Increased posterior translation but similar clinical outcomes using ultracongruent instead of posterior stabilized total knee arthroplasties in a prospective randomized trial

ABSTRACT

**Purpose:** The aim of this study was to compare the posterior tibial translation after ultracongruent (UC) and posterior-stabilized (PS) total knee arthroplasty (TKA) with two different UC with different heights in the anterior lip, and two different PS designs. This study also aimed to compare the range of motion (ROM) and outcomes scores after the use of these TKA models. It was hypothesised less posterior tibial translation after PS than after UC TKA, and less posterior tibial translation with a higher anterior lip in the UC insert than with a lower one.

**Methods:** It was designed as a prospective randomized study of a group of 120 patients operated with a cemented TKA. In order to clarify the main purpose of the study, four groups were analysed using different polyethylene designs: Triathlon PS insert in group one, Triathlon UC insert in group two, U2 PS insert in group three and U2 UC insert in group four. One year after surgery, a forced posterior drawer with a Telos Stress applying 15 Kg of force posteriorly on the proximal tibia at 90° of knee flexion was analysed in the lateral radiograph. Limb alignment, tibial posterior slope and posterior condylar offset were also studied.

**Results:** 30 patients were included in each group. The average age was 73 years. There were 72.2% female and 27.8% male patients. There were no significant differences in any demographic or radiographic studied variables, preoperative range of motion (ROM) or preoperative Knee Society Scores (KSS) among the different groups. One year after surgery, the average postoperative ROM and the postoperative KSS Knee and KSS Function scores improved in respect of the preoperative values in all the groups. There were no significant differences in the postoperative outcome scores among the different groups (p=n.s.). Postoperative alignment of the limb, tibial posterior slope and posterior condylar offset were similar in the 4 study groups (p=n.s.). The postoperative posterior tibial translation was different between groups: the PS groups (groups 1 and 3) showed significant inferior values (p<0.001) in respect of the UC groups (groups 2 and 4). There were no differences between both groups of PS models, but there was a significant increase in the posterior tibial translation of the Triathlon UC insert (11.2 mm SD 3.2) in respect of the U2 UC insert (6.1 mm SD 4.5) (p=0.004).

**Conclusions:** UC inserts restrict the posterior tibial translation after TKA less than PS inserts, but a design with a high anterior lip in the polyethylene UC insert can better control the posterior tibial translation than an insert with a small anterior lip.

**Level of evidence:** Level I. Randomised controlled trial

**Keywords:** Total knee arthroplasty; Insert; Posterior-stabilized; Ultracongruent; Knee Society Score; Posterior tibial translation
INTRODUCTION

There is a significant controversy over the importance of the posterior cruciate ligament (PCL) in total knee arthroplasty (TKA). The decision to keep the PCL and use a cruciate-retaining (CR) implant or to sacrifice it and use a posterior-stabilized (PS) implant mainly depends on the surgeon's preference [23, 25]. No difference in outcomes has been demonstrated between CR and PS designs, except for a marginal increase in the knee flexion in PS TKA [25]. However, in certain situations, such as a significant fixed flexion contracture, a PCL insufficiency or a severe malalignment, the sacrifice and substitution of the PCL is almost mandatory [17].

The classical solution to PCL sacrifice has been its substitution by a box and cam mechanism, with a PS implant. However, the box femoral preparation reduces the bone stock in this area [20], can increase the wear because of the contact of the post-cam mechanism [17] and increases the risk of complications such as condyle fractures [22] or patellar clunk syndrome [7]. In the last decades, the ultracongruent (UC) insert with a higher anterior lip has emerged as an alternative to the PS design to be used with a standard femoral component to control the posterior translation of the tibia in flexion after PCL sacrifice [10,20,21]. Many manufacturers have developed UC inserts for TKA [10, 20], but there are big differences in the height of the anterior lip of these inserts, but we suspect that differences in the height of the anterior lip of the UC inserts can influence in the posterior stability of the knee in flexion.

The aim of this study was to compare the posterior tibial translation after UC and PS TKA with two different UC and two different PS designs. The study also aimed to compare the range of motion (ROM) and outcomes scores after the use of these four TKA models. The hypothesis of the study was that less posterior tibial translation can be seen after PS than after UC TKA, and less posterior tibial translation with a higher anterior lip in the UC insert than with a small one.

MATERIALS AND METHODS

This is a prospective randomised study of a group of 120 patients operated on at our institution between March-2018 and November-2018 who had a cemented TKA implanted. After informed consent, patients scheduled for a TKA were asked to participate in this study. Inclusion criteria were unilateral TKA surgery because of primary osteoarthritis and age more than 18 years. Exclusion criteria were partial or revision knee arthroplasties, any prior open surgery on the knee, the use of prosthetic stems or augments, deformities greater than 10° of varus or valgus in the preoperative evaluation and diagnosis of inflammatory arthritis or post-traumatic osteoarthritis.

The morning of the surgery, patients were randomised into one of the four groups based on a randomising computer list generated by Miniwebtool, to be treated with one of the four prosthetic designs. A total of 30 patients were allocated to each group of randomisation using different polyethylene designs: Triathlon Knee System® (Stryker, Mahwah, New Jersey) with PS insert in group 1, Triathlon with UC insert in group 2, U2 Knee System TKA® (United Orthopedic Corporation, Taiwan) with PS insert in group 3 and U2 with UC insert in group 4 (Figure 1). In each case, the employed prostheses consisted in a femoral component made of CoCrMo alloy, a tibial baseplate made of Ti6Al4V alloy and a polyethylene insert. In both PS models, a box in the distal femur was created and a cam-post system was used to prevent an excessive
posterior tibial translation. In both UC models a conventional CR femoral component was used and an insert with an anterior lip higher than the CR insert was implanted: in group 2 (Triathlon UC) the lip was 5 mm high and in group 4 (U2 UC) the lip was 12.5 mm high in average (11.3 to 13.9 mm depending on the insert size) (figure 1). In all cases, the prostheses were implanted with cement and a polyethylene patellar component was used. Five of the randomised patients could not be analysed because they were lost during the follow-up (figure 2).

**Operative technique:**

Prophylactic antibiotics (2gr preoperative cephazolin IV and 1gr/8h postoperative for one day) were used in each case. Vancomycin was used in patients with an allergy to penicillin. Four different surgeons were involved in the procedures. In all cases, the whole procedure was done under ischaemia with a pneumatic tourniquet. A standard anterior incision and a medial parapatellar approach were used. The PCL was sectioned in all the knees and the use of a PS or a UC insert was decided based on randomisation. Standard bone cuts were done. When a PS insert was used, the bone cuts to fit the box in the femur were performed while when a UC insert was used, two holes in the distal femoral cut were done to fit the femoral pegs. When necessary, soft tissue releases were performed to achieve gap differences within 2 mm in flexion and extension [23]. All the prosthetic components were implanted with cement and the patella was replaced in all the knees.

**Clinical analysis:**

For the clinical analysis, the KSS questionnaire in its Spanish validated version [3] was used in the preoperative period and 12 months after surgery. The ROM of the knee was assessed using a goniometer centred on the lateral epicondyle of the femur in the preoperative period and 12 months after surgery.

**Radiographic analysis:**

Preoperative radiographs were taken in the last 3 months before the surgery and postoperative radiographs 1 year after the surgery. A full-length standardised digital anteroposterior view and a true lateral view of the knee centred in the joint line were analysed. The hip-knee-ankle angle was measured on the full-length view and the tibial slope and the posterior condylar offset in the lateral view [24], both in the preoperative and the postoperative analysis.

One year after surgery, a forced posterior drawer with a Telos Stress Device (Telos, Hungen, Germany) applying a 15 Kg force posteriorly on the proximal tibia at 90° of knee flexion was done, as it was described by Sur et al [23]. A remote control was used to assure a true lateral view with correct alignment of both femoral condyles (figure 3).

In 30 consecutive cases the radiographic measurements were assessed twice (at least one-week interval between the two measurements) by two different experienced evaluators, independent of the surgical team. The interclass correlations were 0.83-0.91 for inter-observer measurement correlations and 0.86-0.94 for intra-observer measurement correlations,
indicating an excellent reproducibility of these measurements. The first value of the first evaluator was taken into consideration in those cases.

The present study received IRB approval by the Parc de Salut Mar Ethical Committee (2017/7170/I).

**Statistical analysis:**

A descriptive analysis of the sample was done using number and percentage for categorical variables, and the mean and standard deviation for continuous variables. To compare differences among binary groups, a Chi-square or a Fisher exact test was used for analysis of categorical variables; a Student t-test was used for continuous variables. Between group comparisons of continuous variables for the type of TKA were performed by using one-way ANOVA post hoc Tukey tests. The level of significance was set at p<0.05. Statistical analysis was carried out using Stata/MP 15 (StataCorp LLC, Texas, USA).

Based on the study by Sur et al. [23], a power analysis was performed and based on the Student t-test for independent data with a power of 80% and α error<0.05, 9 patients should be analysed in each group to identify differences in the instrumented posterior tibial translation between the PS and the UC groups. Post-hoc power calculation was performed, taking the posterior tibial translation as the main outcome and using the results of our analysis. For one-way analysis of variance with four groups, having within-groups mean square error equal to 9.67, power was found at 100%.

**RESULTS**

**Clinical results**

Of the 115 studied patients, 83 (72.2 %) were female and 32 (27.8%) were male. The average age was 73 (SD 8.5) years (range 51–90 years). There were 64 (55.7 %) right knees and 51 (44.3%) left knees. The mean weight of the patients was 78.1 (SD 14.5) Kg, the mean height was 159 (SD 9.1) cm and the mean body mass index (BMI) was 31.0 (SD 5.1) Kg/m². There were no significant differences in any of these demographic variables among the different groups. The preoperative ROM and KSS scores were also similar among all 4 groups (table 1). Preoperative alignment of the limb, tibial posterior slope and posterior condylar offset were also similar in the 4 study groups (p=n.s.).

The postoperative KSS Knee and KSS Function scores were improved in respect of the preoperative values in all the groups. There were no significant differences in the postoperative outcome scores among the different groups (table 2).

The average postoperative ROM (113.1°, SD 9.6) was increased in respect of the preoperative ROM (108.3°, SD 11.1) globally and in each group. The average postoperative ROM in group 4 (109.3°, SD 9.9) was inferior (p=0.04) to the average postoperative ROM in group 1 (116.5°, SD 8.2), but there were no other differences among groups in the postoperative ROM.

**Radiographic analysis**
Postoperative alignment of the limb, tibial posterior slope and posterior condylar offset were similar in the 4 study groups (table 3).

The postoperative tibial translation was not related to any of the studied variables, except for the weight, the BMI and the study group. There was a positive correlation between the postoperative tibial translation and the weight (rho=0.23; p-Value=0.029), and between the posterior tibial translation and the BMI (rho=0.264; p-Value=0.011). There was no correlation between the postoperative tibial translation and outcome scores (p=n.s.).

The postoperative posterior tibial translation was different among groups: the PS groups (group 1 and group 3) showed significant lower posterior tibial translation (3.3 mm SD 2.3 – range 0-7.7mm-) than the UC groups (group 2 and 4) (8.7 mm SD 3.8 – range 4.8-15.4mm-) (p<0.001). There were no significant differences between both groups of PS model, but posterior tibial translation in the two UC models were different: in group 2 (Stryker UC) (11.2 mm SD 3.2) was significantly higher than in group 4 (United Orthopedic Corporation UC) (6.1 mm SD 4.5) (p=0.004) (table 3).

DISCUSSION

The most important finding of this study is that two different UC insert designs are associated with different patterns of posterior tibial translation in knee flexion, with a more normal pattern when a higher anterior lip in the polyethylene insert has been built. Moreover, both UC inserts showed a higher posterior tibial translation in knee flexion than both PS inserts, as it has been previously described [14].

Despite the different patterns of posterior tibial translation, the clinical outcomes observed in this study when using UC or PS designs are similar, and this is consistent with previous findings of some other studies with mobile-bearing [14,15,19] or fixed-bearing TKA [1,13,16,23]. This study has also found similar functional outcomes between UC and PS designs, as it has been previously described in some studies [4,21].

In this study, using fixed-bearing TKA, no significant differences have been found in the ROM after surgery when comparing UC and PS designs globally, and only a small difference in the ROM was observed when comparing groups 1 and 4. Some studies have demonstrated a small reduction in the ROM for UC compared to PS designs [8,9,19,26], but many other studies found similar ROM for both designs [11,14,17]. Most of the prior research was based on mobile-bearing TKA. As the clinical outcomes and ROM are similar between UC and PS inserts, it is probably worth using UC instead of PS inserts in order to decrease the risk of some complications that have been associated with the use of PS designs, such as patellar clunk syndrome [7] or condyle fractures in small size femoral components [22].

Previous studies have analysed knee kinematics with a navigation system, and showed less posterior tibial translation between 60° and 120° of flexion of the PS knees compared to the UC knees [4,5,8,14,17]. Despite the different kinematics, there were similar outcomes in the KSS, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Forgotten Joint scores between PS and UC groups [13,18]. In our study, the regular use of a patellar
component could have prevented possible anterior knee pain in cases with increased posterior tibial translation.

As in the current study, some previous works have analysed the sagittal femoro-tibial translation by means of either a TELOS device [2,9,23] or an arthrometer [11,12]. These types of studies have the advantage over intraoperative navigation ones of considering the true translation after soft tissues sutures and healing. Sur et al. found a significant increase in the tibial translation in the UC group in respect of the PS group (9.8 vs 3.0 mm in average) [23]. In the present study, an increased posterior tibial translation has been found when using UC regardless the implant brands. However, the effect was much smaller when an insert with a high anterior lip was used, as in the U2 Knee System UC (6.1 mm in average) compared to a low anterior lip as in the Triathlon UC (11.2 mm in average). There is still no consensus on the optimal posterior laxity of the knee following TKA: a postoperative AP translation of approximately 5 to 10 mm is believed to be the ideal value for TKA, as this range has been correlated with better ROM and better outcomes scores in CR and UC TKA [12]. In the current study, both PS models obtained similar posterior laxity. However, the UC models obtained higher values of posterior laxity, with figures similar to those obtained by Sur et al. with the Triathlon UC implant [24]. The more normal values found with the U2 System UC implant, suggest that the design with a higher anterior lip in this insert can be more efficient in controlling the posterior tibial translation. Most of the patients with a higher anterior lip UC insert keep the ideal translation of 5 to 10 mm, while the majority of patients with the lower anterior lip UC insert showed a posterior tibial translation greater than 10 mm. As far as we know, only one study has previously compared differences in posterior tibial translation with two different UC designs, but they failed to find differences between them [2].

Another interesting finding of the current study is the positive correlation between a higher BMI and a greater posterior tibial translation, according to the TELOS radiograph. No similar findings have been found in the prior literature. However, Can et al. suggested the routine use of PS implants in female obese patients due to the high rate of tibio-femoral instability and early TKA revision rate in this particular population when using CR implants [6].

This study included several limitations to be recognized: First, the size of the sample was calculated to detect differences in the posterior tibial translation, but maybe it was too small to detect differences in the clinical outcomes. Second, the follow-up period is limited to one year and the effect of the different posterior tibial translation patterns on the polyethylene wear over time cannot be detected. However, both wear and implant survivorship were out of the scope of the present study. Third, all the studied designs are fixed-bearing and the conclusions of the study could not be applicable to mobile-bearing TKAs. And fourth, blinding of the surgeon and the evaluators was not possible due to the implant’s design.

**Conclusion**

The main conclusion of this study is that UC inserts restrict the posterior tibial translation after TKA less than PS inserts, but a UC polyethylene insert design with a higher anterior lip can better control the posterior displacement of the tibia when a posterior force is applied in knee flexion. On the other hand, the difference of the posterior tibial translation with different insert designs seems not to be correlated with different clinical outcomes in the short term.
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