Constrained prosthesis in primary total knee arthroplasty

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Abstract

Introduction: The objective of this retrospective study was to show the functional results and indication criteria for prostheses for primary TKA with more constraint than posterior stabilization.

Methods: Forty-three TKA were analyzed in 40 patients, with an average follow-up of 6.2 years. Preoperative diagnoses were valgus osteoarthritis (38 cases) and varus osteoarthritis (5 cases). Sufficiency of the collateral ligaments was classified as sufficient, attenuated or incompetent, through physical examination and X-rays with varus-valgus stress. Functional results were evaluated using the KSS.

Results: Posterior-stabilized plus implants were used in 28 cases, with an average alignment of 15.9°: 26 were valgus knees, 21 of which presented sufficient and 5 attenuated ligaments. Constrained prostheses were used in 7 patients with an average valgus alignment of 21.6° (2 with sufficient and 5 with attenuated ligaments). Rotating-hinge prostheses were used in 8 patients, 5 with an average valgus alignment of 24.6° (3 of them associated with recurvatum), 4 with incompetent ligaments and one with attenuated ligaments. The average post-operative KSS was 84 (range 73-94) points. No instabilities were detected and prosthetic survival was 100% at the end of the follow-up.

Conclusions: We recommend using posterior-stabilized plus implants in deformities <20°, with sufficient collateral ligaments and no bone defects; constrained prosthesis in patients with greater deformity (>20°) and collateral ligaments with some degree of sufficiency (attenuated at the most); and rotating-hinge implants in knees with collateral or multidirectional ligament insufficiency, associated with recurvatum, significant bone defects or severe deformities in rheumatoid arthritis or with neuropathic origin.

Key words: Valgus; recurvatum; instability; constrained prosthesis; rotating-hinge implant.
Level of Evidence: IV

Indicación y resultados de la prótesis con estabilidad aumentada en la artroplastia primaria de rodilla

Resumen

Introducción: El objetivo de este estudio retrospectivo fue mostrar los criterios de indicación para implantes con una estabilidad superior a la estabilización posterior en la artroplastia total de rodilla primaria, puntualizando su estabilidad y resultados funcionales.

Materiales y Métodos: Se analizaron 43 artroplastias totales de rodilla en 40 pacientes, con seguimiento promedio de 6.2 años; 38 casos con deseje valgo y 5 en varo. La suficiencia de los ligamentos colaterales se definió como suficiente, atenuada o incompetente, mediante maniobras y radiografías con estrés varo-valgo. Los resultados funcionales se evaluaron mediante el KSS.

Conflict of interests: The authors have reported none.

Resultados: Se utilizaron 28 prótesis con estabilización posterior plus en pacientes con deseje coronal promedio de 15,9° (21 presentaron ligamentos suficientes y 5 atenuados). Prótesis constreñidas en 7 pacientes con deseje valgo promedio de 21,6° (2 con ligamentos suficientes y 5 atenuados). Se utilizaron 8 prótesis abisagradas rotatorias, 5 en pacientes con genu valgo promedio de 24,6° (3 asociados a recurvatum), 4 con ligamentos incompetentes y 1 con ligamentos atenuados, y 3 genu varo de 16° promedio. El KSS promedio posoperatorio fue de 84 (rango 73-94). No se detectaron inestabilidades. La supervivencia protésica fue del 100% al final del seguimiento.
Conclusiones: Se recomienda utilizar las prótesis estabilizadas plus en desejes < 20°, con ligamentos colaterales suficientes en ausencia de defectos óseos y las prótesis constreñidas en pacientes con grandes desejes con ligamentos colaterales y algún grado de suficiencia (a lo sumo atenuados). Las prótesis abisagradas rotatorias se reservan para rodillas con incompetencia ligamentaria colateral o multidireccional, grandes defectos óseos o deformidades severas en artritis reumatoide o de origen neuropático.

Palabras clave: Genu valgo; recurvatum; inestabilidad; constreñido; bisagra rotatoria.
Nivel de Evidencia: IV

Introduction

Instability in the tibio-femoral joint can show in the coronal (varus-valgus) plane, the sagittal (AP) plane, or in a combination of both (multidirectional instability). [1-4] At the time of carrying out primary total knee arthroplasty (TKA), the use of an implant with enhanced stabilization (greater than that in a posteriorly-stabilized prosthesis) is infrequent. This should be considered in knees where it is not possible to get adequate stabilization by soft tissues-intraoperative balance due to partial or complete insufficiency of collateral ligaments, especially the medial collateral ligament (MCL).[1-3] This should be evaluated in the preoperative patient's assessment.

In knee osteoarthritis, ligament insufficiency is relatively frequent in severe knee valgus deformity (>20º)[4] in patients with sequela of poliomyelitis or neuropathic arthropathy, and even due to iatrogenic intraoperative injuries of the MCL.[1,3,5-8]

Severe knee valgus osteoarthritis (>20º) oftentimes shows some degree of MCL insufficiency; therefore, a standard implant may not be able to get a stable knee, especially medium-term stability.[1,4,7,8]

On the contrary, that severe knee varus osteoarthritis requires an implant with greater stabilization is less frequent, because the lateral collateral ligament is usually sufficient.

Prostheses with polyethylene plus (Sigma Plus®, DePuy®, Johnson & Johnson®) have a posterior stabilization post which is slightly higher and wider than the standard one is. These implants require sufficient collateral ligaments and represent just little assistance in knee postoperative stability, which will still depend on ligaments and other soft tissues.

Constrained implants have a central post which is higher and wider than those in the previous ones, sometimes with a central metallic reinforcement which fits in between prosthetic femoral condyles in femoral implants with more significant drawer than the standards, what generates coronal and sagittal stability. The femoral and tibial components are not linked to each other; therefore, they require some degree of ligament sufficiency. These implants allow the patient to make 2º or 3 º axial and rotational movements, but the central post has not been designed to sustain such complete loads in the medium and long terms. These implants have acceptable medium-term survival, but little is known about them beyond the 10th postoperative year.[2,3,9-11]

Rotating-hinge prostheses are mechanically stable in all directions because the tibial and femoral components are linked to each other by an axis that prevents the device from rotating and translating on the coronal and sagittal planes. These implants do not require ligament sufficiency whatsoever.

In the medium and long terms, the use of more constrained implants involve potential problems, such as wear, rupture of the stabilization elements, and risk of mechanic loosening due to the transmission of stress to the interface.[2,9,12,13] The purpose of this study is to define a clear method of assessment in patients with knee osteoarthritis associated with ligament insufficiency, and describe the indication of prostheses with enhanced stabilization in primary TKA, as well as their functional results.

Materials and Methods

Between 2006 and 2014 we carried out 1079 primary TKAs at the Center we work at—in 45 patients (4.17%) we used prostheses with a degree of stabilization greater than that in posteriorly-stabilized prostheses.

The inclusion criteria were: 1) primary TKA, 2) the use of an implant with a degree of stabilization greater than that in posteriorly-stabilized prostheses, 3) minimal 3-year follow-up.

Two patients were excluded from the study because they did not meet a minimal follow-up; therefore, the series was made up of 43 TKAs in 40 patients (34 females and 6 males who averaged 68.7 years of age [ranging from 41 to 84]) and met a minimal follow-up of 6.2

years (ranging from 3 to 11). Twenty of them were right TKAs, whereas 23 were left TKAs. Three patients were operated on in both knees—two of them simultaneously, and the other one with a 14-month interval. Preoperative diagnoses were: 38 knees with knee valgum osteoarthritis (4 of them with knee recurvatum), and 5 with knee varum osteoarthritis (1 of them with knee recurvatum) (Table 1).

Preoperative Assessment

We evaluated stability and joint range of motion, ligament sufficiency, occurrence of bone defects and the type and severity of knee deformity.

We evaluated ligament sufficiency in both collateral ligaments with varus-valgus stress maneuvers, relating findings at physical examination to monopodalic bearing AP, lateral, axial and varus-valgus stress AP knee X-rays to evaluate ligament sufficiency and joint stability (clinical evaluation can underestimate real instability)[10].

Table 1. Preoperative diagnoses

Preoperative diagnoses	n (%)
Idiopathic valgus deformity	30 (69.7)
Idiopathic valgus deformity + recurvatum	3 (6.9)
Idiopathic valgus deformity + recurvatum + tibial bone defect	1 (2.3)
Post-traumatic valgus deformity	2 (4.6)
Valgus deformity in rheumatoid osteoarthritis	2 (4.6)
Idiopathic varus deformity	4 (9.3)
Idiopathic varus deformity + tibial bone defect	1 (2.3)

We regarded collateral ligaments (usually the MCL) as sufficient when stress maneuvers did not increase joint deformity; as attenuated, when stress maneuvers did in-

Figure 1. A. Patient showing 22º-valgus knee misalignment with attenuated medial collateral ligament. **B y C.** Patient with Ahlback's grade 5 knee varus osteoarthritis and significant bone defect in medial tibial plateau. **D.** Rotating-hinge plus autograft in medial tibial pleateau.

Figure 2. A. Seventy-one year-old female showing severe left knee valgus osteoarthritis and incompetent medial collateral ligament. **B y C.** Monopodalic bearing and valgus-stress X-rays showing bone defect in lateral tibial plateau and increase in deformity (55º) with no mechanic ligament stop (incompetent medial collateral ligament). **D.** Rotating hinge. Immediately postoperative X-ray. **E.** Three years after the surgery, visible space between tibial plateau and implant, what is usual in this prosthetic design.

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crease joint deformity but showed a clear mechanic stop (Figure 1); and as incompetent, when knee deformity increased like a hinge, with no stop (Figure 2).

We used the Ahlback classification for knee varus osteoarthritis: grade 1, <50% medial compartment narrowing; grade 2, complete medial joint narrowing; grade 3, <5 mm tibial bone defect; grade 4, >5 mm tibial bone defect; grade 5, tibio-femoral subluxation (Figure 1).

For knee valgus osteoarthritis we used a classification aimed at relating in a reproducible way the knee about to be treated to the type of implant: grade 1, <50% lateral compartment narrowing; grade 2, complete lateral joint narrowing with <20º valgus deformity; grade 3, >20º knee valgus osteoarthritis (severe deformity) with sufficient MCL; grade 4, knee valgus osteoarthritis with attenuated MCL; grade 5, knee valgus osteoarthritis with incompetent MCL or >10º recurvatum. Any of such grades (especially the most severe ones) can be described with or without bone defects.

We used routinely the least possibly stabilized implant.

Surgeries were carried out at a laminar flow surgical theatre with hypotensive spinal anesthesia and hemostatic cuff. We used a medial parapatellar approach in all cases and we administered three doses of 1 g- i.v. cefazolin (before, during and after the surgery). We administered low-molecular weight heparin as antithrombotic prophylaxis. In the cases of severe knee valgus deformity, we carried out progressive release and balance of soft tissues starting by the tenotomy of the tensor fasciae latae muscle, the release of the lateral collateral ligament by osteotomy of the femoral lateral epicondyle, and popliteal section only if required.

In no cases did we carry out ligament reparation, including patients with incompetent ligaments.

The enhanced-stabilization plus prostheses that we used were 28 PFC Sigma® (DePuy®, Johnson & Johnson®, Warsaw, IN, US); constrained prostheses were six TC3® (DePuy®, Johnson & Johnson®, Warsaw, IN, US) and one Optetrak® (Exactech®, Gainesville, FL, US), and rotating-hinge prostheses were seven Endo-Modell® (Waldemar Link®, Hamburgo, Germany) and one Rotax® FII SA (Saint Just Malmont, France).

Postoperative clinical and radiological checkups were conducted at postoperative weeks three, six and nine, three and six months after the surgery and then on a yearly basis.

We used the Knee Society Score for clinical evaluation.[14] We evaluated prosthetic demarcation, signs of wear and prosthetic failure, considering implant failure as need for revision.

Results

We used posteriorly-stabilized plus prostheses in 28 knees with average coronal misalignment of 15.9º. Among these ones, 26 showed knee valgus osteoarthritis (ranging from 8º to 25º); 18 were classified as grade 2 in the new classification; three were classified as grade 3; and five, as grade 4. The remaining two knees had 2º and 9º-knee varus osteoarthritis and were classified as Ahlback's grade 4.

We inserted constrained prostheses in seven patients with knee valgus osteoarthritis and average misalignment of 23º (ranging from 17º to 37º) (Figure 1, Table 2). Two knees were classified as grade 3 and, five, as grade 4 in the classification of knee valgus osteoarthritis.

We used rotating-hinge prostheses in eight knees (Table 3); three in patients with knee varus osteoarthritis and average misalignment of 16º, and five in patients with knee valgus osteoarthritis and average misalignment of 24.6º. Among the five patients with knee valgus osteoarthritis, one was classified as grade 4 and the remaining four, as grade 5.

In one case it was necessary to use a metallic supplement in the medial tibial plateau in a loose bone defect whereas, in another case, we used autograft due to a fixed bone defect.

Whenever we used constrained or hinged prostheses, we used femoral and tibial cemented stems.

Average preoperative mobility was 106º (ranging from 80º to 135º) and average postoperative mobility was 109º (ranging from 80º to 125º). Stabilized plus prostheses showed average 107º; constrained prostheses, average 108.7º, and rotating-hinge prostheses, average 110.5º.

Only one case in the series did not get complete knee extension. It was the case of a patient with rheumatoid osteoarthritis who received rotating-hinge prosthesis and, at last follow-up, showed 5º of knee extension deficit.

We did not verify any case of residual instability at postoperative checkups.

The average postoperative Knee Society Score was a 84-score (ranging from 73 to 94), what implies a 33-score improvement as compared with the preoperative 51-score (ranging from 40 to 59);on the other hand, the functional score improved from an average preoperative 56-score

Table 2. Data about patients with constrained implants

Patient	Valgus misalignment	Degree	Extra-information
1	25°	4	
2	22°	4	Post-traumatic deformity
3	22°	3	Rheumatoid osteoarthritis
4	37°	4	
5	20°	3	
6	18°	4	
7	17°	4	
Average	23°		

Table 3. Information about the preoperative characteristics of the patients who received rotating-hinge prostheses

Misalignment	Valgus	Varus	Grade	Recurvatum	Detalle
Varus		16°	Ahlback 4	24°	Stroke
Varus		10°	Ahlback 4		Ataxia
Varus		22°	Ahlback 5		Bone defect
Valgus	12°		Valgus 5	30°	
Valgus	28°		Valgus 5	15°	
Valgus	12°		Valgus 5	15°	
Valgus	16°		Valgus 4		Rheumatoid osteoarthritis
Valgus	55°		Valgus 5		Bone defect
Average	24,6°	16°		21°	

(ranging from 34 to 62) to an average postoperative 79-score (ranging from 70 to 82).

Five patients (11.6%) needed a cane as permanent assistance for outdoors walking after the surgery. Seven patients (16.3%) reported postoperative pain and need for sporadic pain-killers. All of them reported satisfaction with the procedure at last checkup.

Postoperatively knees showed average 4.2º-valgus axes (ranging from 0º to 9º). Four knees showed a final varus axis—two of them neutral axes (0º), and two, final 2º-valgus axes.

Three tibial components were inserted in varum position, in 2º-varus alignment on average, with no clinical impact so far.

Four patients (9.3%) had demarcation in some of the prosthetic components. One patient with rotating-hinge prosthesis showed demarcation in tibal zone 1 in the tibial AP X-ray at 2-year postoperative follow-up. Three patients with stabilized plus prostheses had demarcation in tibial zones 1 and 4 in the tibial AP X-ray and in tibial zone 2 in the tibial lateral X-ray. All these patients were asymptomatic up to their last follow-up.

No prosthesis was revised up to patients' last follow-up.

There were two minor complications (4.65%). One patient with rotating-hinge prosthesis had symptomatic patellar subluxation and was treated with physiotherapy, with moderate success. Another patient who had received a constrained prosthesis showed delay in the distal closure of their surgical wound due to tissue suffering, what led to frequent dressing changes with favorable results.

Discussion

We used implants with enhanced stabilization in knees with some degree of collateral ligament insufficiency, recurvatum or impaired muscle scores. Severity of joint deformity and misalignment were not determinant factors at the time of choosing the implant, because we verified different degrees of ligament sufficiency in knees with similar misalignment profiles, and not always severe misalignment was correlated to ligament attenuation or incompetence. This can be verified in that misalignment average in patients who received rotating-hinge prostheses was similar to misalignment average in those who received constrained implants.

Five knees with plus implant had attenuated MCL. All these patients were operated on by the most experienced surgeon in the team, what suggests that the selection of the constraint degree of the implant could be reversely proportional to the surgeon's experience. The more experienced the surgeon, the less constrained the implant.

This report includes the surgical team's learning curve in the field of the use of different degrees of constraint, what may have generated some discrepancies in indications to patients with similar knee misalignment or knee instability degrees.

Most knees that received constrained implants or rotating-hinge prostheses had some degree of collateral ligament insufficiency.

Constrained prostheses were indicated to knees with insufficiency only on the coronal plane (5 patients with attenuated MCL), without serious bone defects or neuromuscular conditions (Table 2). On the other hand, rotating-hinge prostheses were indicated to patients with MCL incompetence (4 cases) or some co-morbidity that affected knee stability (recurvatum, ataxia, etc.) (Table 3).

At the time of carrying out pre-operative physical examination, it is necessary to evaluate the status of collateral ligaments stating clearly their sufficiency, attenuation or incompetence, and recording these assessments along with their respective stress X-rays. It is essential to repeat physical examination at immediately preoperative checkups to confirm the degree of collateral ligament suf-

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ficiency, because in two cases it was necessary to change indications from constrained implant to rotating-hinge prosthesis because patients developed a complete injury of the MCL within the month previous to surgery. Both patients showed >20º knee valgus osteoarthritis and decided to undergo surgical treatment in view that they were not able to walk due to sudden pain, what was interpreted as the final stages of medial collateral ligament injury.

Lachiwicz et al.[7] report prosthetic survival rates of 96% at postoperative year 10 in 54 patients operated on with a constrained implant TC3®. Patients had average 20º knee valgus osteoarthritis associated with MCL insufficiency or intraoperative misbalance in flexion-extension gaps. Among complications they report one case of posterior dislocation, two cases of mechanic loosening and one case of late infection.

Maynard et al.[15] analyzed 127 cases with a minimal follow-up of seven years. In all of them the decision of using constrained implants was intraoperative due to >5mm medial or lateral collateral ligament insufficiency. Complication rates in this series are significant (19.7%), the most frequent ones being patellar click (4.7%) and peri-prosthetic fracture (3.2%). They report reoperation rates of 10.2% with 97%-prosthetic survival at postoperative year 10. In this series, they used constrained implants in patients with average misalignment of 23º (ranging from 17º to 37º) and instability only on the coronal plane. They do not report complications with this prosthetic model.

Petrou et al.[16] report survival rates of 96.1% at postoperative year 15 in their series of 100 primary TKAs (Endo-Modell®); they also report two infections, one prosthetic dislocation and one peri-prosthetic fracture. However, they do not specify the preoperative diagnoses that led them to indicate this degree of prosthetic constraint.

Likewise, Kowalczewski et al.[17] used Endo-Modell® prostheses in primary surgeries and report 12 cases with a minimal follow-up of 10 years in patients with severe misalignment, undefined MCL instability and knee flexion contracture.

Yang et al.[18] published 50 cases with 15-year follow-up in unstable knees, patients with rheumatoid osteoarthritis, ligament laxity and bone stock deficit. They highlight the frequent patients' need for some kind of postoperative assistance to walk and infection rates of 14%.

Hernández Vaquero et al.[19] published 26 cases treated with rotating-hinge prostheses in patients with collateral ligament insufficiency. Among these ones, only five were primary TKAs with valgus misalignment between 20º and 30º, combined with MCL insufficiency or bone defects. Although results of primary surgeries and revisions are not differentiated between them, and there is just 24-month follow-up, they report three revisions, two due to infection and the other one due to peri-prosthetic fracture. Among indications of primary TKA they include severe misalignment (without specifying degrees), instability due to loss of bone stock, comminute fracture or distal femur non-union in old people, muscle deficit, tumor resection, congenital knee dislocation and ankylosis with severe postoperative instability.

Gehrke et al.[20] describe the indications or rotating-hinge prostheses and recommend that they are used only in selected patients, of old age, with ligament insufficiency, (varus or valgus) >20º misalignment, significant bone defects that require re-insertion of collateral ligaments, significant misbalance in the flexion-extension gap, ankylosis or hyperlaxity.

In this series and coincidentally with the aforementioned authors, we used rotating-hinge prostheses in patients with 10º to 55º misalignment, ligament insufficiency, multidirectional instability, bone defect, neuromuscular misbalance or rheumatoid osteoarthritis.

In the cases of knee varus osteoarthritis, the degree of constraint increased proportionally to the reasons for non-ligament joint instability (stroke, ataxia, bone defect). It is worth mentioning that, in the patient with Ahlback's grade 5- knee varus osteoarthritis and bone defect treated with rotating-hinge prosthesis (Figure 1), after bone cutting we noticed that flexion and extension drawers were symmetric and stable and, although we had suspected attenuation in the lateral collateral ligament, this one was functional.

On the other hand, in the cases of knee valgus osteoarthritis, the reasons for enhanced prosthetic constraint was, in general, some degree of MCL insufficiency or recurvatum. The rule was that the constraint degree decreased proportionally to the surgeon's experience and even in relationship with every particular surgeon, as their professional experience increased.

The limitations of this study are the ones inherent in retrospective designs, including this condition's learning curve and the different prosthetic models that we used which, oftentimes, generate discrepancies in doctors' indications. Moreover, follow-up in this series is insufficient to assess prosthetic survival rates. The strengths of this study are its number of patients, patients' equal preoperative and postoperative assessment, patients being operated on by the same surgical team, the similar surgical technique that we used in all of them, and the fact of having included only primary surgeries.

Conclusions

Although the design of this work does not allow us to define indications when it comes to the use of these prosthetic models, we can infer that posteriorly-stabilized plus implants should be indicated to <20º misalignments with sufficient collateral ligaments. However, an experienced surgeon may well use them even in knees with attenuated MCL.

Varus-valgus constrained models should be indicated to knees with significant misalignment, but only attenuated collateral ligaments.

On the other hand, rotating-hinge prostheses should be used in knees with collateral ligament incompetence, combined instability, recurvatum deformity and some degree of neuromuscular deficit.

All these indications considered, enhanced-stability prostheses get favorable results in all cases at average 6.2-year follow-up in primary TKA.

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