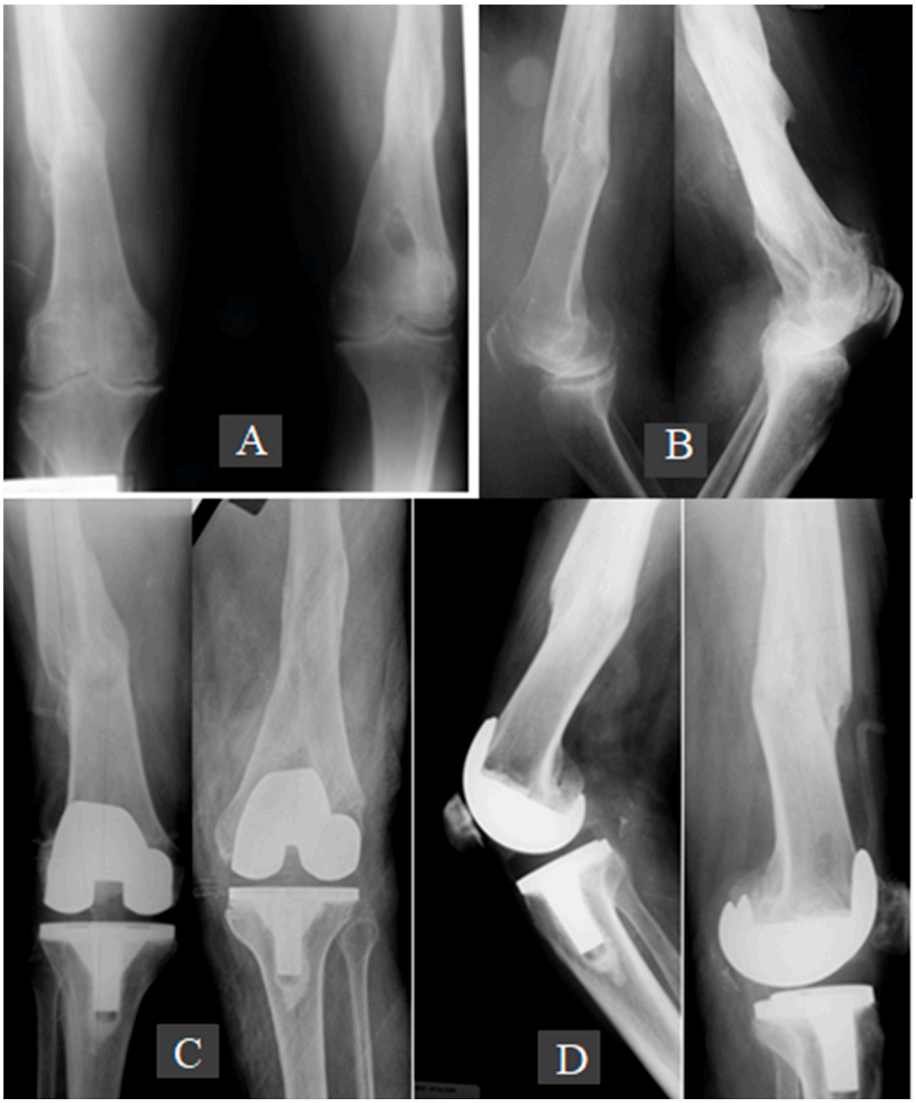

Fig. 1. A & B- A 79 year old man who suffered 27 years ago a bilateral femoral shaft fracture treated non operatively. Right femur with a medial displacement of 3 cm of the distal bone segment and 13° of recurvatum, and left femur with a valgus deformity of 12° and 9° of recurvatum. Note the bilateral obliteration of the femoral canals precluding the use of long intramedullary guides. **C & D-** Bilateral non-simultaneous TKA, the left one 13 months after the right one.

average of 19.7° and 8° respectively. No patients showed a rotational deformity higher than 5°.

The prosthesis used where 21 PFC Sigma™ (Johnson & Johnson™, Warsaw, Ind, USA), 14 with metal tibial trays and seven all poly, 4 Scorpio™ (Stryker™, Kennesaw, Ga, USA) and 4 Insall Burstein™ (Zimmer™, Warsaw, Ind, USA). The average number of previous surgeries was of 1.5 (0–3) and the time between the cause of the deformity and the TKA was 13 years in average (10 months–44 years).

The pre-operative average Knee Society Score was 24.3 points (10–46), and improves to 86 points (69–90) at one year after surgery. The functional score rises from an average of 34 points pre-operative (12–53) to 85.3 points (73–91) one year after surgery.

The post-operative average range of motion was 107.1° (86°–125°) at the last control, with an average improvement of 23.3°. The mechanical axis average deviation was restored from 11.8° preoperatively to 0.9° postoperatively, and the post-operative average anatomical axis was 6.3°.

There were two mayor complications. One patient with femoral osteomyelitis and poor soft tissue due to previous surgeries developed a deep infection and was revised to a cement spacer with antibiotics. Another patient with a 20° valgus deformity and a sequel of a distal femoral varus osteotomy, developed 2 years after surgery, a medial knee instability due to an insufficiency of the medial collateral ligament, requiring the revision to a constrained prosthesis.

4. Discussion

When performing a TKA the objective is to restore the normal anatomy of the limb by correcting the mechanical axis, to conserve as much bone as possible, to preserve the collateral ligaments and the extensor mechanism intact and to place the prosthesis in a correct position (and if is possible, using a non-constrained implant).[8]

TKA proper alignment is considered one of the key factors involved in the long-term results.[9] It is also important to optimize both the mechanical and shear stress of the bearing surfaces and the bone-prosthesis interface. Furthermore, the correct alignment balances the loads transmitted through the soft tissue envelope, wich is an important aspect of the suitable functioning of the knee joint.

The surgeon's aim during TKA is to achieve a optimal alignment of the prosthesis components, restoring the knee joint alignment to be within 3° of mechanical axis.[9] Failing to achieve these principles has been linked with poorer prosthesis survivorship and worsens outcomes.[10]

Most of the extra-articular deformities can be corrected with IBR associated with soft-tissue balance. Correct pre-operative clinical and radiographical evaluation and appropriate surgical planning are mandatory to define the adequate femoral and tibial bone resections and to anticipate and avoid most of the complications related to the arthroplasty. Post-operative TKA instability due to a iatrogenic injury of the collateral ligaments during IBR is one of the most serious ones.[11]

Several additional aspects must also be evaluated including patients age, clinical and surgical previous records, activity level and cause and type of deformity, joint range of motion, stiffness and/or flexion contracture, combined deformities, neuro-vascular status, previous osteosynthesis and the quality of the muscles and other soft tissues. Regarding the surgical approach, in order to prevent skin and soft tissue necrosis, it is advisable to use one of the previous incisions.[12]

It is important to understand the etiology of the deformity and its location in order to evaluate its real incidence in the mechanical axis of the limb.[13,14] The nearer to the joint the deformity is, it will be more difficult to correct the axis through IBR (Fig. 2). In the radiological evaluation it is important that the weight bearing AP radiographs includes the femoral head and the ankle in standing position (Fig. 3). The knee must be in extension and in neutral rotation. These images will allow to evaluate the impact of the deformity in the limb axis, measure the implant size and define the necessary IBR. It is advisable also to have

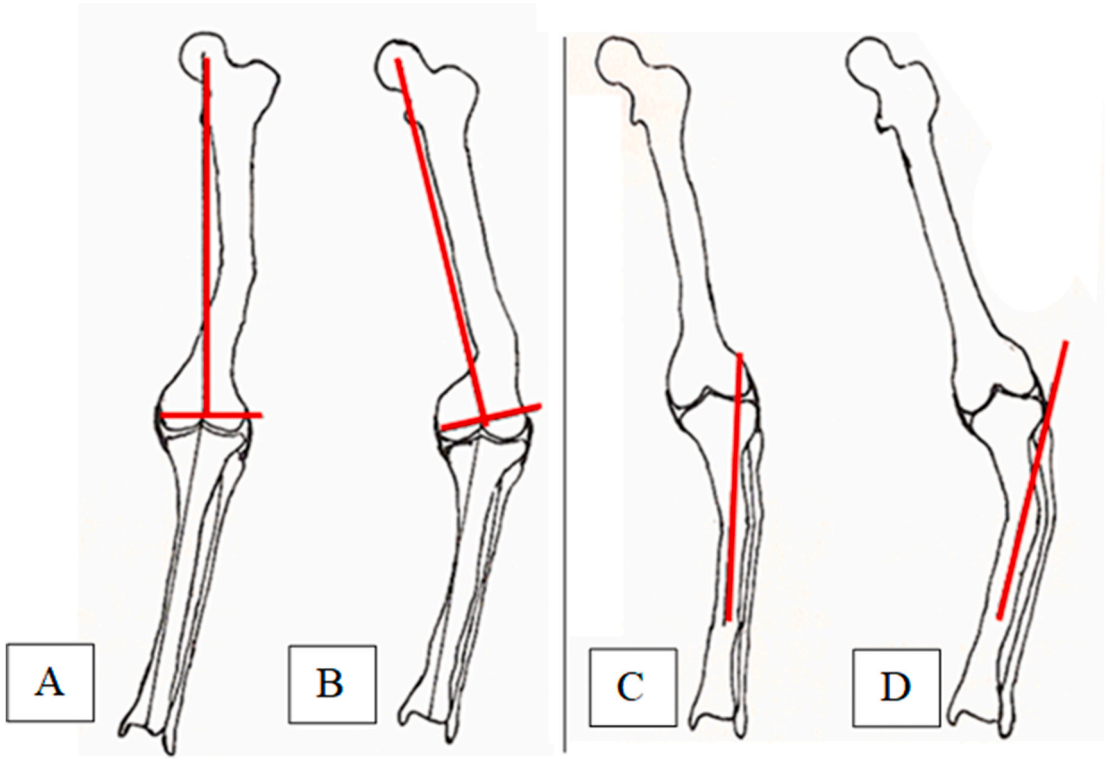

Fig. 2. A & B- For the distal femoral cut planning, a line at 90° to the femoral mechanical axis is used: If the line passes below both epicondyles, the IBR should be enough to correct the deformity. If the epicondyle ligament insertions are compromised, a correcting femoral osteotomy at the apex of the deformity is recomended. **C-** For tibial planning, the tibial axis distal to the deformity is used. If the line passes inside the tibial plateaus, the correction can be made through IBR, without compromising the knee stability. **D-** If it passes outside of the tibial plateaus, a correcting osteotomy is recomended.

Fig. 3. A, B & C- 35 year old man, with terminal fibular Hemimelia of the left lower limb, homolateral knee osteoarthritis, previous femoral nailing and a 20° varus and 28° sagittal antecurvatum tibial deformity, as a sequel of a lengthening treatment. **D & E-** Severe knee osteoarthritis, posterior tibial subluxation and Patella baja. **F & G-** AP and lateral view of the TKA. An osteotomy of the tibial tuberosity was performed.

a conventional AP radiograph centered on the joint line.[14]

The *mechanical axis* of the limb is outlined (from the center of the femoral head to the center of the ankle), and should pass through the center of the knee. In patients with a varus deformity (intra or extra articular) the mechanical axis will pass medial to the center of the knee, and if the deformity is in valgus, it will pass laterally (Fig. 4).

In order to evaluate the extra-articular deformity, the angle formed by the axis of the shaft at both sides of the deformity is measured (Fig. 4). Rotational deformities cannot be properly evaluated with radiographs, so a CT scan is suggested.

In patients with a femoral varus extra-articular deformity, preoperative planning will show that a greater resection of the lateral femoral condyle will be necessary, while in a valgus deformity, there will be a greater medial condyle resection. Besides, tibial varus deformities will need a greater resection of the lateral tibial plateau, and those in valgus, of the medial plateau.[8] These resections, which generate an asymmetrical gap (of extension in femoral deformities and of all the range of motion in tibial deformities) produce a ligament disbalance which must not be underestimated. To avoid joint instability the corresponding release of soft tissues in the concave side of the deformity must be performed (Fig. 4).[8]

The distal femoral bone resection must be planned at 90° of the femoral mechanical axis. The correction of the extra-articular deformity can be made through IBR of the condyles when the femoral distal cut line respects the insertions of the collateral ligaments in both epicondyles (Fig. 2 A & B).[7] Is important to keep in mind that, when performing IBR win an femoral extra-articular deformity case, an asymmetrical extension gap is crated, which must be compensated through the soft tissue release.[8]

The proximal tibial bone resection must be made at 90° to the axis of the tibial shaft distal to the deformity (Fig. 2C & D).[11] A difference is that the tibial bone resection crates an asymmetrical gap in all the range of motion of the knee, which makes these deformities easier to correct through the proper soft tissue release.

Nevertheless, there is a lot of controversy about the severity of the deformity in which the correction must be performed with an extra-articular osteotomy.[6] In patients with multiplanar or complex deformities, this possibility is more evident.

Mann and col.[3] treated, through IBR and soft tissue releases, 11 patients with a femoral deformity with an average varus of 14° in the coronal plane (5°–22°) and 12° in the sagittal plane (0°–23°), achieving good results after 2 years of follow up.

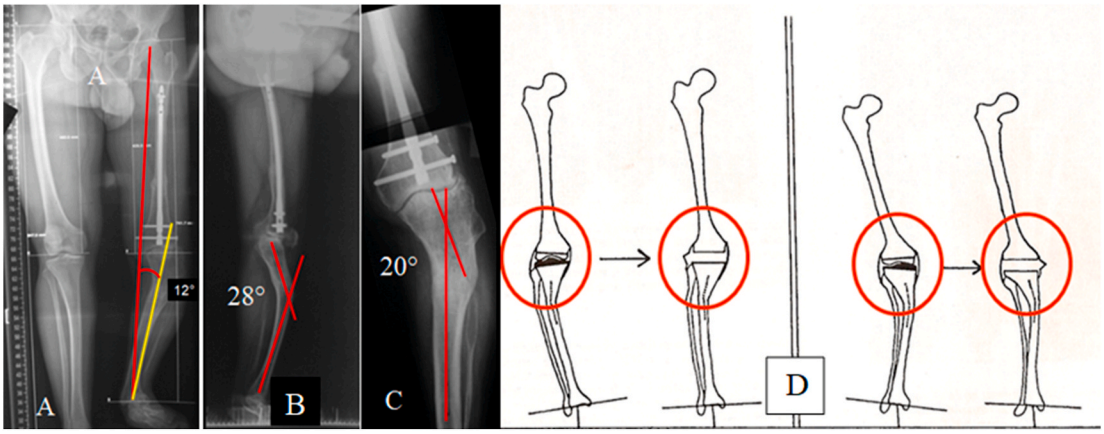

Fig. 4. A- The *mechanical axis* of the limb is outlined. **B & C-** Deformity measurement. **D-** Soft tissue release will be needed to compensate the asymmetric gaps.

Wang and col.[17] reported 7 patients with tibial coronal deformity of 20° average in varus (12°–30°), treated through a large medial soft tissues release and resecting a greater quantity of the lateral tibial plateau. In all cases, posterior stabilized prosthesis were used.

The approach of correcting the axis through IBR and soft tissues release shows certain advantages, as it requires only one surgery, it allows a fast rehabilitation and avoids the possible complications of a complementary osteotomy (nonunion, infection and hardware failure) or of the ligament tightening proposed by Wolff.[18] In our experience, the ligament retightening is not a good option to achieve stability after any TKA and least of all in these difficult cases.

Some authors consider that when the deformity exceeds 10° in the tibial or femoral coronal plane, a complex knee instability must be considered. Even if there is no consensus, most of the publications point out that IBR is the first option in patients with femoral deformities in the coronal and/or sagittal plane of up to 20°, and we agree. Regarding the tibia, deformities up to 30° in the coronal plane can also be treated this way.[3,8] When the deformity exceeds such limits, the IBR can affect the insertions of the collateral ligaments or generate an extension gap too asymmetric and impossible to compensate through soft tissue release. In these cases, an extra-articular osteotomy must be evaluated,[9] and even the need of a constrained or hinged implant.[20]

When performing a TKA in a patient with an extra-articular tibial deformity, the tibial cut should be parallel to the tibio-talar joint. If the tibial deformity is too close to the ankle, it is advisable to correct this before the knee replacement, as if this situation is severe, it can be very badly tolerated.[21] Therefore, the suggestion of Wolff[18] to use, in patients with tibial deformity, the mechanical axis of the tibia as a reference for the cuts is not correct, as this does not correct the obliquity between the articular lines after the TKA.[21]

The weaknesses of this study are its short follow-up period and the small number of patients considered.

5. Conclusion

Performing a TKA in patients with knee osteoarthritis associated to an extra-articular deformity exceeding 10° is an uncommon situation which must be thoroughly evaluated, considering that each patient has its very own characteristics and challenges, therefore needing a particular approach by the surgeon. Careful planning is essential to avoid the multiple possible complications and thus optimizing the outcome of the TKA, even in the short term.

There are two ways to correct the deformity of the limb. In femoral deformities up to 20° and in tibial ones up to 30°, IBR should be performed associated to a proper soft tissue release. Otherwise, an osteotomy to correct the deformity is necessary.

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