

# Total knee arthroplasty for gonarthrosis in patients < 55 years old A 2 to 13-year follow-up study

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## ABSTRACT

**Introduction:** Total knee arthroplasties in young patients are on the increase. There are inconsistent reports on function and complications, even in patients with rheumatoid osteoarthritis. The aim of this study was to analyze a group of total knee arthroplasties in <55 year-old patients so as to evaluate prosthetic survival, radiologic failure and functional results.

**Materials and Methods:** We analyzed retrospectively 53 total knee arthroplasties in 46 patients (age average: 49 years old [26-54 range]) and an average follow-up of 6.5 years (2-15 range). Preoperative diagnoses were: 46 idiopathic gonarthrosis, 5 post-traumatic gonarthrosis and 2 osteonecrosis. Twenty-two patients had previous surgeries. We used 49 imported implants and 4 made-in-Argentina implants. Medical-functional results were assessed using the *Knee Society Score* and the WOMAC; radiologic evaluation was carried out by the Knee Society system.

**Results:** The functional KSS score improved from 49.3 to 92.6 on average, and the knee own score went from 46.8 to post-operative 91.4. Average WOMAC scores were 2.3 for pain, 2.6 for rigidity, and 27.3 for functional capability. Sixty percent of the patients showed <1-mm radioluscent lines that did not advance. There were three infections that required two-stage revision and did well, and four cases of rigidity treated by arthroscopic mobilization. Prosthetic survival was 94.34%.

**Conclusions:** Total knee arthroplasty in <55 year-old patients was a trustworthy procedure regarding function improvement, with acceptable prosthetic survival considering surgical history. There were no radiologic failures at last follow-up.

**Key words:** Total knee arthroplasty; knee; young patients; primary osteoarthritis; secondary osteoarthritis.

**Level of evidence:** IV

## REEMPLAZO TOTAL DE RODILLA EN PACIENTES MENORES DE 55 AÑOS CON GONARTROSIS. SEGUIMIENTO DE 2 A 13 AÑOS

## RESUMEN

**Introducción:** Los reemplazos totales de rodilla en jóvenes siguen aumentando. Se publicaron resultados inconstantes sobre la función y las complicaciones, inclusive en pacientes con artritis reumatoide. El propósito de este estudio fue analizar un grupo de reemplazos totales de rodilla en pacientes <55 años para evaluar la sobrevida de la prótesis, las fallas radiológicas y los resultados funcionales.

**Materiales y Métodos:** Se analizaron retrospectivamente 53 reemplazos totales de rodilla en 46 pacientes (promedio de edad: 49 años [rango 26-54]) y un seguimiento promedio de 6.5 años (rango 2-15). Los diagnósticos preoperatorios

Conflict of interests: The authors have reported none.

fueron: 46 gonartrosis idiopáticas, 5 postraumáticas y 2 osteonecrosis. Veintidós tenían cirugías previas. Se utilizaron 49 implantes importados y 4 nacionales. Los resultados clínico-funcionales se evaluaron mediante el *Knee Society Score* y el WOMAC, la evaluación radiológica se efectuó con el sistema de la Knee Society.

**Resultados:** El puntaje KSS funcional mejoró de 49,3 a 92,6 en promedio y el puntaje propio de rodilla pasó de 46,8 a 91,4 en el posoperatorio. El puntaje WOMAC promedio fue de 2,3 para dolor, 2,6 para rigidez y 27,3 para capacidad funcional. El 16% presentó líneas de radiolúcidas <1 mm que no progresaron. Hubo tres infecciones que requirieron una revisión en dos tiempos, con evolución favorable, y cuatro casos de rigidez tratados mediante movilización artroscópica. La sobrevida de la prótesis fue del 94,34%.

**Conclusiones:** El reemplazo total de rodilla en pacientes <55 años fue un procedimiento confiable en cuanto a la mejoría de la función, con una aceptable sobrevida de la prótesis considerando los antecedentes quirúrgicos. No se observaron fallas radiológicas al final del seguimiento.

**Palabras clave:** Reemplazo total; rodilla; jóvenes; artrosis primaria; artrosis secundaria.

**Nivel de Evidencia:** IV

## Introduction

Total knee arthroplasty (TKA) is a successful procedure in the treatment of advanced gonarthrosis.<sup>1-3</sup> Its results are predictable and reproducible, especially in >65 year-old patients—there are reports that show excellent prosthetic survival, higher than 95% at 20-year follow-up.<sup>4-6</sup> However, due to the patient's active lifestyle and, therefore, the theoretical possibility of future mechanical loosening, many surgeons delay the indication of arthroplasty in <55 year-old patients.

Kuts et al.<sup>7</sup> report on approximately 70,000 TKAs in <55 year-old persons per year in the US and project, extrapolating data from the latest two decades, that by 2030 there will be 1,000,000 TKAs. W-Dahl et al.<sup>8</sup> inform that these tendency is not exclusively American, since both Swedish and Australian records show similar projections. Obviously, the number of TKAs in this age group is increasing remarkably in the world. However, there are not many publications on long-term follow-up in young patients with gonarthrosis, and most of them include patients with rheumatoid osteoarthritis.

The aim of this study was to carry out a retrospective analysis assessing a series of <55 year-old patients with diagnosis of osteoarthritis subject to TKA, so as to determine the prosthetic survival, functionality, and radiologic failure.

## Materials and Methods

Between 1997 and 2011 we carried out 1049 primary TKAs—117 in <55 year-old patients. Inclusion criteria were: 1) diagnosis of osteoarthritis, 2) age < 55 years old, 3) a minimum of 2-year follow-up and 4) complete medical and radiologic follow-ups by the last evaluation.

Among the 117 patients, 62 had diagnosis of rheumatoid osteoarthritis; therefore, they were excluded from the

analysis. Another patient (2 TKAs) was also excluded because of shear inconsistencies with the rest of the population stemming from his underlying condition (myelomeningocele).

Eventually, the series was made up of 53 TRAs in 46 patients (28 women and 18 men who averaged 49 years old [ranging from 26 to 54] at the time of the surgery), with an average follow-up of 6.5 years (ranging from 2 to 14); we treated 30 right knees and 23 left knees. Twenty-two out of the 46 patients had previous surgeries: 10 (21.7%) had been subject to knee arthroscopy for partial meniscectomy, and two (4.34%) for reconstruction of the anterior cruciate ligament; three (6.5%) showed osteosynthesis for tibial plateau fracture, and seven (15.2%), tibial osteotomy to correct misalignment.

Pre-operative diagnoses were as follows: 46 cases of primary gonarthrosis, two cases of osteonecrosis, five cases of post-traumatic gonarthrosis—two consecutive to ligament (anterior cruciate ligament) injury, and three consecutive to tibial plateau fracture.

We used made-in-Argentina prostheses in four cases (Implantes Fico®, Villalba®), and imported prostheses in 49 knees: PFC® Sigma® (DePuy Orthopaedics, Johnson & Johnson, Warsaw, Ind., US) in 26 cases; PFC Sigma All-Poly® (DePuy Orthopaedics, Johnson & Johnson, Warsaw, Ind., US) in 10, PFC Sigma® RP® (rotator plateau) (DePuy Orthopaedics, Johnson & Johnson, Warsaw, Ind., US) in eight; Scorpio® (Stryker Howmedica, Newbury, United Kingdom) in three; NexGen® (Zimmer®, Winterthur, Switzerland) in another case and TC3® (DePuy, Johnson & Johnson, Warsaw, Ind., US) in the knee of one patient with serious 25°-valgum knee deformity and incompetent medial collateral ligament.

All the surgeries were carried out by the same surgical team, which used the same surgical technique in a laminar-flow operating-room with hypotensive spinal anesthesia and a 320-mmHg haemostatic cuff.

We carried out a knee anterior approach with medial parapatellar arthrotomy in the 53 cases. We used a femoral intramedullary cutting guide and a tibial extramedullary cutting guide. We administered the patient three prophylactic doses of *e.v.* 1 g-cefazolin (before, during and after the surgery) and abdominal subcutaneous low molecular weight heparin during three weeks to prevent them from developing thromboembolic episodes.

All the patients were applied a Robert Jones-type bandage in the limb operated on during three weeks, until stitches were removed. Rehab consisted of sitting on the bed border the first 24 post-operative hours and of two-leg standing and walker-assisted walking at post-operative day 2, so as to move on to two Canadian clubs-assisted walking during three weeks. Post-operative follow-ups were carried out at post-operative weeks 3, 6, and 9 and then at post-operative months 3 and 6, so as to continue later with yearly control evaluations.

The medical and functional assessment of the series was carried out using the *Knee Society Score*<sup>9</sup> (KSS) both pre-operatively and at last follow-up. We also used the WOMAC (*Western Ontario and McMaster Universities Osteoarthritis index*)<sup>10</sup> post-operatively. Moreover, we performed an X-ray analysis to assess pre-operative and post-operative femoral-tibial axes, the orientation of the tibial bone cut, osteolytic zones or radiolucent lines and their advance comparing the immediately post-operative one with the last follow-up X-ray. We used the protocol described by Ewald (*Knee Society*)<sup>11</sup> to locate radiolucency in the cement-bone inter-phase. With respect to the inclination of the tibial osteotomy to insert the prosthesis,

we considered a neutral-to-3°-varum orientation as the appropriate tibial cut. All >5mm<sup>2</sup> radiolucent zones not found in the immediately post-operative X-ray were considered as osteolysis zones.<sup>12</sup>

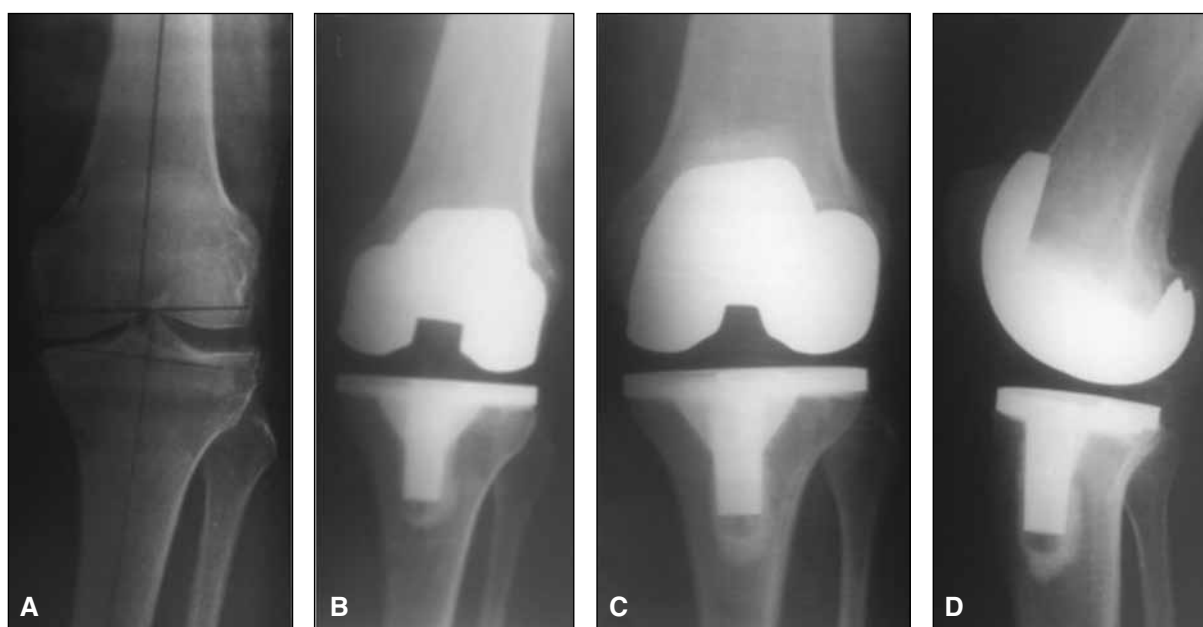
## Results

### Medical results

The KSS results showed functional improvement of 43 marks—from average 49.3 (ranging from 21 to 76) before the surgery to average 92.6 marks (ranging from 47 to 98) after the surgery. Medical assessment showed an increase from 46.8 (ranging from 18 to 78) before the surgery to average 91.4 (ranging from 62 to 100) after the surgery. The average WOMAC scores were: 2.3 (ranging from 0 to 4) for pain; 2.6 (ranging from 0 to 4) for rigidity and 27.3 (ranging from 5 to 48) for functional capability at last follow-up. We detected an increase in ROM from average 87° (ranging from 10° to 130°) before the surgery to average 109° (ranging from 2° to 130°) after the surgery. Forty-three patients reported satisfaction with the procedure.

### Radiologic results

The pre-operative radiologic assessment showed a neutral-to-varum tibial-femoral axis in 22 knees, a neutral-to-3°-valgum in 12 cases, a 4°-to-8°-valgum in seven knees and a >8° valgum in 12 knees. On the other hand, post-operatively we found a final neutral-to-3°-valgum in 22 knees and a 4°-to-8°-valgum in 31 cases (Figure 1).



▲ **Figure 1.** A. Fifty-two year-old patient with osteoarthritic varum knee deformity and 15-year history of medial meniscectomy. B. Total knee arthroplasty at three-week follow-up. C and D. X-rays at 8.2-year follow-up.

We found <1mm-radiolucent lines in zones 1 and 2 in the tibial component in eight cases; in zone 4 in three knees and in zone 1 in three femoral components in the immediately post-operative radiologic evaluation. At last radiologic follow-up, we did not detect advance or evidence of osteolysis, neither did we see >1mm radiolucent lines. In 47 (88.68%) out of the 53 knees, we verified an appropriate tibial osteotomy (from neutral to 3°-varum). In two cases, the bone cut showed a neutral-to-3°-valgum orientation, whereas in the remaining four knees, there was a 4°-to-5°-varum inclination.

### Complications

There were three (5.6%) prosthetic infections, which were treated with two-stage revision using spacer and prosthetic change. One of them occurred nine years after the surgery due to the knee joint introduction of a foreign body through a stabbing wound. Another infection occurred one month after the TKA in a patient with previous diagnosis of sequela of tibial plateau fracture, operated on two years before with infection-failure osteosynthesis that had to be removed with surgical irrigation (Figure 2). The third patient with prosthetic infection attended evaluation with inflammatory signs three months after the surgery; he had an extra-articular deformity with previous surgeries. The three patients did well—they have had a longer-than-2-year follow-up of the prosthesis re-implantation with no complications.

There were four (7.54%) cases of knee rigidity that were treated with arthroscopic mobilization, after which all patients showed >90°-ROM.

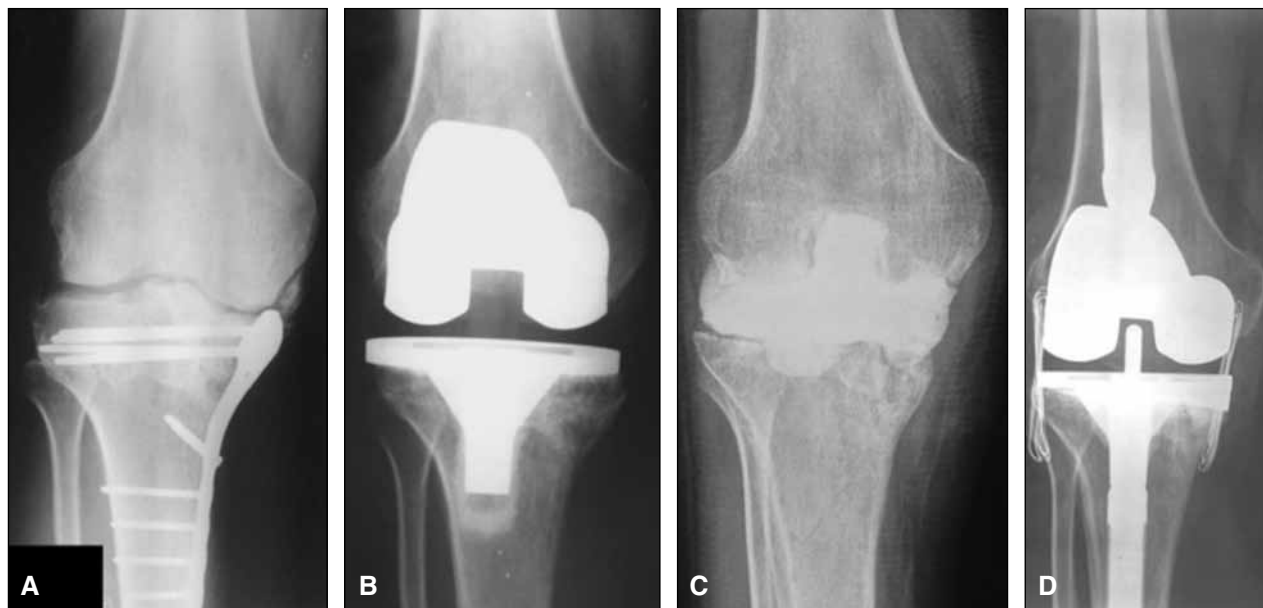
At last follow-up, prosthetic survival rates taking implant revision for any reason as end point were of 94.34%.

### Discussion

Although in our series 47.8% of the patients had history of surgery, we found considerable functional improvement and pain relief. Although complications rates were higher than 13%, at last follow-up prosthetic survival rates were of 94.34%; three cases required revision for infection, something that we neither associate with age nor with activity levels.

In the two patients that suffered near post-operative infections, surgery was highly challenging due to the arthrofibrosis that came as a consequence of the previous surgeries, what prolonged unavoidably surgical times. Moreover, one of them had suffered a tibial plateau fracture which had been treated with osteosynthesis three years before the surgery; afterwards this patient developed a septic process that was treated with surgical irrigation and specific antibiotic treatment, with remission of the infectious process. Even though we were careful enough, we consider prolonged surgical times, previous osteosynthesis or surgeries and previous septic processes as recognized risk factors for the development of septic complications following TKA.<sup>13-15</sup>

The remaining patient had a septic prosthetic loosening as a consequence of a stabbing wound and foreign body



▲ **Figura 2.** A. Twenty-six year-old patient with history of osteosynthesis in medial tibial plateau in right knee. B. Total knee arthroplasty. C. Prosthetic infection one month after the surgery. The patient is given a knee spacer. D. Prosthetic re-implantation at post-operative month three, once infection has healed.

introduction in the knee joint nine years after the surgery; therefore, in spite of surgical history, we do not associate infection with surgery.

We did not find differences in KSS and WOMAC scores among the different prostheses that we used.

At the time of analyzing the causes of early development of gonarthrosis in middle-age populations, we find that, although idiopathic gonarthrosis is still dominant, other entities such as cartilage, meniscus and ligament injuries, and fractures and osteotomies around the knee play more crucial a role, since they cause greater wear in the joint.<sup>16-21</sup> Moreover, a great percentage of the published series involves patients who also have rheumatoid osteoarthritis, generating an heterogeneous group of conditions with inconsistent or contradictory post-operative results (Table).<sup>21-33</sup>

Harrison et al.,<sup>23</sup> as well as W-Dahl et al.<sup>8</sup>, reported greater risks of revision in <60 and <55 year-old patients, respectively, as compared to elder patients. Moreover, they highlight that TKAs represent the procedure associated with the lowest revision rates as compared to unicompartmental knee replacements and proximal tibia osteotomies. Rand et al.<sup>24</sup> analyzed more than 11,000 TKAs in a span of 22 years, and reported lower prosthetic survival rates in young men with primary diagnosis of gonarthrosis.

On the contrary, in a revision of literature in 2007, Keeney et al.<sup>25</sup> reported prosthetic survival rates of 90.6-99% in <55 year-old patients during the first 6-10 years

of follow-up, and those of 85-96.5% in a 15-year projection, affirming that the most frequent reasons for revision might be failure of the patellar component, instability or infection, what does not seem to differ from the reasons for revision in elder patients.

Among the reports that involve exclusively patients with gonarthrosis, it is worth mentioning Diduch et al.'s<sup>26</sup>, which analyzed results in 103 TKAs for idiopathic and post-traumatic gonarthrosis in <55 year-old patients. They report excellent results at eight-year follow-up and estimate an implant survival of 87% at 18-year follow-up; moreover, they highlight improvement in activity levels in 98% of the individuals. Duffy et al.<sup>27</sup> report 52 TKAs in patients who averaged 53 years old, with prosthetic survival rates of 96% at 10 year-follow up and those of 86% at 15-year follow-up. Mont et al.<sup>28</sup> in their series of 35 patients 10 years younger on average (43 years old), report prosthetic survival rates of 97% at seven-year follow-up. Stern et al.<sup>29</sup> evaluated a series of 68 TKAs with an average follow-up of 6.2 years and average 50 years of age. They published excellent functional results, no cases of mechanic failure, and prosthetic survival rates of 94%, due exclusively to the use of metallic-based patellar implants that had to be revised.

Series such as Odland et al.'s<sup>30</sup> and Loner et al.'s<sup>31</sup>, with average follow-ups of 12.5 years and 7.9 years respectively, are the ones that report the highest rates of failure due to mechanic loosening. These percentages were as-

**Table.** Series that include patients with osteoarthritis and rheumatoid osteoarthritis or only rheumatoid osteoarthritis.

Authors (year)	Diagnosis	Number of patients/Age	Follow-up (years)	Prosthetic Survival	Complications
Crowder et al. <sup>32</sup> (2005)	100% of rheumatoid osteoarthritis	47/43	18	100% at 15 years 93,7% at 20 years	12% of polyethylene-osteolisis wear
Hoffmann et al. <sup>33</sup> (2002)	57% of osteoarthritis 25% of reumatoid osteoarthritis 18% other	75/42	9.3	100%	0% of mechanical failure 12 linner changes
Sorrells et al. <sup>34</sup> (2001)	79% of osteoarthritis 21% of rheumatoid osteoarthritis	117/56	8.5	85% at 14 years	7% of revisions
Duffy et al. <sup>35</sup> (1998)	63% of rheumatoid osteoarthritis 24% of osteoarthritis 13% other	74/43	12.6	95% at 15 years	Patellofemoral pain Patellar fracture
Gill et al. <sup>36</sup> (1997)	54% of osteoarthritis 43% of rheumatoid osteoarthritis 3% of others	68/50.7	9.9	96% at 18 years	4.4% of patellofemoral pain 2,9% of septic loosening
Ranawat et al. <sup>37</sup> (1989)	73% of rheumatoid osteoarthritis 27% of osteoarthritis	62/52	6	99% rheumatoid osteoarthritis 94% osteoarthritis	Radiolucency
Garabano et al. <sup>38</sup> (2014)	100% of rheumatoid osteoarthritis	24/47.4	5.8	95%	4,1% of mechanical loosening

sociated with well defined and determined causes—In the former group failure was supposed to have been caused by the sterilization method of the polyethylene insert. Upon converting the method to vacuum gamma radiation, they did not find any other patient with prosthetic wear, and their revision rates were zero. In the latter group, failure also involved the polyethylene insert, but in this case the reason was quality, which caused failure in 75% of the patients; thereafter, they gave up these types of implants. In the Table we detail the different series, which include patients with osteoarthritis and rheumatoid osteoarthritis.

In the present series there is considerable improvement in function as put forward by KSS and WOMAC scores, which result to be similar to Diduch et al.'s<sup>26</sup>, Duffy et al.'s, and Stern et al.'s<sup>29</sup>, among others.

Sixty percent of the patients in our series had radiolucent lines and, although they did not advance over time, they were within the 3.8-30% reported by bibliography.<sup>25</sup>

At the time of comparing this series with others of similar follow-up, prosthetic survival in this series resulted similar to those reported by Mont et al.<sup>28</sup> (97% at 7-year follow-up) and Stern et al.<sup>29</sup> (94% at 6-year follow-up).

The most frequent complication in this series was post-operative rigidity, which required arthroscopic manipulation under anesthesia in four (7.54%) patients, percentage that results substantially lower than that reported by Mont et al.<sup>28</sup> (24%) or Gill et al.<sup>36</sup> (11.7%). All these patients had history of previous surgeries, something that we believe influenced on the final arthroplasty outcomes and rigidity.

Post-operative infection was the only cause of revision, with an incidence of 5.6%. These rates result more than two-fold higher than the general average at our Center (<2%) and we believe that they are influenced by medical history, as previously stated. Comparatively, these rates resulted higher than those in other series, such as Diduch et al.<sup>26</sup> (1.94%) and Lonner et al.<sup>31</sup> (3.1%).

Finally, as a consequence of the complication rates and the percentages of surgical history seen in this series, plus the fact that according to different reports,<sup>26,39,40</sup> satisfaction rates in this group seem to be lower than those among elder patients, we believe that before the surgery we must be cautious so as not to create false expectations with respect to surgery results and post-operative complications.

The limitations of this study are those of a retrospective one—we used different prosthetic models, and the patients were different from the surgical history point of view and with different complications, what we believe affected arthroplasty results. Anyway, we emphasize the limited number of similar reports involving exclusively patients with osteoarthritis. The study strengths have mainly to do with that fact that all the surgeries were carried out by the same surgical team, with identical technique and appropriate pre-operative and post-operative analyses. It is also worth highlighting the importance of excluding patients with rheumatoid osteoarthritis, since we believe that, due to its exclusive and distinctive characteristics, this condition affects directly arthroplasty results.

## Conclusions

We believe the TKA in the <55 years old group of patients is a trustworthy procedure regarding functional improvement. Although we found neither mechanical loosening nor radiologic failure, the need of additional procedures such as arthroscopic mobilization and septic revision was high, what is mainly associated with previous procedures and infections. We believe that, although this series' follow-up is not long, prosthetic survival resulted acceptable. We will continue these patients' follow-up so as to determine in the long run whether or not there is theoretical risk of loosening, because, according to the bibliography that we analyzed, implant survival rates in this group of "young" patients seem to decrease after the first post-operative decade.

It is necessary to carry out studies involving an appropriate number of patients, homogeneous pre-operative diagnoses and currently available implants so as to determine conclusively long-term results in this kind of procedures, especially during the second post-operative decade.

Finally, this study leaves us with some queries that we will try to answer in future analyses; for example, if in spite of the surgical history that we detail these patients are more physically active than >65 years old patients just because they are younger, and if the group's satisfaction levels are similar to those reported by patients also operated on at our Center who average an older age.

## Bibliography

1. Meding JB, Meding LK, Ritter MA, Keating EM. Pain relief and functional improvement remain 20 years after knee arthroplasty. *Clin Orthop Relat Res* 2012;470:144-149.
2. Callahan CM, Drake BG, Heck DA, Dittus RS. Patient outcomes following tricompartmental total knee replacement: a meta-analysis. *JAMA* 1994;271:1349-1357.
3. Gioe TJ, Novak C, Sinner P, Ma W, Mehle S. Knee arthroplasty in the young patient: survival in a community registry. *Clin Orthop Relat Res* 2007;464:83-87.
4. Lachiewicz PF, Soileau ES. Fifteen-year survival and osteolysis associated with a modular posterior stabilized knee replacement: a concise follow-up of a previous report. *J Bone Joint Surg Am* 2009;91:1419-1423.
5. Ma HM, Lu YC, Ho FY, Huang CH. Long-term results of total condylar knee arthroplasty. *J Arthroplasty* 2005;20:580-584.
6. Ritter MA. The Anatomical Graduated Component total knee replacement: a long-term evaluation with 20-year survival analysis. *J Bone Joint Surg Br* 2009;91:745-749.
7. Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030. *Clin Orthop Relat Res* 2009;467:2606-2612.
8. W-Dahl A, Robertsson O, Lidgren L. Surgery for knee osteoarthritis in younger patients: a Swedish Register Study. *Acta Orthop* 2010;81:161-164.
9. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res* 1989;248:13-14.
10. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: A health status instrument for measuring clinically important patient relevant outcomes to anti-rheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol* 1988;15:1833-1840.
11. Ewald FC. The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. *Clin Orthop Relat Res* 1989;248:9-12.
12. O'Rourke MR, Callaghan JJ, Goetz DD, Sullivan PM, Johnston RC. Osteolysis associated with a cemented modular posterior cruciate-substituting total knee design: five to eight-year followup. *J Bone Joint Surg Am* 2002;84:1362-1371.
13. Lonner JH, Pedlow FX, Siliski JM. Total knee arthroplasty for posttraumatic arthrosis of the knee. *J Arthroplasty* 1999;14:969-975.
14. Larson AN, Hanssen AD, Cass JR. Does prior infection alter the outcome of TKA after tibial plateau fracture? *Clin Orthop Relat Res* 2009;467:1793-1799.
15. Pulido L, Ghanem E, Joshi A, Purtill JJ, Parvizi J. Periprosthetic joint infection. The incidence, timing and predisposing factors. *Clin Orthop Relat Res* 2008;466:1710-1715.
16. Messner K, Maletius W. The long-term prognosis for severe damage to weight-bearing cartilage in the knee. *Acta Orthop Scand* 1996;67:165-168.
17. McDaniel Jr. WJ, Dameron Jr. TB. The untreated anterior cruciate ligament rupture. *Clin Orthop Relat Res* 1983;172:158-163.
18. Tegner Y, Lysholm J. Rating systems and evaluation of knee ligament injury. *Clin Orthop Relat Res* 1985;198:43-49.
19. Insall JN, Joseph DM, Masika C. High tibial osteotomy for varus gonarthrosis. A long term follow-up study. *J Bone Joint Surg Am* 1984;66:1040-1048.
20. Nagle A, Insall JN, Scuderi GR. Proximal tibial osteotomy. A subjective outcome study. *J Bone Joint Surg Am* 1996;78:1353-1358.
21. Tai CC, Cross MJ. Five- to 12-year follow-up of a hydroxyapatite-coated, cementless total knee replacement in young, active patients. *J Bone Joint Surg Br* 2006;88: 1158-1163.
22. Himanen AK, Belt E, Nevalainen J, Hämäläinen M, Lehto MU. Survival of the AGC total knee arthroplasty is similar for arthrosis and rheumatoid arthritis: Finnish Arthroplasty Register report on 8,467 operations carried out between 1985 and 1999. *Acta Orthop* 2005;76:85-88.
23. Harrison O, Robertsson O, Nayfeh J. Higher cumulative revision rate of knee arthroplasties in younger patients with osteoarthritis. *Clin Orthop Relat Res* 2004;421:162-168.
24. Rand JA, Trousdale RT, Ilstrup DM, Harmsen WS. Factors affecting the durability of primary total knee prostheses. *J Bone Joint Surg Am* 2003;85:259-265.
25. Keneey JA, Eunice S, Pashos PGS, Wright RW, Clohisey JC. What is the evidence for total knee arthroplasty in young patients? A systematic review of the literature. *Clin Orthop Relat Res* 2011;469:574-583.

26. Diduch DR, Insall JN, Scott WN, Scuderi GR, Font-Rodriguez D. Total knee replacement in young, active patients. Long-term follow-up and functional outcome. *J Bone Joint Surg Am* 1997;79:575-582.
27. Duffy GP, Crowder AR, Trousdale RR, Berry DJ. Cemented total knee arthroplasty using a modern prosthesis in young patients with osteoarthritis. *J Arthroplasty* 2007;22(6 Suppl 2):67-70.
28. Mont MA, Lee CW, Sheldon M, Lennon WC, Hungerford DS. Total knee arthroplasty in patients  $\leq$ 50 years old. *J Arthroplasty* 2002;17:538-543.
29. Stern SH, Bowen MK, Insall JN, Scuderi GR. Cemented total knee arthroplasty for gonarthrosis in patients 55 years old or younger. *Clin Orthop Relat Res* 1990;260:124-129.
30. Odland A, Callaghan J, Liu S, Wells C. Wear and lysis is the problem in modular TKA in the young OA patient at 10 years. *Clin Orthop Relat Res* 2011;469:41-47.
31. Lonner JH, Hershman S, Mont M, Lotke PA. Total knee arthroplasty in patients 40 years of age and younger with osteoarthritis. *Clin Orthop Relat Res* 2000;(380):85-90.
32. Crowder AR, Duffy GP, Trousdale RT. Long-term results of total knee arthroplasty in young patients with rheumatoid arthritis. *J Arthroplasty* 2005; 20(7 Suppl 3):12-16.
33. Hoffmann AA, Heithoff SM, Camargo M. Cementless total knee arthroplasty in patients 50 years or younger. *Clin Orthop Relat Res* 2002;404:102-107.
34. Sorrells BR, Stichl JB, Voorhorst PE. Midterm results of mobile-bearing total knee arthroplasty in patients younger than 65 years. *Clin Orthop Relat Res* 2001;390:182-189.
35. Duffy GP, Trousdale RT, Stuart MJ. Total knee arthroplasty in patients 55 years old or younger. 10- to 17-year results. *Clin Orthop Relat Res* 1998;356:22-27.
36. Gill GS, Chan KC, Mills DM. 5- to 18-year follow-up study of cemented total knee arthroplasty for patients 55 years old or younger. *J Arthroplasty* 1997;12:49-54.
37. Ranawat CS, Padgett DE, Ohashi Y. Total knee arthroplasty for patients younger than 55 years. *Clin Orthop Relat Res* 1989; 248:27-33.
38. Garabano G, Lopreite F y del Sel H. Artroplastia total de rodilla en pacientes jóvenes con artritis reumatoide. *Rev Asoc Argent Ortop Traumatol* 2014;79(2):92-98.
39. Dalury DF, Ewald FC, Christie MJ, Scott RD. Total knee arthroplasty in a group of patients less than 45 years of age. *J Arthroplasty* 1995;10:598-602.
40. Fehring TK, Murphy JA, Hayes TD, Roberts DW, Pomeroy DL, Griffin WL. Factors influencing wear and osteolysis in press-fit condylar modular total knee replacements. *Clin Orthop Relat Res* 2004;(428):40-50.