Total Knee Replacement After High Tibial Osteotomy. Retrospective Comparative Study Between Subtractive and Additive Osteotomies

Fernando Tillet, Joaquín A. Rodríguez, Hernán del Sel, Fernando A. Lopreite
Orthopedics and Traumatology Service, Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina

ABSTRACT

Introduction: Total knee replacement after a high tibial osteotomy presents additional technical difficulties. The objective of this study was to analyze the clinical and radiological outcomes of conversion to total knee replacement after a high tibial osteotomy and to compare the evolution of patients with a history of a closing (subtractive) versus opening (additive) osteotomy. **Materials and Methods:** A series of 46 knee arthroplasties performed between 1997 and 2019 in 39 patients with a history of a high tibial osteotomy was retrospectively analyzed. The clinical and radiographic parameters were evaluated before and after the arthroplasty by measuring the femorotibial axis, the posterior tibial slope, the Insall Salvati value, and the Knee Society Score. At the same time, the results were compared in patients with a history of subtractive versus additive tibial osteotomy. **Results:** In the series of 46 patients, an average follow-up of 5.72 years was achieved (minimum 1, maximum 19). The Knee Society Score for the entire series had an average improvement from 42.3 to 79.8 points. The posterior tibial slope and the IS value did not show great modifications after surgery. In this series, the average survival of additive osteotomy until conversion to total knee replacement was 5.5 years, while for the subtractive one it was 13.5 years. **Conclusions:** Despite the technical difficulty that it may present, total knee replacement after a valgus high tibial osteotomy presented a good clinical-radiological evolution in the short and medium term and the type of osteotomy did not affect the results obtained after arthroplasty.

Key words: Total knee replacement; high tibial osteotomy; closing osteotomy; opening osteotomy.
Level of Evidence: IV

Artroplastia total de rodilla después de una osteotomía tibial alta. Estudio retrospectivo comparativo entre osteotomías sustractivas y aditivas

RESUMEN

Introducción: El reemplazo total de rodilla luego de una osteotomía tibial alta plantea dificultades técnicas adicionales. El objetivo de este estudio fue analizar los resultados clínicos y radiográficos de la conversión a reemplazo total de rodilla luego de una osteotomía tibial alta y comparar la evolución de los pacientes con una osteotomía de cierre (sustractiva) o de apertura (aditiva) previa. **Materiales y Métodos:** Se analizó retrospectivamente una serie de 46 artroplastias de rodilla realizadas entre 1997 y 2019, en 39 pacientes con antecedente de osteotomía tibial alta. Se evaluaron los parámetros clínicos y radiográficos antes de la artroplastia y después, determinando el eje femorotibial, la caída tibial a posterior, el valor de Insall-Salvati y el *Knee Society Score*. También se compararon los resultados en pacientes con antecedente de osteotomía tibial sustractiva vs. aditiva. **Resultados:** El seguimiento promedio fue de 5.72 años (mín. 1, máx. 19). El *Knee Society Score* de la serie tuvo una mejoría promedio de 42,3 a 79,8. La caída posterior tibial y el índice de Insall-Salvati no sufrieron grandes modificaciones luego de la cirugía. La supervivencia promedio de la osteotomía aditiva hasta la conversión a reemplazo total de rodilla fue de 5.5 años, mientras que la de la sustractiva, de 13.5 años. **Conclusiones:** Pese a la dificultad técnica que puede plantear, el reemplazo total de rodilla luego de una osteotomía tibial alta valguizante tuvo una buena evolución clínico-radiográfica a corto y mediano plazo, y el tipo de osteotomía no repercutió en los resultados luego de la artroplastia.

Palabras clave: Reemplazo total de rodilla; osteotomía tibial alta; osteotomía de cierre; osteotomía de apertura.
Nivel de Evidencia: IV

Received on November 3rd, 2020. Accepted after evaluation on May 11th, 2021 • Dr. FERNANDO TILLET • fernandotillet@icloud.com https://orcid.org/0000-0003-2658-9856

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INTRODUCTION

High tibial osteotomy is indicated for arthritic genu varum in early stages, usually in young and active people, but good initial outcomes tend to deteriorate over time. In such cases, conversion to total knee replacement is indicated, which has an incidence of 23% at 10 years.[1]

Conversion from high tibial osteotomy (HTO) to total knee replacement (TKR) has been suggested to be a more technically demanding procedure than primary arthroplasty. This is due to the possible difficulty in extracting the osteosynthesis material, the previous surgical approach, the frequent decrease in the range of motion, the height of the patella, and the management of ligament balance. In addition, after HTO, the anatomy of the proximal tibia may be altered as a result of the change in the angle of the posterior tibial slope, the translational displacement of the epiphysis with respect to the metaphysis, with the consequent discordance with the tibial anatomical axis, and the risk of contact of the tibial keel or stem with the cortical.[2]

Several authors published less satisfactory outcomes in patients with a history of HTO compared to those who underwent primary arthroplasties.[3]

TKR after a closing wedge HTO compared to an opening wedge one achieves a similar outcome, although more technical difficulties are reported in the former.[3,4]

Our objective was to analyze the clinical and radiographic outcomes of conversion to TKR after HTO and to compare the evolution of patients with a previous closing wedge HTO versus an opening wedge HTO.

MATERIALS AND METHODS

We carried out a retrospective descriptive study between 1997 and 2019. We included patients with a history of valgus HTO, both opening and closing, who had undergone TKR and completed a minimum follow-up of one year. The exclusion criteria were: Varicose HTO, follow-up <1 year, and incomplete clinical-radiographic data in the medical records.

The series included 46 arthroplasties in 39 patients (7 bilateral cases). Thirty-nine (84.78%) had a previous subtractive HTO and seven (15.21%) had an additive one. The characteristics of the studied population are detailed in Table 1.

Table 1. Characteristics of the sample.

	Opening HTO	Closing HTO	p
n (%)	7 (15.22)	39 (84.78)	
Sex (%) Male Female	 3 (42.86) 4 (57.14)	 16 (41.03) 23 (58.97)	0.92
Laterality (%) Right Left	 7 (100) 0 (0)	 21 (53.85) 18 (46.15)	0.02
Age when HTO was performed ± SD	51.14 ± 7.62	58.05 ± .7.05	0.06
Age when TKR was performed ± SD	56.57 ± 6.39	71.30 ± 6.50	0.001
Time between HTO and TKR ± DE	5.57 ± 5.12	13.04 ± 6.98	0.007

HTO = high tibial osteotomy, TKR = total knee replacement, SD = standard deviation.

Surgical technique and prosthesis

All prosthetic surgeries were performed in a laminar flow operating room under hypotensive spinal anesthesia. In 18 knees (39.1%), the HTO was fixed with a plate; in 10 (21.7%), with staples; and in another 18 (39.1%), no osteosynthesis material was used and they were treated with cast immobilization until their consolidation. Of the 28 patients with osteosynthesis material, either staples or plate, only three had the material removed in a surgical stage before TKR due to suspected infection (which was negative), while in the other 25, the osteosynthesis material was removed in the same procedure.

Regarding the approach, in knees with opening HTO, the medial parapatellar approach was used, which allowed direct access. Through it, the osteosynthesis material was removed and the arthroplasty was performed (Figure 1). On the other hand, in the closing HTOs with plates and screws, two independent approaches were used: one on the lateral scar to remove the osteosynthesis and another anterior longitudinal one through which the TKR was performed, always leaving a minimum space of 5 cm between both incisions. As an alternative, in three patients, it was decided to remove only the proximal osteosynthesis screws through small incisions to free the proximal segment of the tibia and place the tibial component leaving the osteosynthesis *in situ* (Figure 2).

Figure 1. A. Preoperative knee radiograph with a history of anterior cruciate ligament reconstruction and opening valgus osteotomy 11 years before conversion to total knee replacement. **B.** Postoperative anteroposterior and lateral knee radiograph after conversion to total knee replacement.

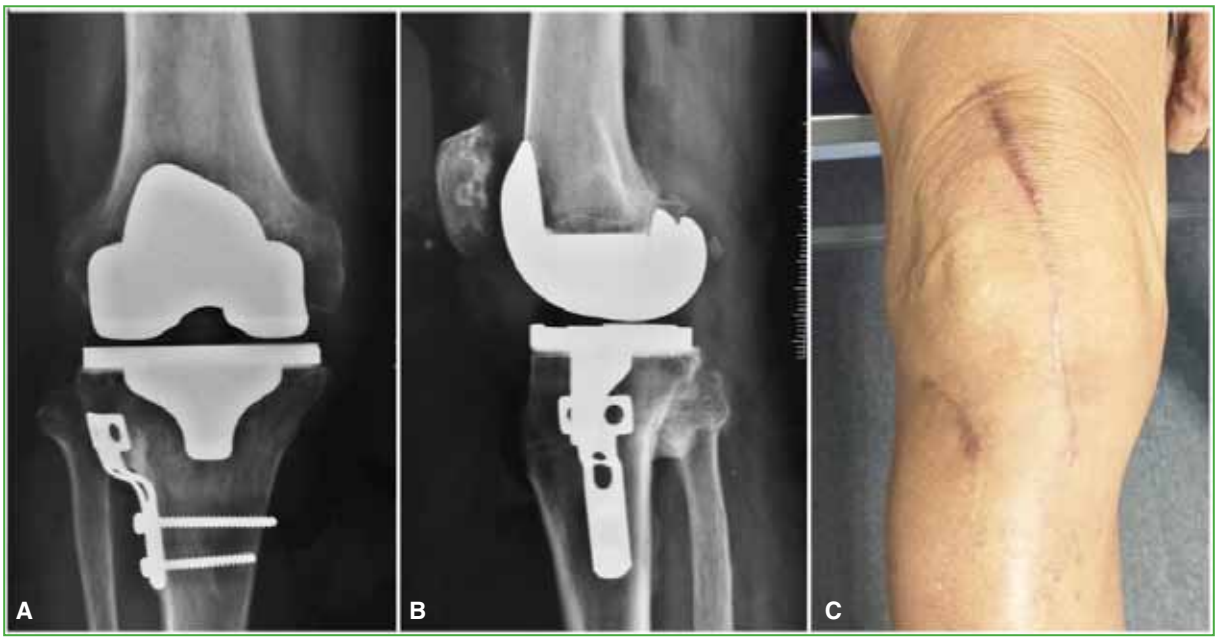

Figure 2. Anteroposterior (**A**) and lateral (**B**) knee radiographs. The tibial component is observed with the osteosynthesis in situ, trying to avoid contact between the two. **C.** There is a good evolution of the skin and soft tissues after total knee replacement.

Arthrotomies were medial; in nine instances (19.5%), it was necessary to perform a rectus snip to evert the patella. A release was performed in non-reducible valgus cases to obtain ligament balance, this was achieved through the resection of the iliotibial band and, if necessary, the osteotomy of the lateral epicondyle and the release of the posterior external capsule. In recurrent varus cases, classical medial release was sufficient.

The patellar prosthesis was placed in 20 of the 46 TKRs, according to the state of the patella during surgery and the preference of the treating surgeon.

Tibial stems were used in seven cases in order to bypass the area of weakness generated by the HTO (Figure 3). In addition, a stem was placed in a patient with a delayed union at the site of the HTO and in another with a severe valgus of 25°, in which a constrained prosthesis was used.

Figure 3. A. Subtractive valgus osteotomy radiograph with evident undercorrection and failure before 1 year. **B.** Anteroposterior and lateral knee radiographs after conversion to total knee replacement.

On two occasions, offset stems were used due to the lateral translation of the tibial epiphysis and the medialization of the medullary canal.

The components of the prosthesis were fixed with antibiotic-loaded cement. Antibiotic (24-hour cefazolin) and antithrombotic (low-molecular-weight heparin) prophylaxis were prescribed for all patients. Postoperative controls were carried out at 3 and 6 weeks, 3 and 6 months, and then annually. The prostheses used are detailed in Table 2.

The data were obtained from the electronic medical records and the radiographic file. Demographic data, type of implant used, and clinical follow-up were analyzed using the Knee Society Score (KSS).[5]

In the preoperative and postoperative radiographic analyses, the femorotibial axis, the posterior tibial slope, and the Insall-Salvati index were measured. To study the loosening of the prosthesis, the Ewald score was used to evaluate the radiolucency lines as follows: 4 lines or less, not significant; 5 to 9 lines, should be closely monitored; and 10 or more lines, possible failure, regardless of symptoms.[6,7]

In addition, the survival of HTO until conversion to TKR, the complications associated with TKR, and the survival of the prosthesis to date were evaluated.

Table 2. Prostheses used

Prosthesis used	Arthroplasties
PFC® SIGMA® (DePuy Synthes)	22
PFC® SIGMA® All Poly (DePuy Synthes)	6
National Insall	5
Scorpio® (Stryker®)	5
Triathlon® (Stryker®)	3
U-Motion™ (United®)	2
Genesis™ II (Smith & Nephew)	1
NexGen® (Zimmer®)	1
Optetrak® (Exactech)	1

Statistical analysis

Quantitative variables are expressed as average and standard deviation, and categorical variables, as a percentage. The t-test was used to compare the differences in quantitative variables between the groups, and the chi-square test for the differences between proportions. A p-value <0.05 was considered statistically significant. The STATA version 13.0 program was used for the statistical analysis.

RESULTS

The average follow-up of the TKR was 5.72 years (range 1-19). In clinical outcomes, an average KSS improvement from 42.3 to 79.8 was observed. Radiographic parameters also had a favorable evolution. An average postoperative femorotibial valgus axis of 5.39° was obtained (no patient with varus axis after TKR), as well as a posterior tibial slope of 3.10°, and an Insall-Salvati index of 0.89 (Table 3).

Table 3. Clinical-radiographic evolution of the patients before and after total knee replacement.

	Before total knee replacement	After total knee replacement
Femorotibial axis in valgus (°) ± SD	3.73 ± 5.70	5.39 ± 2.36
Posterior slope (°) ± SD	3.86 ± 3.63	3.10 ± 2.30
Insall-Salvati index ± SD	0.91 ± 0.11	0.89 ± 0.16
KSS ± SD	42.34 ± 7.53	79.86 ± 6.88

SD = standard deviation, KSS = Knee Society Score.

Likewise, according to the Ewald radiographic score, only three patients (6.52%) had a radiolucent line <2 mm, although with no clinical repercussions.[7]

After the arthroplasty, the following complications were recorded: wound dehiscence in the distal third, which resolved with a flat dressing in six weeks; a case of erysipelas distal and ipsilateral to the arthroplasty, treated with oral antibiotics; a periprosthetic infection in the early postoperative period, which required surgical cleaning, without recurrence so far; a case of instability of the prosthesis in flexion, resolved by placing a larger tibial insert; and, lastly, a case of stiffness, accompanied by patella baja, with a postoperative flexion-extension range of 10° -70°. This last patient underwent mobilization under anesthesia two months after TKR, obtaining a range of 10° to 120°.

Four patients died during the study, none from surgical complications, and all of them had completed a minimum follow-up of five years.

DISCUSSION

After a satisfactory initial evolution, the result of an HTO deteriorates over time, the survival rate ranges between 71% and 95% at 5 years, and between 51% and 98% at 10 years.[8-11] According to some authors, it is estimated that the annual failure rate increases markedly after 11 years.[3]

In this series, the survival rate for an HTO was approximately 11.9 years, with even more favorable results in the closing HTO group compared to the opening group (13.04 vs. 5.57 years.) However, this piece of information is biased, since the closing HTOs were carried out between 1981 and 2006; and the opening HTOs, between 2007 and 2016. Therefore, the follow-up of the latter was shorter as it was a later procedure.

There is no consensus in the literature on whether the material should be withdrawn in one or two stages. Mont et al. highlighted that the advantage of performing it in two stages is that it results in a more predictable surgery and allows samples to be taken for culture. However, a single-stage procedure reduces costs and is more comfortable for the patient, since a second procedure is avoided.[12]

In our series, of the 25 knees that had osteosynthesis, the material was removed in the same surgical stage in 22 cases, whereas in the remaining three cases it was removed in two stages. In the remaining 21 cases, the knee was immobilized with a plaster cast, so there was no need to remove the osteosynthesis material.

The most common surgical challenge is patellar eversion; therefore, the rectus snip is the most commonly used technique to achieve joint exposure. In our series, it was performed in nine patients (19.5%), of which seven were from the closing HTO group and two from the opening HTO group; these data are similar to those reported by other authors, such as Gill et al. (23%), Bastos Filho et al. (25%), and Mont et al. (<40%).[13-15] Regarding these findings, a systematic review found greater technical difficulties in joint exposure in closing HTOs, which made it necessary to perform the rectus snip or the osteotomy of the anterior tuberosity of the tibia more frequently.[16]

The literature reports that HTO, both closing and opening, predisposes to patella baja. Lateral closing HTO causes the proximity of the anterior tuberosity of the tibia to the joint interline, which would theoretically cause patella alta; however, patella baja is more likely to occur due to the immobilization and postoperative fibrosis of the patellar tendon. This fibrosis and shortening of the patellar tendon could be one of the causes of the difficulty to evert the patella that arises in these patients.

After TKR, only 30.43% (14 patients) had an Insall-Salvati index <0.8, five of them already had this condition before joint replacement and only one of them was accompanied by postoperative stiffness, with a flexion-extension range between 10° and 70°. This percentage is low when compared with that reported by Haddad and Bentley (50%), who also describe it as a frequent finding.[17,18] Furthermore, when evaluating the variation of the Insall-Salvati index after arthroplasty, did not obtain significant changes, as published by Song et al.[3]

Patella replacement remains a controversial issue and, in this series, patella arthroplasty was performed in slightly less than half of the cases (43.4%), when the surgeon considered that there was evident patellar deterioration during surgery. The results do not show a clinical difference between those with or without a patella prosthesis.[3,19]

The rate of complications reported in knees with a history of HTO converted to TKR is 6-15%,[4] similar to our findings, which corresponded to five knees (10.8%). Two required revision: one case due to flexion instability in which the tibial insert was replaced with a thicker one and another due to an infection in the immediate postoperative period that was resolved by surgical debridement. The main cause of revision reported in the literature, however, is aseptic loosening. We have not registered this finding until the end of follow-up.[20]

Regarding the clinical and radiographic outcomes by HTO type, we did not obtain significant differences between these groups, as shown in Table 4, which coincides with what was found in a systematic review of 10 studies.[16]

Finally, we highlight the clinical and functional improvement obtained after TKR, evaluated using the KSS, taking into account that published studies report a decreased range of motion in this group of patients.[3,14,19,21-23]

Table 4. Evolutionary comparison according to the type of high tibial osteotomy.

	Opening HTO	Closing HTO	p
Femorotibial axis (°) ± SD			
Before TKR	3.85 ± 2.96	3.71 ± 6.09	0.92
After the TKR	6.42 ± 1.27	5.20 ± 2.47	0.06
Posterior slope (°) ± SD			
Before TKR	7 ± 6.11	3.30 ± 2.75	0.16
After the TKR	2.28 ± 2.43	3.25 ± 2.27	0.35
Insall-Salvati index ± SD			
Before TKR	0.93 ± 0.14	0.91 ± 0.11	0.72
After the TKR	0.90 ± 0.16	0.87 ± 0.17	0.93
KSS ± standard deviation			
Before TKR	41.86 ± 6.61	42.43 ± 7.76	0.84
After the TKR	80.57 ± 6.75	79.74 ± 6.98	0.77

SD = standard deviation, TKR = total knee replacement, KSS = Knee Society Score.

One of the main limitations of our series is its retrospective nature and the size of the sample, since there is a difference between the groups compared.

As expected, not all HTOs were performed at our institution, which generates a heterogeneous sample, while all arthroplasties were performed at our institution with the same surgical technique.

In our case series, good outcomes were obtained in the short and medium term, with both clinical and radiographic improvement after conversion, and patella baja was a frequent finding, although without clinical repercussion.

No differences were found in the evolution of the TKRs between the closing and opening HTOs; still, it is necessary to emphasize the technical differences regarding the approach and removal of osteosynthesis.

To our knowledge, there are at least two publications on the results of TKR after subtractive HTO; ours is the first study that compares the outcomes of subtractive and additive HTO.[24,25]

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

J. A. Rodríguez ORCID ID: https://orcid.org/0000-0002-1089-3071
H. del Sel ORCID ID: https://orcid.org/0000-0002-3655-1408
F. A. Lopreite ORCID ID: https://orcid.org/0000-0002-2065-8649

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