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Clinical and radiological assessment of unicompartmental knee prostheses implanted with a minimally invasive technique

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KEYWORDS
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Abstract
Purpose: To assess the radiological position and the short-term clinical outcome of a series of unicompartmental knee prostheses implanted through a small incision.
Materials and methods: Retrospective review of the first 44 arthroplasties of this kind performed in our Department with a minimum 1-year follow-up. The study includes an analysis of the relationship between the result obtained in terms of the American Knee Society score and the patients' age, gender, body mass index, diagnosis, number of previous surgeries and 25 radiological variables recorded on the basis of anteroposterior, lateral and axial views. Any errors in the positioning of each of the components on the different planes were also determined.
Results: The results obtained are significantly poorer the higher the body mass index (r=-0.42; p=0.01) and the higher the degree of posterior inclination of the tibial component (r=-0.34; p=0.02); this difference is statistically significant from 8º (t=-2.15; p=0.04) onwards. The greatest variability in terms of prosthetic placement is found in the degree of rotation of the tibial component on the axial plane and in the flexion-extension of the femoral component on the sagittal plane. Surgical expertise is crucial when it comes to sound prosthetic placement, with significantly fewer errors being committed by surgeons who perform the procedure habitually (t=2,06; p=0,04).
Conclusions: Unidcondylar knee replacement is an attractive yet technically demanding therapeutic alternative for unicompartmental pathology, which is associated to a mandatory learning curve. In addition to appropriate patient selection, correct implant placement is crucial to obtain a satisfactory end result.

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PALABRAS CLAVE
Rodilla;
Prótesis;
Unicompartimental;
Cirugía mínimamente invasiva

Valoración clínica y radiológica de las prótesis unicompartimentales de rodilla implantadas con técnica mínimamente invasiva

Resumen

Objetivos: Valorar la posición radiológica y el resultado clínico a corto plazo de una serie de prótesis unicompartimentales de rodilla implantadas mediante mínima incisión.

Material y método: Revisión retrospectiva de las primeras 44 artroplastias de este tipo realizadas en el servicio de este hospital con un seguimiento mínimo de un año. Se analizó la relación existente entre el resultado obtenido según la escala de la American Knee Society y la edad del sujeto, el sexo, el indice de masa corporal (IMC), el diagnóstico, el número de cirugías previas y 25 variables radiológicas registradas a partir de proyecciones anteroposterior, lateral y axial. Se determinaron, a su vez, los errores en el posicionamiento de cada uno de los componentes en todos los planos.

Resultados: Se encontraron resultados significativamente peores cuanto mayor era el IMC (coeficiente de correlación [r] = -0,42; p = 0,01) y cuanto mayor era el grado de inclinación posterior del componente tibial (r = -0,34; p = 0,02), estadísticamente a partir de los 81 (t = -2,15; p = 0,04). La mayor variabilidad en la colocación protésica se encontró en el grado de rotación del componente tibial en el plano axial y en el grado de flexoextensión del femoral en el plano sagital. La experiencia quirúrgica es determinante en la implantación correcta de la prótesis, y se han demostrado menores errores de forma significativa cuanto mayor número de cirugías se realizara (t = 2,06; p = 0,04).

Conclusiones: La prótesis unicondílea de rodilla es una alternativa terapéutica atractiva para la enfermedad unicompartimental, aunque es técnicamente demandante y necesita una curva de aprendizaje obligada. Además de una buena selección del sujeto, la implantación correcta de los componentes resulta fundamental para un resultado final satisfactorio.

Introduction

Among the treatments available for arthritis and bone necrosis in the knee, unicompartmental knee replacement has long placed a limited role, overshadowed by classical osteotomy and total arthroplasty due to its uncertain initial results and lower survivorship rates[1]. At present, performance of a unicondylar arthroplasty is controversial, with its degree of acceptance varying from country to country, from region to region and even within the same hospital[2].

Although unicondylar prostheses are usually implanted in different types of patients, some of their indications overlap with those for high tibial osteotomy and total knee replacement and, in some cases, they can be regarded as an attractive alternative for subjects with medial knee arthritis[3-8]. Some authors have reported numerous advantages for unicompartmental knee arthroplasty vis-à-vis osteotomy[6,7,9] and total knee replacement[3,5,6,10-12] in certain pathologies.

Recent reports of survivorship rates higher than 90%over periods in excess of 10 years[4,13-16], improvements in implant design and instrumentation[4,11,17,18], and the advent of minimally invasive surgery[12,19,20], have promoted a greater therapeutic interest in unicompartmental replacement[3,5,10,11].

The majority of authors insists on the need of a correct indication to obtain good clinical results[2,4,10,19,21]. However, in many of the series published recently many of the restrictive criteria laid down by Kozin and Scott[9] have been extended, with the percentage of candidates for this type of arthroplasty rising from 10 to 30% of all knee replacements[11,13,14,16]. This has been due, among other things, to the procedure being indicated in younger patients (in an attempt to delay the implantation of a total prosthesis in younger patients)[22,23].

Appropriate implantation is also essential to obtain satisfactory clinical and radiological results, and for final survivorship[22,24-26]. Component malpositioning has been reported in over 20% of cases[17,20,21,26]. The majority of authors claim that this may be due to a more demanding surgical technique and a longer learning curve[5,9,10,18].

The purpose of the present work has been to analyze the short-term clinical and radiological results of unicompartmental knee replacements implanted through a minimal-incision approach as well as to study the radiologic position of implants on the 3 planes (sagittal, coronal and axial) and determine the relationship between clinical and radiological results. Another aim was to find out the relationship between clinical and radiological results and surgical experience.

Materials and methods

A clinical and radiological analysis was carried out of the first 44 unicompartmental knee prostheses (Preservation, DePuy, Leeds, U.K.) implanted by one same surgeon from

Table 1 Description. characteristics. past history and complications in the operated subjects

No.	Sex	Age	BMI	Diagnosis	Side	Components*	Follow-up (months)	History	Complications
01	Female	58	24.7	Meniscectomy	Right	2-2-9.5F	38.00	Meniscectomy	
02	Female	69	25.7	Necrosis	Left	2-1-9.5F	38.00		
03	Female	45	29.3	Meniscectomy	Right	2-2-12.5M	36.00	Meniscectomy	
04	Female	65	28.9	Necrosis	Right	2-2-9.5F	36.00		
05	Female	55	26.6	Kneearthritis	Left	3-2-11.5F	36.00		
06	Female	59	34.4	Kneearthritis	Left	2-2-9.5F	33.00	Arthroscopy	
07	Female	57	25.7	Meniscectomy	Left	3-3-11.5F	—	Meniscectomy	Infection and TKR
08	Female	74	27.8	Necrosis	Left	2-2-9.5F	32.00		
09	Female	60	32.7	Kneearthritis	Right	1-1-9.5F	32.00		Tibial plateau fracture
10	Male	62	31.9	Chondropathy	Right	3-3-11.5F	31.00	Arthroscopy	Hemarthrosis
11	Female	56	29.6	Kneearthritis	Right	2-1-9.5F	30.00		
12	Male	48	39.1	Chondropathy	Left	3-2-11.5F	29.00	3 Arthroscopies	
13	Female	70	31.2	Necrosis	Left	2-2-9.5F	27.00	Arthroscopy	
14	Female	70	29.3	Kneearthritis	Left	2-2-9.5F	26.00		
15	Female	51	32.1	Kneearthritis	Right	1-1-9.5F	26.00		Baker's cyst
16	Female	64	30.1	Kneearthritis	Right	2-2-9.5F	25.00	Arthroscopy	
17	Female	76	24.5	Kneearthritis	Right	2-2-13.5F	25.00		
18	Female	65	34.4	Kneearthritis	Left	3-2-9.5F	25.00		
19	Female	59	28	Necrosis	Left	2-2-9.5F	24.00	Arthroscopy	
20	Female	56	36.2	Kneearthritis	Right	2-2-9.5F	24.00		
21	Female	68	29.9	Kneearthritis	Left	3-2-9.5F	22.00		
22	Female	69	29.7	Kneearthritis	Left	1-2-9.5F	22.00	Arthroscopy	
23	Female	66	28.5	Chondropathy	Left	1-2-9.5F	22.00	Arthroscopy	
24	Male	63	34.6	Kneearthritis	Right	3-3-9.5F	21.00	Osteotomy	
25	Male	46	30.4	Chondropathy	Left	3-3-9.5F	21.00	5 Arthroscopies	
26	Female	57	28.1	Kneearthritis	Right	3-3-9.5F	21.00		
27	Female	81	28.0	Chondropathy	Right	1-1-9.5F	21.00		
28	Female	71	36.8	Kneearthritis	Left	1-1-9.5F	20.00		
29	Female	59	27.9	Kneearthritis	Right	2-2-9.5F	20.00	Arthroscopy	
30	Female	69	29.3	Necrosis	Left	1-1-9.5F	—		Loosening and TKR
31	Female	59	32.5	Kneearthritis	Right	2-2-9.5F	19.00		Tibial plateau fracture
32	Male	62	31.2	Kneearthritis	Left	3-3-9.5F	19.00		
33	Female	58	28.3	Kneearthritis	Right	2-2-9.5F	19.00	Arthroscopy	
34	Female	63	29.1	Kneearthritis	Right	2-2-9.5F	17.00		
35	Female	69	32.8	Kneearthritis	Right	2-2-9.5F	17.00		
36	Female	53	35.3	Kneearthritis	Right	2-2-9.5F	17.00		
37	Female	65	26.6	Necrosis	Right	3-2-9.5F	16.00		
38	Female	63	30.2	Kneearthritis	Right	3-2-9.5F	16.00		Condylar fracture
39	Male	53	26.1	Necrosis	Right	3-3-9.5F	14.00		
40	Female	55	35.6	Kneearthritis	Left	3-2-9.5F	13.00	Arthroscopy	
41	Female	57	37.9	Necrosis	Right	2-2-9.5F	13.00	Arthroscopy	
42	Female	73	29.9	Kneearthritis	Right	2-2-9.5F	13.00		
43	Female	66	27.7	Kneearthritis	Right	3-2-9.5F	13.00		
44	Male	66	24.5	Necrosis	Left	3-2-9.5F	12.00		DVT

F: fixed; BMI: body mass index; M: mobile; N: number of patients; TKR: total knee replacement; DVT: deep vein thrombosis.
*Components (size of femoral, tibial and polyethylene components).

our Department by means of minimally invasive surgery between December 2003 and February 2006 (table 1). Most patients were female (only 7 males) and their mean age was 62.0±7.9 years. The affected side was the right side in 59.1% of cases and the affected compartment was the medial compartment in 97.7%of cases. Mean follow-up was 23.4 months and minimum follow-up was 12 months.

Patient selection criteria were unicompartmental tibiofemoral mechanical pain, range of motion above 90°, flexum contracture below 10°, varus or valgus deformity of less than 15°, tibial epiphyseal deformity of less than 6° and ligament stability on physical examination. N No absolute limitations were established in terms of age or weight. Preoperative diagnosis was primary knee arthritis in

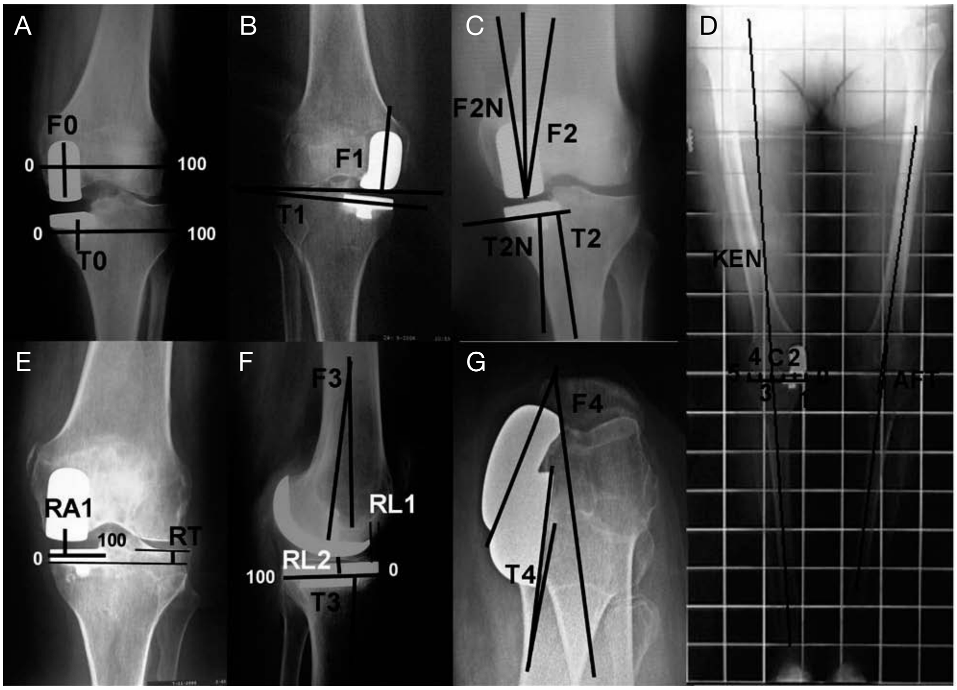

Figure 1 Different x-ray assessments performed. See descriptions in the text (A-G).

26 subjects (6 of them with a history of partial arthroscopic meniscectomy), femoral condyle osteonecrosis in 10 patients, focal chondral lesions refractory to other treatments in 5 subjects and complete previous open meniscectomy in 3 patients. In addition to the meniscectomies described, the previous surgical history of the same knee was: high tibial osteotomy 5 years before (1 patient) and arthroscopy, either for joint lavage or for treatment of chondral lesions (7 patients).

Prior to implantation, in the same surgical procedure 5 diagnostic arthroscopies were carried out in 5 subjects to confirm the appropriateness of the prosthetic indication (during one of these a partial lateral meniscectomy was performed to address an associated tear), removal of a tibial plate used for a precious osteotomy, excision of a symptomatic bipartite patella and fixation of an intraoperative fracture of the medial femoral condyle.

The so-called minimally invasive approach was used, with a 6-7 cm long incision and without the need for patellar eversion during surgery. The integrity of the contralateral and patellofemoral compartments and of the anterior cruciate ligament (ACL) was confirmed intraoperatively. In 2 patients with no clinical history of instability there was a partial ACL tear. The presence of patellar chondropathy (provided that it was asymptomatic) was not a contraindication for the implant. Osteophytes were resected with minimal soft tissue debridement. In order to facilitate the femoral approach with the knee flexed a few millimeters were resected from the medial patellar facet. A set of instruments specifically designed for this type of approach was used, which included an extramedullary tibial guide. The tibial cut is the critical step in this technique since it is the basis on which the cuts determining the femoral component position and the final limb alignment will be made. In our most recent cases, the polyethylene insert was snapped into the tibial tray outside the surgical field since, when we initially followed the classical technique whereby the polyethylene component had to be inserted into an already implanted tibial tray, serious difficulties and complications arose, including 2 tibial plateau fractures. Both components were cemented and a Mobile-bearing implant was used only in the oldest patient in the series.

For every subject, a record was made of body mass index (BMI), length of hospital stay and hematocrit decrease 24 h after surgery. Clinical results were quantified according to the scale of the American Knee Society (AKS). Furthermore, in all cases we measured knee flexion range, clinical varus and valgus axis, the need for external walking aids and patient satisfaction.

Weightbearing anteroposterior x-rays were performed at 1 meter distance and with the beam pointing toward the joint line; axial patellar views were taken at 45° and 90° flexion; and a full lower limb telerradiometry with the first toe and the anterior part of the knees facing forward and the posterior part in contact with the plate[25]. All subjects were required to give their informed consent.

Twenty-five variables were measured in the x-ray views mentioned above in order to determine the position of the femoral and tibial components on all planes (sagittal, coronal and axial) as well as the relationship between them (fig. 1). These variables were quantified at 2 different points in time by the same observer (in order to minimize intra-observer differences) taking as a valid value the arithmetic mean of both measurements if they were not equal. Given the absence of standardized references in the medical literature, optimal values were subjectively established with normalcy limits of ±5° or 5 mm for each case (this is taken to be a broad enough range for a subsequent analysis of malposition).

Angles T1, T2, T2N, T3 and T4 reflect the angular position of the tibial component with respect to the joint line, the tibial diaphyseal axis and the loading axis, as well as its posterior tilt on the lateral view and its rotation on the axial plane, respectively. The T0 variable shows the degree of medialization or lateralization on the anteroposterior plane with respect to the proximal tibial metaphysis. The difference between preoperative posterior tilt of the tibial plateau and the inclination obtained following implantation of the tibial component is quantified in the DT3 value.

Angles F1, F2, F2N, F3 y F4 reflect the angular position of the femoral component with respect to the joint line, the femoral diaphyseal axis and the loading axis, as well as its inclination on the lateral view and its rotation on the axial view, respectively. The F0 variable shows the degree of medialization or lateralization in the anteroposterior plane vis-à-vis the distal femur.

TFA is the tibiofemoral angle following prosthetic implantation and DFT represents the degree of correction achieved following surgery with respect to the preoperative situation. Apart from the tibiofemoral angle, telerradiometry determines the Kennedy value[8], which shows the position of the prosthesis with respect to the loading axis between the femoral head and the tibiotalar joint.

Tibial and femoral resections [TR and FR] were also measured (in millimeters) as well as the relationship between both components on the frontal plane (contact area between femoral and tibial component [RA1] and angular difference between F2N and T2N [RA2]), lateral (displacement in millimeters between components [RL1], contact area between components [RL2] and angular difference between F3 and T3 [RL3]) and axial (angular difference between F4 and T4 [RAX]).

The degree of patellofemoral involvement was evaluated on the axial view. It was rated on a scale from 0 (normal) to 1 (maximum arthritis) on the basis of the presence of degenerative signs in the form of chondropathy, joint impingement, osteophytosis or external malalignment.

All statistical analyses were carried out with the SPSS 13.0 for Windows software. The Spearman's rank correlation coefficient was calculated in order to analyze the correlation between quantitative variables. Student's "t" test was used to compare any sex- or group-related differences on the basis of the radiographic alterations detected. For the assessment of the differences between diagnoses an ANOVA-type analysis (variance analysis) was conducted. To evaluate intra-observer variability in the measurement of radiographic variables, the statistical value of κ was calculated In all cases, a 95% confidence interval was established and statistical significance was established at $p<0.05$.

Results

In terms of intraoperative complications, there was a femoral condyle fracture (in which large fragment screw fixation was required) (fig. 2) and 2 tibial plateau fractures (diagnosed at a follow-up visit and treated conservatively with nonweightbearing and a temporary orthosis) (fig. 3).

Figure 2 Healed femoral condyle fracture, stabilized with a cortical screw.

Mean hematocrit decrease was 4.4±1.9%, with blood transfusion being required in only 2 subjects. Mean length of hospital stay was 3.8±3.3 days.

A case de deep venous thrombosis was confirmed at 5 weeks from surgery, when anti-thrombotic prophylaxis had already been removed, as well as a case of recurrent hemartrosis of unknown origin that resolved spontaneously after a few weeks. A deep infection was diagnosed, which persisted in spite of antibiotic treatment and arthroscopic lavage; the situation was finally resolved by one-stage conversion to a total replacement 12 months after the primary surgery (fig. 4).

A prosthetic revision was necessary in a female patient at 14 months from primary surgery because of a loose tibial component; this loosening was attributed to an uneven contact between the femoral component and the middle third of the tibia. The case was revised with a posterior cruciate ligament (PCL) retaining component with a standard 12.5 mm polyethylene insert, with no bone grafts or prosthetic augments being used. In one patient a a symptomatic Baker's cyst was diagnosed, which had not been apparent before surgery. The cyst was resolved by means of puncture-evacuation-infiltration under sonographic control.

Patient satisfaction levels were good, with clinical improvement over the previous situation in 35 cases (79.5%). Only 3 patients claimed to be dissatisfied (6.8%). Mean knee flexion achieved was123°±7.2°, with an extension lag of 1.3°±0.8°. Mean postoperative clinical valgus was 3.3°±4.8°

Figure 3 Undisplaced tibial plateau fracture, treated conservatively with orthosis and nonweightbearing.

A total of 7 patients used one walking stick to ambulate; only 1 patients required 2 walking-sticks.

Application of the AKS scale showed an improvement from a mean preoperative score of 41/39 points (clinical scale and functional scale) to 81/70 at the end of follow-up. This improvement was more noticeable in females (83/71) than in males (71/62), although there were no significant differences (t=1.30; p=0.20). Nor was there any significant correlation found between the clinical/functional result and age, the different diagnosis or surgical history, although the best scores were obtained in the groups subjected to a prior open meniscectomy (88/80) and a primary arthroplasty with no prior surgery (86/71). A statistically significant relation was found between the clinical/functional result obtained and BMI: the higher the index, the lower the score (correlation coefficient [r]=–0.42; p=0.01).

Table 2 shows the analysis of the 25 radiographic variables studied. The value of κ for intra-observer variability in the measurement of these variables was 0.81. Mean variability for the postoperative tibiofemoral axis was 6.0°±3.3°, and went from 177.6°±3.9° to 183.6°±2.4°. The prosthesis implanted in the lateral compartment went from 8° valgus to a neutral position (0°). The degree of bone resection was considered adequate in 33 cases in the femur and in 35 cases in the tibia.

As regards tibial component positioning, the variable showing the highest variability was T4 (rotation on the axial view) with 10 cases (34%) outside the pre-established limits. On average, 6.12±0.9 malpositioned implants (14.24%) were detected for each tibial parameter studied. Only 17 tibial components (39.5%) had been correctly positioned on all planes. The T3 variable (degree of posterior tilt of the tibial component) is the only one showing a statistically significant correlation with the clinical and functional result obtained (r=–0.34; p=0.02), so that the steeper the component the poorer the mean score obtained; this finding is significant from 8° inclination onwards (t=–2.15; p=0.04).

In the femoral component, the angle with the highest variability was F3 (inclination on the lateral plane) with a total of 13 cases (29%) outside normal limits. A mean of 6.57±1.0 malpositioned implants (15.28%) were detected for each parameter studied. Only 15 prostheses (34.88%) fulfilled all the requirements established for radiological normalcy. No statistical significance was found for any of the femoral variables in terms to clinical or functional values.

When the position of both components in relation to each other was analyzed, the variably with the highest variability of results was RA2 (angular difference between F2N and T2N) with a total of 10 cases (22%) outside the range considered normal. 7.0±1,2 malpositioned prostheses (16.28%) were detected for each variable analyzed. 41.86% of implants (18 cases) were characterized by a correct relationship of both components on all planes. None of these variables proved statistically significant vis-à-vis the American Knee Society scale.

Assessment of the patellofemoral joint revealed 4 cases of joint space narrowing or lateral hyperpressure, one of them with lateral subluxation and the others with osteophytosis. These patients reached scores of 78/73 points, not significantly different from those of other patients in the group without a patellar condition.

There was a significant decrease in radiological malpositioning, which was attributed to increased surgical experience: in the first 22 prostheses there was a mean of 4.32±2,4 alterations per subject, whereas in the last 22 prostheses the mean value was of only 3.00±1,7 alterations per subject (t=2.06; p=0.04) (fig. 5).

Discussion

The authors of this paper believe that unicompartmental knee replacement is a good therapeutic alternative for certain conditions since the results obtained have, in general, been satisfactory, in line with those of other series[2,4,8,13,14,22,23]. In addition, patient satisfaction levels have also been consistently high.

Strict patient selection is an indispensable requirement for a satisfactory final outcome[2,4,10,19]. Widely accepted criteria exist for indicating this type of prosthesis: flexum deformity of less than 15°, minimum range of motion of 90°, corrigible varus or valgus deformity of less than 15°, integrity of contralateral compartment, adequate ligament stability and unicompartmental grade I to III knee arthritis on Ahlbäck's scale[8,17,22]. Although deformity or curvature of the proximal tibial metaphysis in excess of 5° is not often included as a selection criterion, the authors of this study

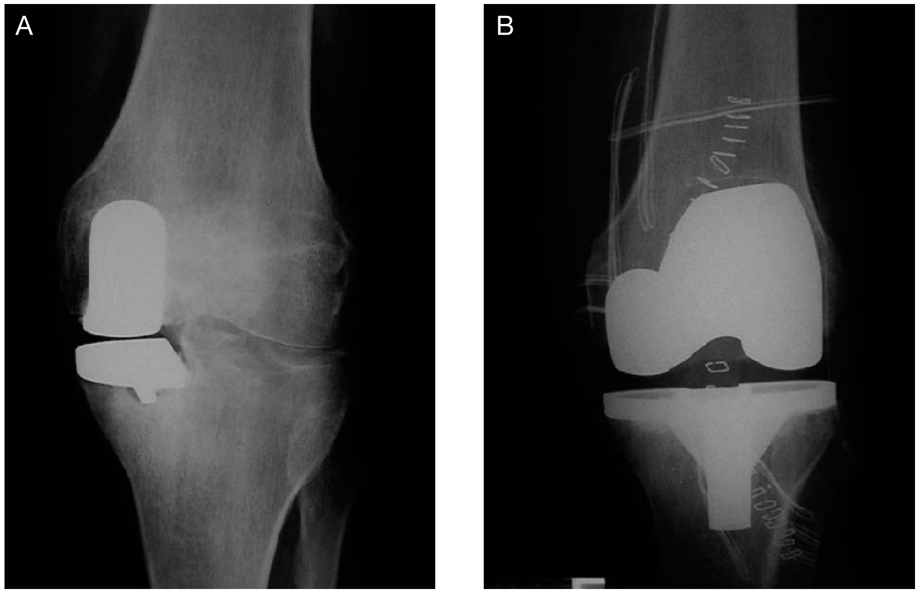

Figure 4 A) Septic loosening of tibial component. B) Subsequent revision to a posterior cruciate ligament preserving total prosthesis.

agree with Swienckowski and Pennington[22] that such deformity or curvature would make a corrective osteotomy the treatment of choice. Unicompartmental replacement is also considered a correct indication for osteonecrosis, although care must be taken in large affected areas[9,10]. The results of procedures performed in our hospital for that indication have been satisfactory.

No significant differences were found between patients of different ages or genders. This leads the authors of this study to consider that there should not be absolute contraindications in this regard: possibly subjects older than 75 and those under 65 may be at an advantage; the former because of their lower surgical intensity rate and the latter because they may require a subsequent revision[23]. In the latter age group, good clinical results have been found beyond 10 years' follow-up[16,22], although Collier et al[28] find a higher revision rate in younger patients. We further recommend prudence when indicating a unicompartmental replacement in subjects under 45 years of age. In our series, the fact that males obtained poorer results may be a result of their greater physical activity or of the paucity of the sample The potential role of gender is also controversial in the medical literature[23,28].

As regards anteroposterior stability, clinical instability has been considered more important for indicating the procedure than the presence or absence of the ACL. Clinical stability depends, among other factors, on the subject's activity. Most authors require an intact ligament to indicate a unicompartmental implantation[2,13,16,26,28], but others simply require that the ligament must be functional[10,23] or, as we have done, establish instability itself as an exclusion criterion[7,20,22]. In the 2 patients in this series with a partial ACL tear short-term results show no differences with the other patients in the group.

Overweight could also be a factor influencing the prognosis of an arthroplasty, although many authors do not consider it a contraindication[13,15,16]. In the present series, clinically poorer clinical results were found in subjects with a higher BMI, for which reason the authors recommend caution with obese patients. Similarly, Pennington et al[16] report poorer results for overweight patients, whereas Collier et al[28] found no weight-related differences in the rate of prosthetic revisions. Initially, Kozin and Scott[9] limited the use of unicompartmental replacement to patients under 90 kg of weight. Some authors have recently contraindicated the procedure in patients weighing over 124.5 kg[14] or 300 lb[26], or with a BMI higher than 45[22].

Nor is the condition of the patellofemoral joint a criterion to contraindicate unicondylar arthroplasty unless the subject presents with symptoms[9,15,21]. The majority of authors would even accept the existence of degenerative changes in this area[4,12,14,16,28]. Furthermore, the few published series have reported a small number of revision procedures caused by pain or progression of patellar arthritis[13,27]. The present series did not find any differences in the results that could be related to radiological alterations in the patellofemoral compartment.

Minimal-incision surgery is currently the preferred option[12,19,20] since it is associated with unquestionable advantages. Its lower aggressiveness is however accompanies by greater technical difficulties: less visibility and more difficulties for correct component positioning[19,26]. Saldanha et al[27] has described prosthetic revisions motivated by medial instability caused by excessive release of the medial collateral ligament. This complication could be more likely following minimally invasive surgery.

Tibial plateau fractures caused by this type of arthroplasty are not unusual in the literature[2,14,21] and are by some authors related to component malpositioning[24]. The authors of this study attribute this complication to the trauma inflicted on the tibial plateau when the tibial component is impacted. For that reason, we decided not to use a mallet for impaction and, instead, place the polyethylene component into the tibial tray outside the surgical field. As

Table 2 Statistical description of the 25 radiological variables considered, analysis of the degree of error for each variable as a function of parameters pre-established as normal and correlation between those variables and the clinical/functional result achieved on the American Knee Society scale (as calculated using Spearman's rank correlation coefficient)

	n	Mean	Standard error (mean)	95%IC	Standard deviation	Ref. value	Normalcy limits	Outliers (%) with AKS. Spearman test	Correlation	p
TFA	44	183.34º	0.36	182.6-184.1	2.43	5º	0-10	0(0)	r = 0.02	0.92
DFT	41	6.09º	0.51	5.1-7-1	3.30	—	0-10	3(7)	r = 0.01	0.99
T0[a]	44	21.56	0.53	20.5-22.6	3.53	20	15-25	6(13)	r = –0.12	0.47
T1[a]	44	0.09º	0.37	–0.6-–0.8	2.47	0º	–5-5	2/4)	r = 0.07	0.66
T2[a]	44	86.56º	0.45	85.7-87.5	2.99	90º	85-95	7(16)	r = 0.03	0.81
T2N[a]	44	89.27º	0.43	88.4-90.1	2.87	90º	85-95	37)	r = 0.01	0.52
T3[a]	44	6.81º	0.49	5.8-7.8	3.26	5º	0-10	6(13)	r = –0.34	0.02
DT3[b]	34	2.14º	0.56	1.0-3.3	3.26	0º	–5-5	6(18)	r = –0.34	0.05
T4[a]	29	2.72º	0.96	0.8-4.7	5.17	0º	–5-5	10(34)	r = 0.02	0.89
F0[c]	44	19.34	0.35	18.6-20.1	2.38	20	15-25	6(13)	r = –.0.05	0.72
F1[c]	44	91.91º	0.50	90.9-92.9	3.36	90º	85-95	6(13)	r = –.0.12	0.45
F2[c]	44	7.95º	0.48	6.9-8.9	3.22	5-7º	0-12	4(9)	r = –.0.01	0.95
F2N[c]	44	0.93°	0.46	–0.0-1.9	3.11	0º	–5-5	4(9)	r = 0.06	0.71
F3[c]	44	–3.29°	0.77	–4.9-–1.7	5.13	0º	–5-5	13(29)	r = –0.19	0.20
F4[c]	32	6.15°	0.81	4.5-7.8	4.62	5-10º	0-15	2(6)	r = 0.02	0.89
FR	43	2.86 mm	0.01	0.2-0.3	0.09	5 mm	0-10	0(0)	r = –0.11	0.52
TR	44	7.79 mm	0.04	0.7-0.9	0.27	5 mm	0-10	8(18)	r = –0.10	0.95
RA1[d]	44	40.22	0.99	38.2-42.2	6.57	50	33-66	6(13)	r = 0.17	0.28
RA2[e]	44	1.68°	0.51	0.6-2.7	3.42	0º	–5-5	10(22)	r = –0.09	0.56
RAX[f]	29	3.82°	1.05	1.7-5.9	5.66	5-10º	0-15	5(17)	r = 0.07	0.69
RL1[g]	35	1.3 mm	0.06	0.0-0.3	0.39	0 mm	–5-5	4(11)	r = 0.10	0.57
RL2[h]	44	46.06	1.21	43.6-48.5	8.09	50	33-66	3(7)	r = –0.15	0.34
RL3[i]	44	–0.13°	0.77	–1.7-1.4	5.12	0º	0-5	9(20)	r = –0.26	0.09
PF	44	0.1	0.01	0.1-0.1	0.08	0	—	—	r = –0.12	0.45
K	37	1.6	0.09	1.4-1.8	0.59	2	1-2.5 (C)	0(0)	r = –0.06	0.74

TFA: tibiofemoral angle; AKS: American Knee Society; (C): C = 2, 5; DFT: degree of tibiofemoral correction; PF: patellofemoral; CI: confidence interval; n: number of evaluations per variable; r: correlation coefficient; FR: femoral resection; TR: tibial resection.

[a] Angles reflecting the angular position of the tibial component.

[b] Difference between preoperative posterior tilt of the tibial plateau and the inclination obtained following tibial component implantation.

[c] Angles reflecting the angular position of the femoral component.

[d] Contact area between femoral and tibial component.

[e] Angle difference between F2N and T2N.

[f] Angle difference between F4 and T4.

[g] Displacement (in millimeters) between femoral and tibial component.

[h] Contact area of femoral and tibial component

[i] Angle difference between F3 and T3.

a result of this change in surgical technique, no more fractures occurred.

An important factor to predict the success of unicompartmental knee replacement is the accuracy with which each of the components is implanted[22,24], although there is no agreement as to their ideal position[17]; there are in fact few useful standardized references to this issue in the literature. Insall and Aglietti[1] reported a mere 9% of malpositioned implants, although their normalcy range was fairly broad. On the other hand, Jenny and Boeri[17] reported 80 to 94% de malpositioned unicompartmental prostheses, but with a narrow normalcy range and without showing that their dismal results led to any significant alterations in survivorship at 5 years. In our series, we also found a significant percentage of implant malpositioning (always in accordance with pre-established reference values), which underscores the difficulty and wide variability inherent in the technique. The influence of minimally invasive surgery as an aggravating factor of component malpositioning is unclear[12,20,26], although lower visibility would seem to warrant the use of a surgical navigation system[20].

A mean tibiofemoral angle from 4° to 8° has been reported in the different series published[8,14,16,19,21]. Some authors insist on the need for overcorrection in order to prevent the progression of arthritis in the contralateral compartment[14], and have been able to align the limb in a

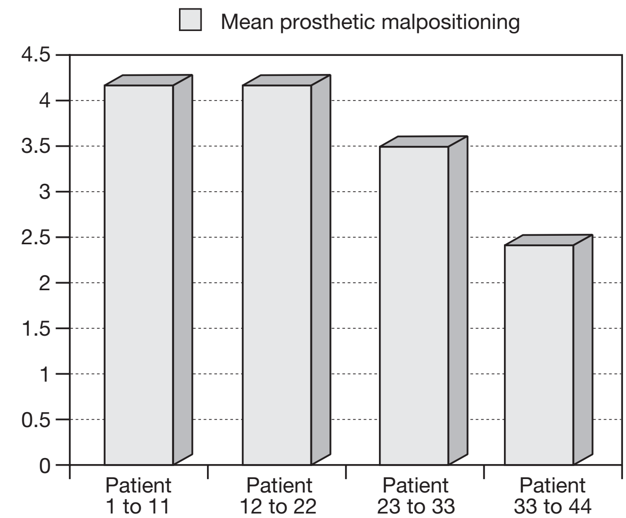

Figure 5 Mean number of errors in implant positioning distributed in groups correlatively according to the date of implantation.

slight varus is some subjects[7,14]. Nevertheless, it has been shown that an increased postoperative varus alignment is significantly related to a higher prosthetic revision rate[28], while on the other hand postoperative valgus alignment does not influence arthritic progression in the contralateral knee[16]. Swieckowski and Pennington[22] consider a tibiofemoral valgus angle of 5° optimal, which is similar to the reference value for our series. The mean tibiofemoral angle obtained in this series was 3.3°, even lower than the one reported by other authors[16,19].

The authors of this paper believe that it is necessary to align the limb in sufficient valgus to center the loading axis on the joint, so that the prosthesis does not have to withstand the excessive load of a residual varus. This situation corresponds to areas 2 and C in Kennedy's diagram[8], which is where most of the cases described herein are located; this is in line with the findings by Emerson and Higgins[19]. In our series, the TFA value is one of the parameters that is best suited to the reference values; no subject was found to be outside the 0°.10° valgus range. Voss et al[21] found 22% malpositioned components with respect to the normal tibiofemoral axis and Jenny and Boeri[17] found 33-48% malpositioned components with respect to the mechanical axis.

The position of the femoral component on the anteroposterior plane depends mainly on the type of tibial cut performed; it is mandatory to preserve physiological valgus (F2). The series published in the literature report an incidence of malpositioning on this plane that ranges between 3 and 60%, depending on the breadth of the limits established[17,20]. The prevalence of errors in the subjects described herein stands between 9 (F2, F2N) and 13% (F0, F1). Rotational variability (F4) is lower in the femoral than in the tibial component, and must always preserve between the 5° and 10° internal rotation of the healthy condyle to maintain adequate congruence with the tibia during knee flexion. No references were found in the literature for this parameter. Malpositioning with respect to femoral implant flexion-extension (F3) affect 29% of subjects in our series, while in other series it affects up to 44% of subjects[17,20].

The most commonly reported instance of malpositioning in the literature is varus placement of the tibial component[21,22,24,26,28], which accounts for 3-35%[17,20] of cases. In our series, we also detected tibial varus; it affects 16% of patients when T2 is taken as a reference and 7% of patients when the reference is T2N. Tibial rotation on the axial view (T4) id the parameter falling furthest away from the pre-established limits; in addition, there are no references in the literature for this value. This angle is determined by the longitudinal cut and, although the anatomical landmarks are clear (anterior tibial tuberosity and second toe), variability is wide and small cutting errors may lead to significant alterations in this area (the use of a longitudinal saw is recommended for this cut). There are few references in the literature about tibial component medialization or lateralization (T0). Müller et al[20] report up to 24% displacements of more than 2 mm with respect to the ideal position (centered on the tibial plateau).

Posterior tilting of the tibial component on the lateral plane (T3) is the most important variable as it is the only one that significantly influences long-term outcome. The majority of authors recommend preservation of preoperative inclination to safeguard anatomic harmony[10,21], but Hernigou and Deschamps[25] recommend tilting of less than 7° arguing that, if that limit is exceeded, then the revision rate will increase, especially in subjects with associated anterior instability. In our series, there was a clear tendency toward increasing posterior tilting to obtain a correct flexion gap, since this facilitated tibial component implantation. However, results were significantly poorer in subjects where posterior tilt was greater than 8°. Nevertheless, Collier et al[28] were not able to correlate tibial component inclination with the need for prosthetic revision. Swieckowski and Pennington[22] established the normalcy range between 5° and 10°, while Müller et al[20] extended it to –5° a 7°. In general, there is wide variability in the medical literature regarding the degree of tilting achieved[28], which depends mainly on the surgical technique and on the type of instrumentation used (3 to 24% of cases of inappropriate posterior tilt were a result of the technical technique used[20] and 30 to 80% were caused by the instrumentation employed[17]). In the series described herein the incidence of error ranges between 13 and 18%.

In addition to the need for correct placement of the tibial and femoral components, both implants need to be congruent with each other and be well supported on all planes. Only Argenson et al[30] studied this relation on the lateral plane (similar to RL1) and found that, in full extension, 47% of their subjects showed anterior displacement of the femoral over the tibial component. In our series, mean anterior displacement was 1.3 mm and in 11% of patients it exceeded 5 mm. Moreover, adequate support of the femoral component on the central area of the tibial implant was seen in 93% of cases on the lateral plane (RL2) and in 87% of cases on the anteroposterior plane (RA1).

From what has been said, it is clear that absolute frequency of errors in prosthetic component positioning is relatively high. For that reason, most authors consider that unicompartmental replacement is a technically demanding type of surgery[9,18], even more so than total arthroplasty[5,10], and therefore requiring a long learning curve until an optimal level of surgical experience is achieved[11,18,24,23]. In the series described herein, significant differences were seen between the first 22 prostheses implanted and the rest when radiological defects were quantified. Lindstrand et al[24] recommend at least 10 to 15 unicompartmental replacements a year to develop a reasonable level of experience, whereas Robertsson et al[18] recommend a number of at least 23 prostheses, since their series shows a higher revision rate for surgeons with fewer cases. Similar data is presented by Furnes et al[11], with significant differences in terms of the revision rate between hospitals that do more than 20 unicompartmental arthroplasties a year and those implanting less than 10.

Although some authors report a higher survivorship rate for total knee replacement than for unicompartmental replacement[11], Griffin et al[6], in a metaanalysis of all comparative studies found in the literature, showed similar survivorship and revision rates for both types of arthroplasty. Disparity between the results of different centers may be attributable to different patient selection criteria and variations in the surgical technique used, both factors being related to the surgeon's experience[13]. In the majority of series, the revision rate ranges between 3 and 10% after 2 to 10 years' follow-up[13,15,17,22,24,27]. In the series reported herein, 2 prosthesis had to be revised, one because of infection and the other for tibial component loosening (secondary to malpositioning), which represents a revision rate of 4.5% at 2 years. This reflects the occurrence of early failures, largely attributable to technical error or poor patient selection[2]. Generally speaking, up to 20% of revisions are attributable to technical error[23], a percentage that could increase by up to 75% in centers with less surgical experience[24].

Numerous publications point out the straightforwardness of converting a unicondylar knee replacement to a total knee replacement following failure of the former (PCL-retaining prostheses are used preferentially)[15,23,27]; in these cases results similar to those of total primary arthroplasty have been reported[29]. Nonetheless, these results largely depend on the surgeon having been conservative enough at the initial surgery. For this reason, minimally invasive techniques are especially advantageous in these cases because they can preserve larger amounts of bone. In the series presented in this study, the 2 revisions were carried out without using wedges or grafts, in line with the recommendations of Tabor et al[23]. The frequency in the use of wedges, stems and bone grafts in the published series is variable and ranges between 0.8 and 23%[15,27,29].

To conclude, treatment of certain knee conditions by unicompartmental replacement affords good clinical and functional results, although it is highly dependent on appropriate patient selection and a careful surgical technique. Special attention must be paid to factors like overweight and the degree of posterior tilting of the tibial component. Given the complexity inherent in correct implant positioning, it is essential that surgeons go through a long learning curve to avoid higher failure rates. Longer-term studies are required in order to precisely determine how malpositioning each of the prosthetic components influences survivorship and final outcome.

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Conflict of interests

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