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ORIGINAL STUDY

Reduced joint awareness after total knee arthroplasty with a cruciate retaining design

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A range of different total knee arthroplasty (TKA) designs have been developed, each specifically designed to relieve pain and restore knee function with the greatest possible patient satisfaction. The purpose of this study was to compare a posterior stabilized design and a cruciate-retaining design. We hypothesized that a cruciate-retaining design would have a higher Forgotten Joint Score (FJS) than a posterior stabilized design.

Ninety-two patients were used in our analysis (46 patients in each group) involving TKA (Attune, Depuy-Synthes) between January 2014 and March 2015. We excluded patients with valgus alignment, post-traumatic arthritis, rheumatoid arthritis and major previous surgery on the knee. We compared the FJS, the Oxford Knee Score (OKS) and their ceiling effects.

FJS was significantly higher in the fixed-bearing cruciate-retaining group (P=0.043). The mean (-SD) FJS for the cruciate-retaining group was 78,4-25.1 compared to 67.6-27.6 for the posterior stabilized group. No significant difference in OKS was detected. The total ceiling effect for FJS and OKS was 32.2% and 45.5%, respectively. In conclusion, patients with cruciate-retaining TKA showed a better FJS in comparison to posterior stabilized TKA. FJS has a higher discriminatory power compared to OKS.

Keywords : Total knee arthroplasty ; Oxford knee score ; forgotten joint score ; cruciate retaining ; posterior stabilized ; patient reported outcome.

INTRODUCTION

Total knee arthroplasty (TKA) has been proven to be an efficient treatment for primary osteoarthritis and has therefore become a standard treatment option for end-stage osteoarthritis. TKA is becoming an increasingly common surgical procedure world-wide *(10)*. Furthermore, the incidence of knee osteoarthritis is also rising, predominantly because of obesity, population aging and changing expectations with regards to the quality of active life *(8,10,17)*. However, despite good surgical indications, the use of appropriate surgical techniques and successful rehabilitation, it is disappointing that one in five patients are not satisfied with the results of their TKA post-operatively *(6)*.

Numerous types of implants are available on the market, each with their own features, and each with their own theoretical advantages and disadvantages.

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There are two major types of implant : posterior cruciate ligament sparing TKA and posterior cruciate substituting TKA. Both of these implants have been available since the 1980s and both have their own advantages and disadvantages. However, as yet, research has not been able to define whether one of these implants is more effective than the other *(12,25)*.

In the long term, an implant with a higher level of constraint is more prone to aseptic loosening but is intrinsically more stable with less reliance on well-functioning ligaments *(16,20)*. When using a cam-post or hinge mechanism, a greater amount of bone has to be removed, thus making this technique less bone sparing. On the other hand, if an implant with a lower level of constraint has to function properly, it needs well-tensioned collateral and cruciate ligaments, both in terms of flexion and extension. If the posterior cruciate ligament (PCL) is insufficient or is not adequately tensioned (in flexion), then there will be no femoral roll-back and concomitant 'clearance' of the posterior tibial plateau, thus leading to limited flexion *(5,31)*.

In order to evaluate the satisfaction of each patient undergoing TKA, clinicians can use a variety of different scoring systems. Furthermore, there is increasing recognition that post-operative evaluation should be more patient-centered *(3)*, thus creating the need for more patient-reported outcome measurement systems (PROMs) to provide a more patient-focused view on surgical outcome *(2)*. As a consequence, a new concept has been developed for PROMs which takes into account the patient's ability to forget the artificial joint in everyday life, thus resulting in the greatest possible patient satisfaction *(3)*. This concept led to the establishment of the validated "Forgotten Joint Score" (FJS) ; reports indicate that the FJS shows high internal consistency and a low ceiling effect *(3,21)*. The aim of the present study was to compare two different types of implant, cruciate-retaining (CR) and posterior-stabilized (PS), in terms of patient satisfaction two years post-operatively, in a single TKA design (Attune, DePuy-Synthes, USA). The hypothesis of this study was that joint awareness would be better with the CR design.

PATIENTS AND METHODS

This retrospective study investigated all patients undergoing TKA between January 2014 and March 2015 by two orthopedic surgeons using the same TKA system (Attune, DePuy-Synthes, USA). Patients with severe osteoarthritis of the knee, suffering incapacitating pain despite conservative treatment, were included in the study. Patients with post-traumatic arthritis, valgus-alignment, rheumatoid arthritis and major previous surgery on the knee were excluded.

Surgeon 1 performed all PS mobile-bearing (MB) TKAs (group 1). Surgeon 2 performed all CR fixed-bearing (FB) TKAs (group 2). Both surgeons perform an identical surgical technique : mechanical alignment with a 5° valgus cut on the femur and 90° cut on the tibia with a 3° tibial slope. A tensioning device was used for gap-balancing in flexion and extension and to set femoral rotation. No soft-tissue releases were performed. When necessary, to balance the knee, a bony correction or recut was performed by adjusting the tibial cut to varus (or valgus) and/or changing the tibial slope. All patients underwent patella resurfacing. During all operations a tourniquet was used with a pressure of 250 mmHg. Routine prophylactic antibiotics (cefazolin or clindamycin) were used peri-operatively. Post-operative rehabilitation protocols included immediate full weight-bearing, protected by crutches, during the first three weeks. Exercises focused on immediate active flexion and extension. All patients received routine prophylaxis with low-molecular-weight heparin for four weeks post- operatively.

Demographic data (gender, age and operation site) were also collected. PROMs were measured by the Oxford Knee Score (OKS) and the Forgotten Joint Score (FJS) two years post-operatively. Ethical approval was obtained for the retrospective analysis of data from the hospital's Ethical Committee. (Clinical Trial Number : B11720163038).

The Oxford Knee Score (OKS) is a knee-specific quality of life outcome questionnaire consisting of 12 questions, all relating to function and pain over the preceding four weeks. The OKS has been used extensively over the last twenty years to report

PROMs. Each question is scored between 0 to 4 and the total score is the sum of all questions with a range from 0 to 48. The higher the score, the better the outcome *(7,9)*.

The FJS consist of 12 questions and was recently translated and validated in Dutch language *(21)*. This questionnaire focuses on the awareness of having a joint prosthesis during the following activities of daily living : in bed at night ; sitting on a chair for more than one hour ; walking for more than 15 minutes ; taking a bath/shower ; travelling in a car ; climbing stairs ; walking on uneven ground ; standing up from a low-sitting m-position ; standing for a long period of time ; doing housework or gardening ; taking a longer walk or during sports activities *(3,21)*. These 12 equally-weighted questions yield a total score ranging from 0 to 100.The higher the score, the better the outcome. The Dutch FJS shows a low ceiling effect and a high internal consistency (Cronbach alpha = 0,961) *(21)*.

We also investigated the ceiling effect for both FJS and OKS. The celling effect was defined as the percentage of patients who scored the maximum score (100 points for the FJS and 48 points for the OKS). Ideally, no more than 10% of patients should be at the top of the scale [19]. In addition, we used the percentage of patients scoring in the extreme 10% of the scale, as also used in analysis reported previously by Jette et al. *(14)* and Hamilton et al. *(11)*. As stated by Hamilton et al. *(11)*, this type of analysis provides information relating to the proportion of patients for whom a minimal clinically-important change would exceed the range of the scale, and as a consequence would not be measurable.

Sample characteristics are shown as numbers, percentages, means with standard deviation (SD) and median with range. Data from two independent samples were compared with the Mann-Whitney U-test while analysis of categorical data was performed with the Chi square test. All data were analyzed using SPSS statistical software (SPSS, Inc., version 24) with the level of significance was set at 5%. Two study groups of 50 patients were considered significant based on previous publications about the FJS *(3,24)*.

RESULTS

During our study period, 145 patients underwent TKA. After exclusion criteria were applied, 92 patients remained and were recruited into our analysis. Thirty-eight valgus knees were excluded, four patients were excluded because of their inability to understand the Dutch language and 11 patients were lost to follow-up. Consequently, our study featured two groups, each with 46 patients (Figure I). Both groups of patients showed similar preoperative demographic parameters, except for follow-up time (Table I). Group 1 (PS) had a shorter follow-up, but was still longer than two years. The mean follow-up period was 31.7-4.1 months while the minimum and maximum follow-up period was 26 and 40 months, respectively.

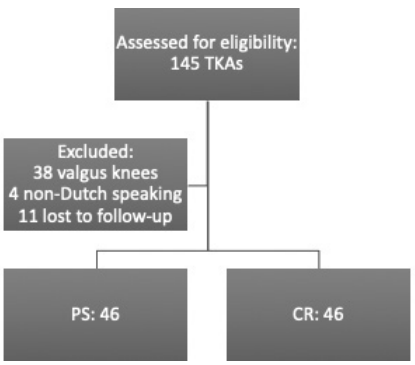

Figure I. — Flow diagram describing patient inclusion and exclusion. TKA, Total Knee Arthroplasty ; PS, posterior stabilized ; CR, cruciate retaining.

There was no significant difference between mean OKS for CR (41.1-7.4) and PS (39.8-7.2 ; P=0.300). The FJS for group 2 (CR, 78.4-25.1) was significantly higher than that for group 1 (PS, 67.6-27.6 ; P=0.043) (Table I). When dividing the study population according to the degree of arthritis (grade 3 versus grade 4), there was no significant difference between FJS and OKS (Table II & III).

The total ceiling effect was calculated for both questionnaires. The total ceiling effect (the proportion of patients in the top 10% of the score range) was 32.2% for FJS and 45.5% for OKS.

Table I. — Demographic factors and patient reported outcome of all patients

	Group 1: PS (n=46)		**Group 2: CR (n=46)**		P-value
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Demographic factor					
Age (y)	71,2 (9,7)	71,5 (48-89)	73,4 (8,8)	75 (55-89)	0,275
Gender (female)	27 (58,7%)	-	27 (58,7%)	-	1
Follow-up (month)	29,9 (2,5)	30 (26-35)	33,4 (4,6)	33 (27-40)	P < 0,001
Bilateral TKA	10 (21,7%)	-	23 (50%)	-	
Artrosis					0,017
Grade 3	34 (73,9%)	-	23 (50%)	-	
Grade 4	12 (26,1%)	-	23 (50%)	-	
PROMs					
FJS	67,6 (27,6)	76 (8,3-100)	78,44 (25,1)	84,4 (0-100)	**0.043**
OKS	39,8 (7,2)	43 (18-48)	41,1 (7,4)	43,5 (9-48)	0.300

PS, posterior stabilized ; CR, cruciate retaining ; FJS, forgotten joint score ; OKS, Oxford Knee Score ; SD, standard deviation.

Table II. — Demographic factors and patient reported outcome of patients with arthritis grade 3

	Group 1: PS (n=34)		**Group 2: CR (n=23)**		P-value
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Demographic factor					
Age (y)	70,3(9,5)	70 (48-87)	73,3 (8,6)	72 (56-88)	0,294
Gender (female)	18 (52,5%)	-	15 (65,2%)	-	0,357
Follow-up (month)	30,03 (2,48)	30 (26-35)	32 (4,6)	30 (27-40)	0,202
Bilateral TKA	5 (14,7%)	-	10 (43,4%)	-	0,283
PROMs					
FJS	66,4 (28,5)	76 (14,6-100)	77,9 (26,1)	83,3 (0-100)	0.160
OKS	39,2 (7,5)	43 (18-48)	42,4 (5,2)	43 (9-48)	0.220

PS, posterior stabilized ; CR, cruciate retaining ; FJS, forgotten joint score ; OKS, Oxford Knee Score ; SD, standard deviation.

Table III. — Demographic factors and patient reported outcome of patients with arthritis grade 4

	Group 1: PS (n=12)		**Group 2: CR (n=23)**		P-value
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Demographic factor					
Age (y)	73,5 (10,3)	74 (50-89)	73,6 (9,3)	75 (55-89)	0,959
Gender (female)	9 (75%)	-	12 (52,2%)	-	0,191
Follow-up (month)	29,5 (2,4)	30 (26-32)	34,8 (4,3)	33 (28-40)	**P < 0,001**
Bilateral TKA	5 (41,7%)	-	13 (56,5%)	-	0,626
PROMs					
FJS	70,8 (25,8)	75 (8,33-100)	79,0 (24,7)	85,4 (6,3-100)	0,234
OKS	41,5 (6,35)	43 (28-48)	41,3 (6,1)	44 (23-46)	0,771

PS, posterior stabilized ; CR, cruciate retaining ; FJS, forgotten joint score ; OKS, Oxford Knee Score ; SD, standard deviation.

DISCUSSION

Our data show that FJS and OKS compare satisfactorily to the previous literature *(3,4,24,25)*. An important finding of this study was that the post-operative FJS was significantly (P=0.043) higher with the CR design when compared to the PS design. The post-operative awareness is better with the CR TKA design. This is one the first study to compare FJS between CR and PS TKA designs.

The existing literature does not show any specific superiority in terms of functional outcome when comparing CR and PS TKA designs. While this literature features several studies concerning functional outcome and PROMs *(29)*, only one of these studies compares FJS between CR and PS TKAs. This one study, by Thippanna et al. *(25)*, reported very good results for FJS in both CR and PS TKAs, although there was no statistically significant difference between these two designs when outcome was compared more than two years after surgery. The findings of Thippanna et al. *(25)*, however, are not in line with the findings of the current study. It is important to note that the Thippanna study involved 336 TKAs, which involved the same design of prosthesis ; unfortunately, however, the surgical techniques used were not described. Thippanna et al. *(25)* concluded that the choice of procedure to be used should be based on considerations other than functional impairment, such as the preference and training of the surgeon involved and the local conditions in the individual joint. Nevertheless, some papers have claimed that proprioceptive function is better with a PCL-retaining prosthesis *(30)*, while others claim that proprioception after TKA depends on a range of structures, other than the PCL, such as collateral ligaments, muscles tendons and the joint capsule *(23)*. CR TKA is said to be a more physiological method in terms of the range of flexion *(18)* and femoral roll back, although good balancing of the posterior cruciate ligament is also required for this design of prosthetic to function well *(31)*.

On the other hand, the decision has to be made as to whether to use MB or FB implants. One of the theoretical advantages of a MB TKA is the ability to self-align the components, while retaining optimal prosthetic congruency and stability. Several studies have attempted to compare MB to FB prostheses in the PS-design. For example, Thienpont et al. *(24)* found that FJS was higher in patients fitted with the FB prosthesis compared to the MB design ; Mean FJS was 71-28 for the FB design and 56.5-30 for the MB design at 18-5 months postoperative follow-up. This difference was explained by the more anterior femorotibial contact point observed in MB TKAs *(24,28)*. Another prospective randomized study comparing MB and FB cruciate-retaining TKAs found no difference in OKS after 2-years of follow-up *(1)*. One study could be found in which OKS and FJS score were included to compare MB and FB cruciate retaining TKA *(19)*. This study showed that knee joint awareness after MB TKA is similar to FB TKA. They found no difference in OKS and FJS. Furthermore, They also concluded that the FJS is a more pronounced PROM to detect treatment effects compared to other PROMs. The FJS should be the PROM of choice when evaluating joint awareness after TKA during short-, mid- and long-term FU.

When we investigated the ceiling effect of the top 10% highest scores, we found a lower ceiling effect for FJS compared to that for OKS. A lower ceiling effect for FJS has also been reported in other publications comparing other patient-reported outcome scales, such as the WOMAC OA index *(3)*. The ceiling effect is related to the number of items in the scale. The more items a scale has, the less likely it is that a patient chooses the highest response category in every single item *(3)*. Since both the scoring systems used in the present study have the same number of options, they should generate more or less the same ceiling effect. Nevertheless, we found that the ceiling effect for OKS was more than 10% higher. Strong ceiling effects impair a scale's sensitivity to changes over time and its ability to discriminate between different groups *(3)*. Consequently, FJS has a higher discriminatory power. In other words, the FJS is more sensitive than the OKS when evaluating small differences in the knee performance of patients with good clinical results after TKA *(26,27)*.

Another question is if this difference in FJS is clinically relevant. In our result, the difference between group 1 and 2 for FJS is approximately

11. Ingelsrud et al. *(13)* investigated this concept of minimal important change (MIC) values for OKS and FJS in patients undergoing a primary TKA. The concept of MIC is defined as the smallest change in a PROM considered important by a notional average patient. They concluded an improvement of 14 for the FJS can be used to interpret longitudinal within-group score changes, but it can also be used as responder criteria when comparing improvements between 2 groups at 1 year after TKA. In this way, our significant result is arguable in term of clinically relevance. It is important to note the applicability of the reported MIC values depends on the methodological approach used to determine the MIC values *(13)*. Our follow-up period is longer than the one-year follow-up in this study. It is possible the MIC values may change with a longer follow-up period. Additional studies are needed to further establish the MIC values for the FJS and other PROMs.

At baseline, there was a significant difference in follow-up time (more than 3.6 months) when compared between the two groups. Earlier studies have confirmed that knee function reaches a plateau beyond one year of follow-up *(15,22)*. Our range of follow-up time was 26 to 35 months in group 1 and 27 to 40 months in group 2. In a recent study, Carlson et al. *(4)* reported that FJS increases significantly until one year post-operation, at which point FJS reaches a plateau. After more than four years of follow-up, the FJS then begins to decrease. However, we believe that this small difference in follow-up time is of no clinical significance after more than two years of follow up.

This study has several limitations. First, this was a retrospective study with a rather small sample size. Although, Two study groups of 50 patients were considered significant based on previous publications about the FJS *(3,24)*. Unfortunately, no preoperative functional scores were available. Second, this is not a randomized controlled trial. This would have required a larger study effort and cost than was available. Third, this was not a single-surgeon study. As explained by Thienpont et al. *(24)*, small differences in surgical technique and patient selection can make a difference and therefore represent a potential confounding effect. However, advantages of this study protocol were that both surgeons worked in the same hospital, herby worked in the same geographic area of the country and they used the same type of cemented implant with an identical surgical technique. Prospective randomized controlled trials using sensitive outcome measures with low-ceiling effect in a single-surgeon protocol with experience in both designs, is needed to confirm our findings. The results of our study can be used as a step towards further investigations.

In conclusion, this retrospective single-centre study compared two different TKA designs of the same implant type. At a follow-up of two years, patients with a cruciate-retaining TKA appeared to have a better clinical outcome compared to posterior stabilized TKA when measured with the FJS. The clinical relevance of this difference is debatable.

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