Comparison Between Computer Navigation-Assisted Surgery and Conventional Surgery in Total Knee Replacement

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ABSTRACT
Introduction: Total knee replacement (TKR) is the treatment of choice in the final stages of degenerative joint disease, and its survival depends largely on the alignment, positioning, and stability of the joint. This research aims to compare the mechanical axis of the lower limb measured by telemetry, after a computer navigation-assisted TKR vs. conventional techniques, performed by the same surgeon and using the same prosthesis. Secondly, to evaluate the degree of satisfaction of the patients submitted to this procedure and its possible variation between these two techniques. **Materials and Methods:** Retrospective, comparative, observational, descriptive study of 200 patients undergoing TKR, divided into two groups: Group A (100 patients), with Columbus® prostheses placed with the OrthoPilot® navigation system; and Group B (100 patients), with the same prosthesis placed with the conventional technique. Postoperative telemetry was performed on all patients to determine and compare the results in both groups. Secondly, the degree of satisfaction with the procedure and body mass index (BMI)—and its possible relationship with the results—were compared. **Results:** Computer navigation-assisted TKR obtained better outcomes with statistically significant differences both in the postoperative mechanical axis and in the degree of satisfaction with the procedure. **Conclusion:** Computer navigation-assisted primary TKRs were shown in our study to be more accurate in achieving final limb alignment on a 0 ° +/- 3 ° limb mechanical axis.
Key words: Computer-assisted surgery; navigation; knee arthroplasty; kinematics.
Level of Evidence: III

Comparación entre cirugía asistida por navegación y cirugía convencional en el reemplazo total de rodilla

RESUMEN
Introducción: El reemplazo total de rodilla es el tratamiento de elección en los estadios finales de la patología degenerativa articular; su duración depende, en gran medida, de la alineación, el posicionamiento y la estabilidad de la articulación. El objetivo de este estudio fue comparar el eje mecánico del miembro inferior medido por telemetría, después de un reemplazo total de rodilla asistido por navegación o con técnicas convencionales, realizado por el mismo cirujano y con la misma prótesis. Se evaluó también el grado de satisfacción de los pacientes sometidos a este procedimiento y su posible variación entre estas dos técnicas. **Materiales y Métodos:** Estudio retrospectivo, comparativo, observacional, descriptivo de 200 pacientes sometidos a un reemplazo total de rodilla, divididos en dos grupos: grupo A (100 pacientes) con prótesis Columbus® colocada con el sistema de navegación OrthoPilot® y grupo B (100 pacientes), con la misma prótesis colocada con técnica convencional. Se realizaron telemetrías posoperatorias para determinar y comparar el resultado en ambos grupos. También se comparó el grado de satisfacción con el procedimiento y el índice de masa corporal y su posible relación con los resultados. **Resultados:** Se obtuvieron mejores resultados en los reemplazos totales de cadera asistidos por navegación, con diferencias estadísticamente significativas tanto en la obtención del eje mecánico posoperatorio como en el grado de satisfacción con el procedimiento. **Conclusión:** Los reemplazos totales de rodilla primarios guiados por un sistema de navegación fueron más precisos para lograr la alineación final del miembro en un eje mecánico de 0°± 3°.
Palabras clave: Artroplastia; rodilla; navegación; alineación.
Nivel de Evidencia: III

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INTRODUCTION

Total knee replacement (TKR) is the treatment of choice for degenerative knee joint pathologies in their advanced stages that do not respond to conservative treatments. Currently, it is a safe, standardized procedure that achieves good long-term outcomes.

The increase in life expectancy and the consequent aging of the population will increase the number of TKRs in the future and it is expected that, by 2030, there will be a 673% increase in TKRs and 601% in revisions.[1] It is also documented that, in recent years, 35% of patients undergoing TKR are under 65 years of age and 12% of them are under 55 years of age. The survival rate of a TKR in men <55 years is 80% at 10 years and 33% at 16 years, and the expectations of these patients are difficult to meet from a functional point of view.[2] The failure of a TKR is multifactorial, but more than 50% of early revisions are due to instability, misalignment, or poor positioning of the components,[3,4] which, in most cases, is the result of a poor surgical technique.

Computer-assisted systems for TKR provide the surgeon with reliable, real-time information on the major knee and lower limb landmarks to accurately determine the level of bone cuts and the orientation of components.[5-7] Managing the soft tissue and obtaining a stable joint, both in extension and in flexion, are essential for the survival of the prosthesis[8] and this depends on the experience of the surgeon. In this regard, it has been shown that computer navigation can not only monitor the sequential release of the ligaments,[9] but also accurately measure the spaces in extension and flexion[10] and, in this way, improve the positioning of the femoral component, its coronal alignment[11-13] and ligament behavior.

The first computer navigation system without loading previous images was developed by Saragaglia and Picard in 1997,[10] who were pioneers in this technology. Today, more than 20 years later, technological advances in computer-assisted orthopedic surgery, the development of new computer programs and the simplification of instruments have achieved excellent outcomes in osteotomies, unicompartmental prostheses and TKR.[14]

The aim of this study was to compare the mechanical axis of the lower limb measured by telemetry after computer-assisted TKR versus conventional techniques, performed by the same surgeon and with the same prosthesis. The degree of satisfaction of patients undergoing this procedure and its possible variation between these two techniques was also evaluated.

MATERIALS AND METHODS

A retrospective, comparative, observational, descriptive study was carried out on patients diagnosed with tricompartmental knee osteoarthritis that had not responded to previous medical treatment, and who had undergone TKR by a single experienced surgeon competent in both surgical techniques, performed in a high complexity center, between January 2010 and December 2019.

The inclusion criteria were: age >50 years, primary anatomical posterior stabilized knee prosthesis (Columbus®, Aesculap Implant Systems®, B. Braun Co.), with postoperative control telemetry and willingness to answer the postoperative satisfaction questionnaire. The exclusion criteria were: age <50 years, previous TKR revision surgery, not having postoperative telemetry or not agreeing to answer the satisfaction questionnaire.

Of 439 TKRs performed between 2010 and 2019, 200 patients were randomly obtained and divided into two groups: group A (100 patients): total knee arthroplasty (Columbus®, Aesculap Implant Systems®, B. Braun Co.) placed using an OrthoPilot® navigation system (B. Braun Co.) and group B (100 patients): prostheses (Columbus®, Aesculap Implant Systems®, B. Braun Co.) placed using conventional techniques (intramedullary/extramedullary). It should be noted that, in the computer-assisted surgery group, we included patients with whom this new technique began to be used and who were part of the learning curve.

We measured the post-surgical mechanical axis of all the telemetries, which were performed in a high-complexity Imaging Diagnostic Institute and verified by a blind observer who was unaware of the surgical technique and recorded the values in the data table.

Age, body mass index (BMI), and patient satisfaction were also assessed. This last data was obtained from all the patients, by telephone, through the *Knee Society Score: POST OP* (updated 2011), in 2021, so they had between 2 and 11 years of evolution. The results were reflected in the table of values according to the score.

The data were analyzed with the IBM SPSS 24.0® program for the comparison of both groups.

Surgical technique

The patient is placed in the supine position and regional anesthesia is administered. An internal parapatellar approach is always performed from 8 cm above the patella to the anterior tibial tuberosity. The patella is reversed and dislocated externally. Hoffa's fat pad and synovial tissue are partially removed if they have an inflammatory appearance. Both menisci and the cruciate ligaments are resected. The first centimeter of the internal tibial plateau is released according to the technique and, by means of a deep flexion maneuver, the tibia is subluxated anteriorly.

In group A patients, a 2 cm incision was also made on the anteromedial aspect of the tibia, 10 cm from the tibial plateau, for the insertion of the tibial rigid body. The femoral rigid body is placed inside the incision 10 cm from the joint line on the anteromedial aspect of the femur. Data are collected according to the program specification, identifying the required anatomical landmarks, as well as the centers of rotation of the hip, knee, and ankle (kinematic data), obtaining, at this time, the information of the axis of the lower limb, both in extension and in any degree of flexion. Under navigated guidance, a proximal tibial cut is made, perpendicular to the axis of the tibia, with a tibial slope of between 1° and 5°. The performed resection is confirmed. Using a specific guide, the femoral angle and the anterior cortex are determined, which defines the size of the femoral component. Femoral osteophytes are resected and ligament balancing is performed in both extension and flexion, if necessary, using a distractor that is placed first with the knee in extension and then in flexion, and both values are recorded. Intraoperative planning is then carried out on the system, where the size of the femoral component, the number of millimeters to be resected from the distal femur, and the degrees of rotation of the femoral component can be modified to achieve an aligned joint in all planes and with excellent ligament balance. Under navigated guidance and according to the planning, the distal cut of the femur is made and corroborated. Subsequently, a guide with 4 cuts is placed, respecting the established rotation and continuing with successive cuts of the anterior, posterior, and oblique sides of the femoral condyle. The femoral slot is carved and the test prosthesis is placed. Metaphyseal carving is performed to receive the tibial component, taking care of proper rotation. Limb axis and ligament balance are verified throughout the range of motion, and these values are recorded. The definitive prosthesis is cemented with the first-generation technique, it is reduced, and the stability and axes are verified again with the navigation system.

In group B patients, the same approach described was used, the corresponding soft tissues were released and an extramedullary tibial guide (Aesculap®, B. Braun C.) was used, the tibial cut was made with a slope of 3° perpendicular to the axis of the tibia. The distal femoral osteotomy was then performed with an intramedullary guide (Aesculap®, B. Braun Co.) with 3-5° of femoral valgus according to preoperative planning. Anterior, posterior, and oblique femoral cuts were made with 3˚ external rotation. The test prosthesis was placed and ligament balance was verified. The definitive prosthesis was cemented with the same technique as in group A.

Both groups received preoperative antibiotic prophylaxis with cefazolin 2 g 30 min before skin incision, and three postoperative doses of 2 g, every 8 hours; in case of allergy, clindamycin 600 mg was administered, in the same scheme. Tranexamic acid 1 g was also administered 30 min before surgery and, later, the same dose, 2 h after the end of surgery. We did not use a tourniquet.

In both groups, a postoperative drain was left in place that was systematically removed 24 hours after the procedure. All patients received thromboprophylaxis for 30 days.

RESULTS

General characteristics

The final sample consisted of 200 patients who had undergone TKR. They were divided into two groups: group A (100 patients): total knee prosthesis placed with a navigation system and group B (100 patients) with a prosthesis placed using conventional techniques. The mean age was 72.3 ± 7.8 years (range: 51-89). 50% were over 73 years old (median). 17.5% had a BMI greater than 35 kg/m2, that is, with a high degree of obesity (type II or type III). The average surgery time was 70 min and the average hospital stay was 72 h in both groups. Postoperative pain management was multimodal and included intra-articular block, intravenous opioids, and nonsteroidal anti-inflammatory drugs during hospitalization, and gabapentin for 15 days after the operation. Postoperative pain management records were satisfactory.

Regarding the range of motion, although we did not have records on all patients, 70% had a range of motion of 115°.

Correlations according to patient group

The patients in group A were, on average, younger than those treated with the conventional technique, the averages were 74.5 and 69.9 years, respectively, with a statistically significant difference.

14% of group A had a BMI >35 kg/m2 and, in group B, it was higher, but the difference was not significant.

Regarding the axis of the limb obtained by postoperative telemetry, expressed in degrees, it was 1° and 3° in the majority of the group with computer-assisted prosthesis (70%) and 0° in 18%. In group B, these percentages were lower: 1-3° (46%), 0° (3%) and 6° or more (21%), with a statistically significant difference (Figures 1 and 2).

Regarding the varus and valgus deviation of the axis, surgeries with the navigation system yielded a result of 10% in valgus (L) and those with the conventional technique, 19%. The rest of the patients had a postoperative varus axis (R).

No significant difference was found between groups when considering patients with a BMI >35 kg/m2 relative to limb axis obtained postoperatively by telemetry.

Three patients suffered complications that were delayed. Two from group A: the first developed a periprosthetic infection and the second, arthrofibrosis. The third patient belonged to group B and also suffered a periprosthetic infection.

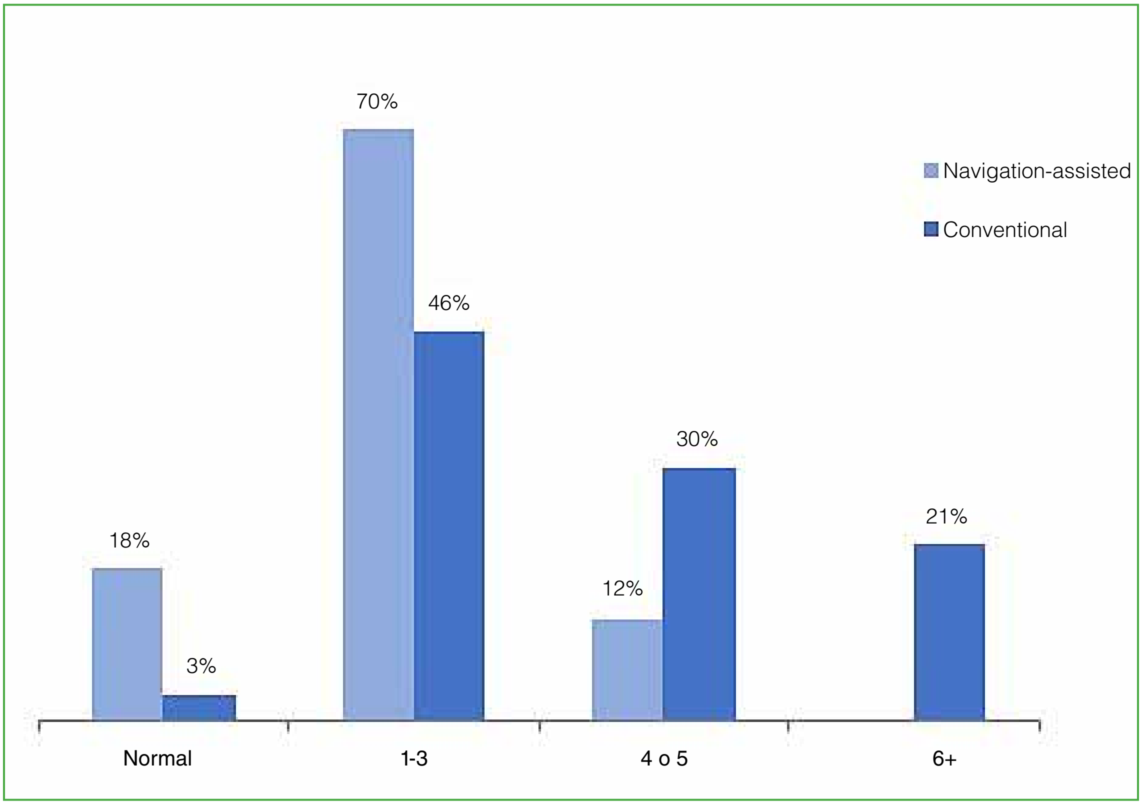

Figure 1. Distribution of postoperative telemetry, expressed in degrees, divided into two groups, according to the placement technique.

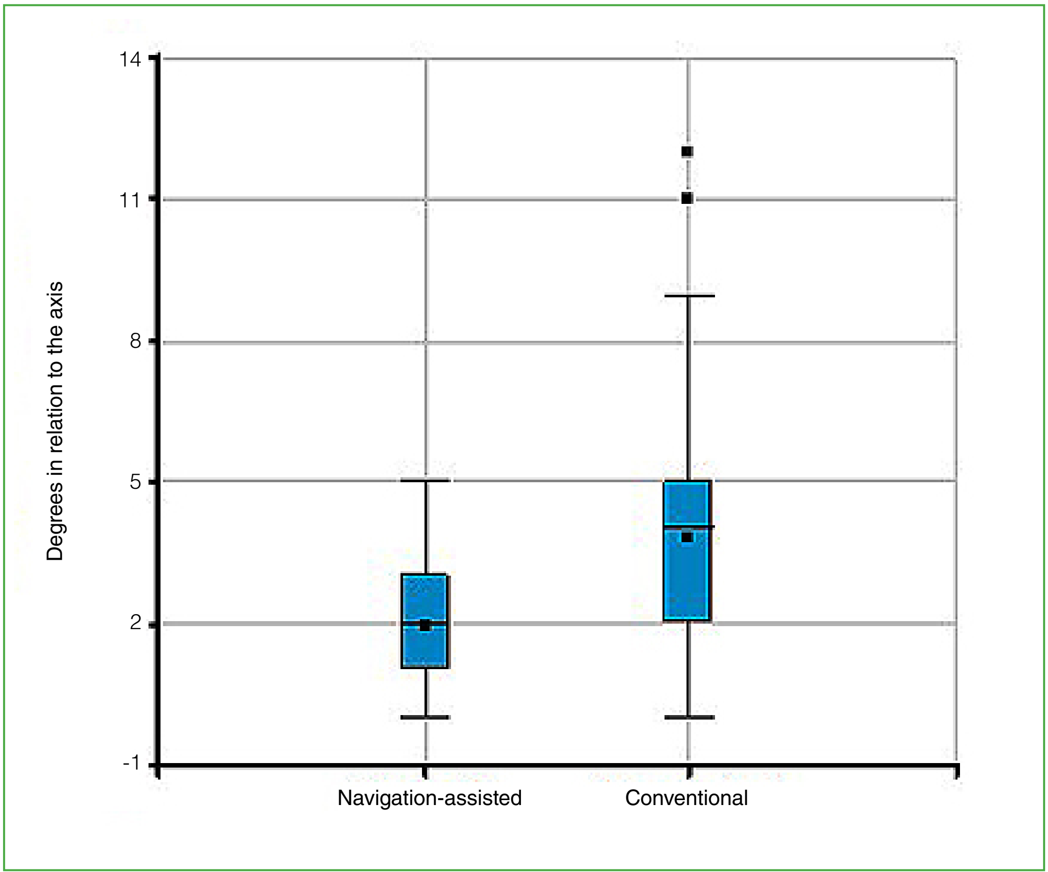

Figure 2. Box plot representing the postoperative final axis measured by telemetry, comparing both study groups. It is expressed in degrees relative to the mechanical axis.

Finally, postoperative patient satisfaction, measured by the *Knee Society Score: POST OP* (updated 2011), in general, was higher in the group of patients with the computer-assisted prosthesis than in the group with the conventional technique (Table). Significant differences were found in the following activities: sitting, lying in bed, getting out of bed, and during leisure time recreational activities.

Statistically significant differences were found in four of the five points that were taken into account.

Table. Degrees of satisfaction of the patient undergoing total knee replacement surgery according to the technique used.

Activity	Degree of satisfaction	Computer-assisted	Conventional	p
Sitting down	Very satisfied/Satisfied	90.7%	77.3%	**0.015**
	Neutral	6.2%	20.5%	
	Dissatisfied/Very dissatisfied	3.1%	2.3%	
Lying in bed	Very satisfied/Satisfied	90.7%	77.3%	**0.022**
	Neutral	9.3%	19.3%	
	Dissatisfied/Very dissatisfied	--	3.4%	
Getting out of bed	Very satisfied/Satisfied	99.0%	79.5%	**0.0001**
	Neutral	1.0%	20.5%	
	Dissatisfied/Very dissatisfied	--	--	
Doing light housework	Very satisfied/Satisfied	88.7%	80.7%	0.130
	Neutral	11.3%	19.3%	
	Dissatisfied/Very dissatisfied	--	--	
Recreational activities	Very satisfied/Satisfied	95.9%	81.8%	**0.006**
	Neutral	3.1%	17.0%	
	Dissatisfied/Very dissatisfied	1.0%	1.1%	

DISCUSSION

In the literature, it is well established that computer-assisted TKR surgery allows for better positioning of the components in both planes[15,16] and better ligament balance throughout the range of motion and, consequently, improves the final alignment of the limb.[17,18] This coincides with the results of our study. However, there is little bibliographic evidence on the role of computer navigation in the management of soft tissue, an important aspect in the outcome of a TKR.[18,19] Achieving adequate soft tissue balance in both extension and flexion improves function and stability of joint replacements. The navigation technique offers the possibility of millimetrically measuring the gaps in each of the compartments both in extension and flexion, as well as verifying ligament tension throughout the range of motion.[20,21] This allows for very precise releases when strictly necessary, and maintains our autonomy in decision-making.[22,23]

In recent years, mechanical alignment has been questioned as a final objective, since obtaining it did not ensure greater patient satisfaction with the result of the procedure. This has given rise to the different kinematic alignments whose main objective is to achieve a joint as similar as possible to the original of each patient, even when it implies leaving joints with axes a few degrees in varus or valgus.[16,23] These alignment methods are very difficult to achieve with conventional techniques and navigation systems, more recently robotic systems, make it possible to achieve results that are very close to preoperative planning.

Our study shows that obtaining a neutral axis ± 3° is significantly more frequent in surgeries with the navigation technique (88%) than in conventional surgeries (50%), it was even possible to perform kinematic alignments adjusted to the original anatomy of each patient.-

Patient satisfaction with the outcome of a TKR is another controversial aspect in the literature.[22,24] Most studies show that only 50-70% of patients are satisfied or very satisfied with the procedure, and the main reasons of discomfort are residual pain, return to activities of daily living and stiffness.[21] In our study, we compared the satisfaction of patients undergoing computer-assisted or conventional surgery, and a statistically significant difference was obtained in favor of the computer-assisted technique, although in our series, the percentage of satisfied/very satisfied patients is greater than 80% in both groups. More precise surgeries, with less soft tissue intervention and adequate ligament balance allow an early return to activities of daily living and better functionality of the limb, which directly influences postoperative patient satisfaction.

Another aspect evaluated in this study is the relationship between BMI and limb alignment and the degree of postoperative satisfaction.[25] Our results are comparable with those of the literature, no significant differences were observed in these two groups of patients.[18]

The weaknesses of our study are its retrospective nature, with a heterogeneous group of patients, over a long period of time, and with a subjective measurement of satisfaction. Regarding its strengths, it stands out that it is a single-center study, of surgeries performed by a single experienced surgeon using the same prosthesis in both groups, and it also lays a foundation to continue with comparative studies of these two techniques in other important and current aspects, such as personalized planning for each patient both in the global axis of the limb and in the orientation of the joint line in relation to the functionality of the operated limb.

In this study, computer-assisted primary TKRs were more accurate in achieving final limb alignment on a 0° ± 3° mechanical axis (Figure 3) compared to conventional TKRs (Figure 4).

Figure 3. A. Preoperative telemetry: 15° varus in the left leg, 18° varus in the right leg. **B.** Postoperative control telemetry: 1° valgus in the right leg, 0° in the left leg, in a patient undergoing computer-assisted total knee replacement surgery.

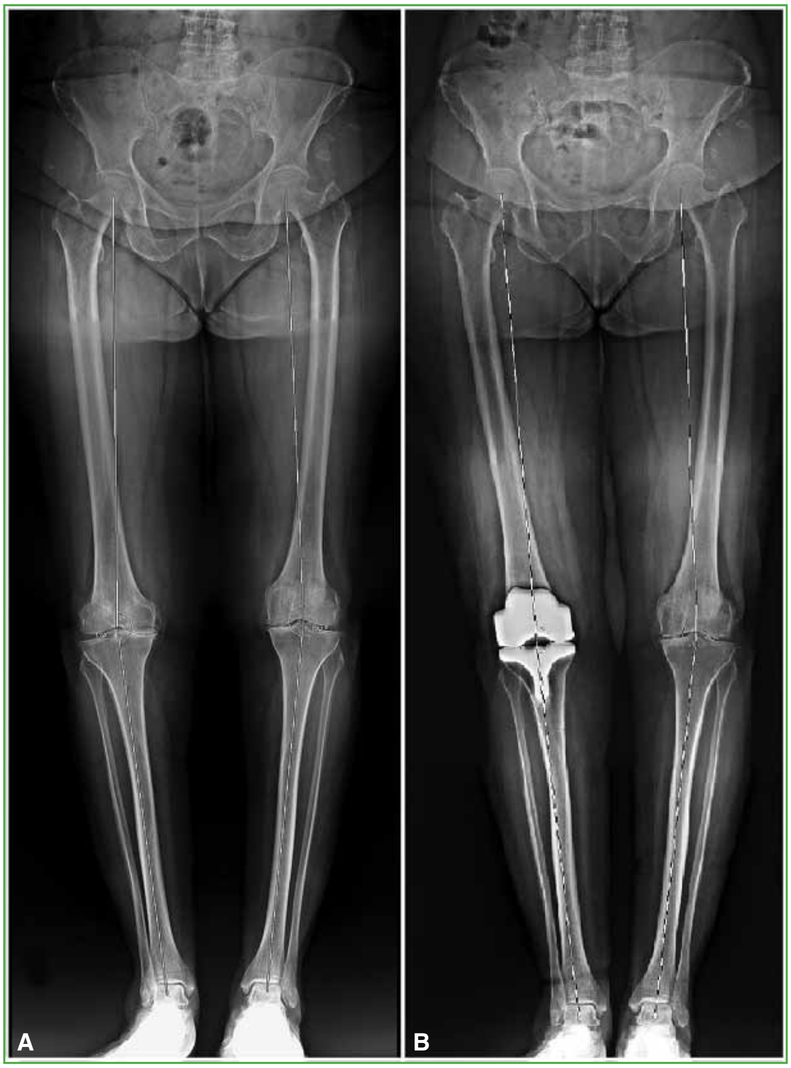

Figure 4. **A.** Preoperative telemetry: 8° varus in the right leg. **B.** Postoperative control telemetry: 3° varus in the right leg, in a patient undergoing conventional total knee replacement surgery.

The fact of having simultaneous intraoperative information allows to achieve better ligament balances throughout the range of motion, better positioning of the components and less release of soft tissues, this translates into less postoperative pain, early recovery of functionality and a prompt return to activities of daily living, and directly influences the degree of patient satisfaction with the procedure.Computer-assisted surgery has stood the test of time and, in the last 20 years, has proven to be a predictable, reproducible and reliable technique in obtaining limb functionality and patient satisfaction, while maintaining the surgeon's autonomy in decision-making.

Conflict of interest: The authors declare no conflicts of interest.

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