

Preoperative Planning in Total Knee Arthroplasty: Osteotomy More Important than Soft Tissue Balancing

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Abstract

When we talk about primary Total Knee Arthroplasty, we must remember that preoperative planning is very important because it is the last surgical option to treat osteoarthritis in the knee, expecting an increase of 673% by the year 2030. In spite of all the factors that can influence the outcome, even before the surgery, the management of medical factors is critical (Knee morphology, joint stability, thrombosis risk, prevention of infections, osteotomies planning, gap balancing), while in the postoperative stage is essential the management of patient factors (Level of patient activity, smoking, weight). Always before performing surgery, we must remember the objectives, which are to eliminate pain and achieve complete and stable mobility with a neutral mechanical axis, that is mean that the mechanical axis passes through the center of the prosthetic implant. To reduce pain and achieve complete and stable active mobility, it depends to take care of each step of the surgical technique, while preoperative planning is essential to achieve a neutral mechanical axis without computer assisted navigation, accelerometer or extramedullary femoral guide.

Keywords: Total Knee Arthroplasty; Full-Length Hip-to-Ankle Weight-Bearing Radiograph; Mechanical Axis; Anatomic Axis; Distal Femoral Osteotomy; Gap Balancing

Introduction

If we talk about the preoperative planning of the primary Knee Total Arthroplasty (TKA), it is important to know where we are and where we want to go. That is, the TKA is the surgical treatment of a very common degenerative pathology, so much that an increase of 673% is expected for the year 2030 [1], therefore, before this procedure, it is important to remember the objectives: To reduce pain, to achieve stable and complete mobility with a Neutral Mechanical Axis (NMA- The Maquet line or MA passes at the center of the prosthetic implant) and to avoid early failure [2].

The TKA is an indicated procedure to treatment severe pain and functional disability secondary to severe osteoarthritis (OA) in the knee, although other relative indications may be instability, stiffness and deformity [3]. In order, to reduce pain and to achieve complete and stable mobility, it is critical to take care of and comply each step of the surgical technique; so to achieve a NMA without a computer assisted navigation, accelerometer or extramedullary femoral rod the preoperative planning is essential [4].

The factors that influence the postoperative outcome are divided into Patient Factors, Implant Factors and Medical-Surgical Factors. The most important factors are: Level of patient activity [5], smoking, weight, vascular insufficiency, postoperative expectations [6], Knee morphology, Joint stability [7,8], Implant tribology, Prosthetic design [9], Thrombosis. risks, Prevention of musculoskeletal infections [10], Distal Femoral Osteotomy (DFO)- Tibial Osteotomy (TO), Gap balancing, Size and position of the prosthetic implants [11].

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Principles of total knee replacement

Knee morphology- Joint stability

When the MA or Maquet line is $180^\circ \pm 3^\circ$ or passes medial 3 - 17 mm to the knee's joint center or the femorotibial angle is $5 - 10^\circ$, MA is considered neutral [12]. But if the MA passes laterally or medially outside the normal ranges, it is called valgus mechanical alignment or varus mechanical alignment, respectively [13]. If the valgus deformity is present, the Krakow classification is: I deformity $< 20^\circ$, II deformity between $20 - 35^\circ$, III deformity $> 35^\circ$, IV with presence of extra-articular deformity (EAD) and V due to dysplasia or torsion [7]; while the varus deformities is present, the Thienpont-Parvizi classification is: Intra-articular (Anteromedial is the most common by intact anterior cruciate ligament), Metaphyseal or Diaphyseal; these separated by a limit line to 5 cm from the joint [8].

If we observe an affected stability by a bone defect, we can use the Ahlbäck classification, where grade III indicates bone defect between 0 - 5 mm, grade IV bone defect between 5 - 10 mm and grade V bone defect > 10 mm [14].

Prosthetic design

To choose the implant design (Design from least to greatest constriction. Category I condylar implant, Category II postero-stabilized implant, Category III varus-valgus constrained implant and Category IV Hinged or linked design [15-18] to be used it is important to consider the morphological classification and joint stability. We have to remember that in case of instability, the cause may be secondary to bone defect and not only to a ligament tear. If we have a patient without joint instability, the reference centers currently suggest that we have to prefer a category II implant [9]. And if the patient presents a bone defect or varo-valgus instability, we can use a category III implant, because we can use metallic augments, stems or an incomplete hinged polyethylene, always to restore joint stability and joint line. So, we can see that a category IV implant can be used for a primary TKA.

Alignment in the TKA

The next step, to know the alignment we are going to use. The classic alignment is used when the TO is performed with 90° to tibial mechanical axis, so when we are going to complete the femoral osteotomies should be considered the 3° of external rotation. In the case, we prefer the anatomical or kinematic alignment, the TO will be performed with 87° to the tibial mechanical axis, and the 3° subtracted in the TO will be added to the femoral valgus planned for the DFO; so if we prefer anatomical or kinematic alignment, we have not to use the 3° of the external rotation to complete the femoral osteotomies [11,19,-21]. This is the example, which it is no accepted a femoral valgus osteotomy with 5° or 7° without preoperative planning.

Femoral joint center- Tibial joint center

In the preoperative planning and during surgery, we have to locate the femoral joint center, because sometimes this point is not the same to the entry site of intramedullary rod suggested by the surgical techniques [13]. On the tibial side, is not critical because we use the extramedullary guide but it's an important landmark.

Joint line

Landmarks to determine the anatomical joint line include the old meniscal scar, one finger width above the fibular head, and one finger width below the inferior pole of the patella. Nevertheless, if the posterior cruciate ligament is preserved, the joint line must be restored to within 3 mm of its original position while we use a category II implant the restoration of the joint line to within 8 mm is necessary to optimize function [22].

Osteotomy- Soft tissue balancing

It is recommended before to made the DFO to present the palpator blade to consider the height of the osteotomy, because a proximal osteotomy to the notch it is not suggested found; height surgically observed with "the eight image"; while for the tibia side we always have to try to obtain a cut as high as possible, because an osteotomy of 1cm below the joint line affect medially the deep part of the medial colla-

teral ligament and semimembranous muscle and the iliotibial band on the lateral part. When planning the DFO and TO we will imagine the configuration of our gap, so which allows us to remember the technique and sequence of soft tissue release [23-26].

When determining the level of the osteotomies, we can identify the configuration of the gap but only in extension, so it is suggested to complete the balance in extension since this will later facilitate the balance in flexion [11,27,28].

For this reason, from the beginning we said that the osteotomy is more important than the soft tissue balancing, not only because it is the previous step to the gap balancing, but also, because if we don't calculate the DFO in the preoperative planning we will be made the "gap balancing" of a knee that it is not going to achieve a NMA. For example, if the preoperative planning of a varus knee suggests a DFO with femoral valgus osteotomy of 8° and hypothetically the osteotomy will be performed with femoral valgus of 3°, the gap will change from a symmetric configuration to a valgus configuration, so that automatically we are going to release laterally, so this change the outcome of our patient. Nevertheless, in case of the preoperative planning of a valgus knee suggests a DFO with femoral valgus osteotomy of 7°, and hypothetically again, the osteotomy will be performed with a femoral valgus of 5° and with a valgus TO (93° in relation to the mechanical tibial axis), the gap is going to change from a valgus configuration to a symmetric configuration, so in this case it would be determined not to perform more release which would result in valgus mechanical alignment.

Finally, it is important to remember that the gap balancing begins with the resection of osteophytes and that the order in the sequence or the release technique may depending on the author [24]. For example, the release sequence for a varus gap is: Osteophytes, hamstring-semimembranous muscles, the deep part of the medial collateral ligament, posteromedial- posterior oblique ligament, posterior cruciate ligament, the superficial portion of medial collateral ligament, and medial- posterior release [23,25]; while in the case of a valgus gap, the sequence is: Osteophytes, iliotibial band or posterolateral corner or lateral-popliteal collateral ligament, posterior cruciate ligament and lateral gastrocnemius muscle [23,25]. Another option of sequential release is with the "pie crusting" technique where we use multiple punctures with needle [19,24].



Figure 1: Maquet line shows a no neutral mechanical axis.



Figure 2: A) Varus knee with extra-articular femoral deformity. B) Valgus knee with extra-articular tibial deformity. The length of the intramedullary rod is represented by the dotted line.

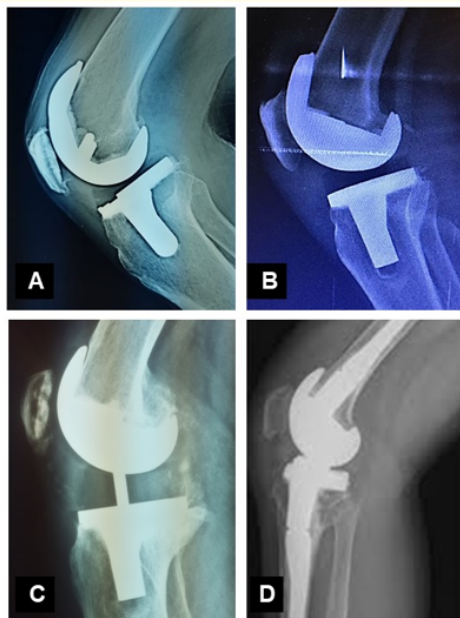


Figure 3: Prosthetic Design. A) Category I, B) Category II, C) Category III, D) Category IV.

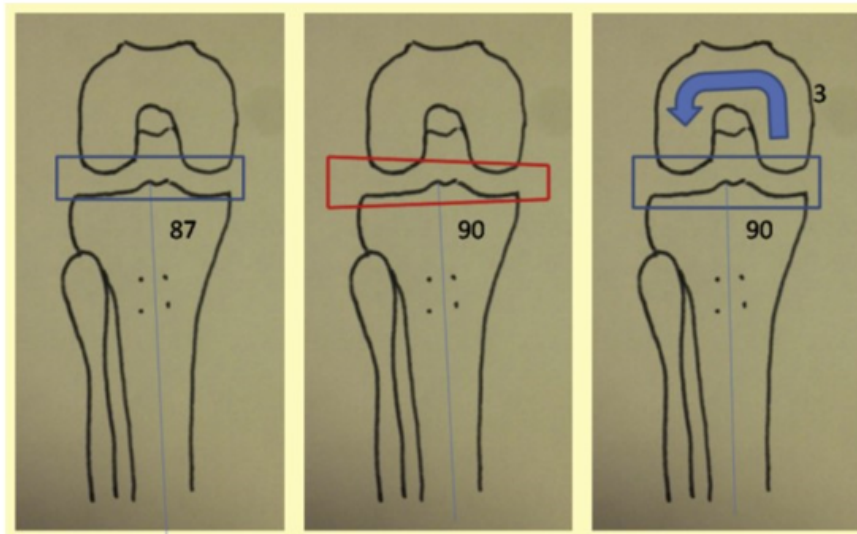


Figure 4: Left; native balanced knee with joint line in slight varus. Middle; proximal tibia is cut perpendicular to mechanical axis leaving wide lateral joint space. Right; flexion gap balanced by externally rotating femoral component 3°. Davidson DJ. Planning and consent for Primary TKR. Orthop Trauma 2013.

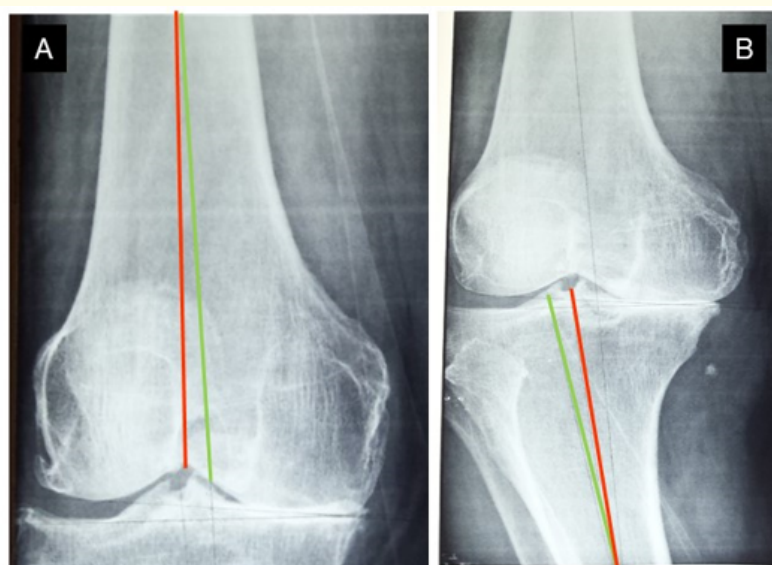


Figure 5: A) Femoral joint center, B) Tibial joint center. The red line represents the point to the entry site of intramedullary rod suggested by the surgical techniques and the green line represents the joint center.

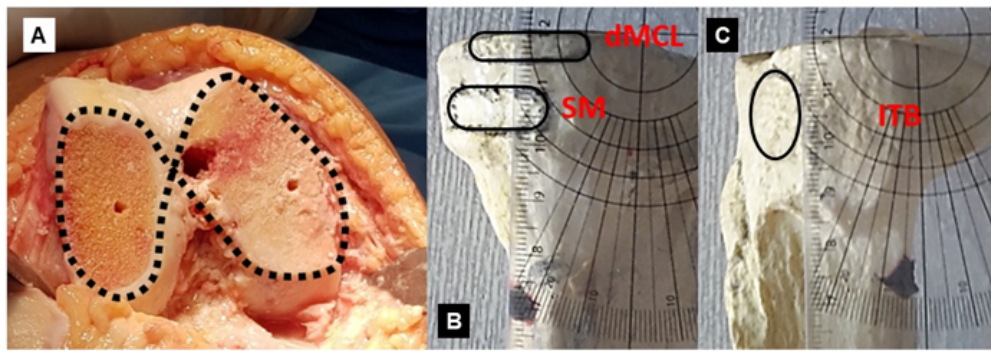


Figure 6: A) Femur: The "Eight" image, B) Tibia: Deep pad of medial collateral ligament and semimembranous muscle on Medially side, C) Tibia: Iliotibial band on lateral pad.

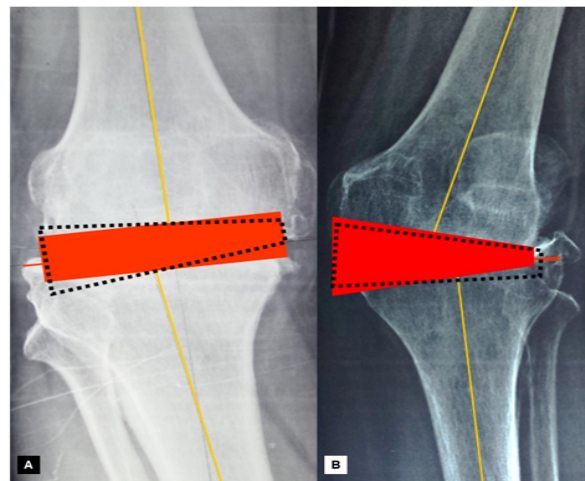


Figure 7: A) Varus knee, B) Valgus knee. The dotted line represents the gap configuration after preoperative planning and the red configuration represents the gap without preoperative planning.

Conclusion

During our daily practice we can see two situations: 1) The TKA is the last surgical option of a common degenerative problem, for someone's considers a health problem, and to the other hand 2) Postoperative criticism with simply seeing a radiographic image, without considering the different preoperative factors, for example, if we see a simple postoperative AP radiograph of the knee with a tibial stem with a medial or lateral inclination (Not central), it can be assumed that a neutral EM was not achieved, without knowing that this case presented a tibial defect in varus or in valgus, so if it were possible to trace the mechanical axis, it would pass to the center of the implant. Therefore, I believe that we should be really demanding with the evaluation of our patient's factors before issuing a criticism of the pro-

cedure performed on another patient. With what is concluded, the preoperative planning should not be underestimated, since the postoperative result can be a success or a complete catastrophe, if the objectives are not achieved. Which should always be remembered before surgery, eliminate pain and achieve full and stable active mobility with neutral EM.

Conflict of Interest

There is not a conflict of interest.

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