The Use of PS or CR Models is not Sufficient to Explain the Differences in the Results of Total Knee Arthroplasty. Study of Interactions

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Authors’ contributions

This work was carried out in collaboration between all authors. Author DHV designed the study, wrote the protocol, and wrote the manuscript. Author JMFC performed the statistical analysis, authors CRG, CMH, JAQD and JAA including and collected patients. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJMMR/2016/22184

Editor(s):
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Complete Peer review History: http://sciencedomain.org/review-history/12460

ABSTRACT

Aim: The study of results of Total Knee Arthroplasty based exclusively on the use of models Posterior stabilized (PS) or Cruciate retaining (CR) may be insufficient if we do not analyse other factors. Our objective is to analyse the interaction of certain factors as age, sex, BMI, prior deformity and use of navigation on the follow-up.
1. INTRODUCTION

Although Total Knee Arthroplasty (TKA) is a procedure that brings a remarkable welfare, we also know that up to 30% of patients is not satisfied with the results. They refer symptoms and limitations on the residual function of the knee. This percentage of dissatisfied patients has not diminished with new prosthetic designs or new techniques [1,2] and is a serious complication in this type of joint replacements.

There are two types of surgical techniques for TKA: with or without resection of the posterior cruciate ligament (PCL). However, in the literature there is no consensus on which method offers better results in terms of pain and knee function. The implantation of a TKA with resection of the posterior cruciate ligament (PS models) is recommended in different clinical situations [3], but there is not a unique criterion of choice in other circumstances. On the one hand, there are certain surgeons who implant these models routinely citing ease in its technique and excellent results achieved. Advocates for PS models ensure obtaining a right ligament balance is easier, and conformation between femur and tibia is greater. But then many surgeons limit their use to certain processes such as inflammatory rheumatism, absence or functional deficit of PCL, severe joint and/or ligamentous deterioration, osseous losses in tibia, deformities varus-valgus greater than 20° and in general when trying to provide greater stability of the arthroplasty. Surgeons advocating models with retention of the PCL (CR) insist on advantages such as inherent stability achieved, less bone resection performed or maintenance of proprioception. Therefore, in this as in other aspects of arthroplasty surgery personal behaviours that are not based on scientific evidence are common [4].

The choice of one technique or another is individual and without broadly accepted criteria. The literature only analyzes this variable as interaction with the results [5], when it is possible that other factors both from the patient and the surgeon can modify the results of TKA. It, therefore, seems advisable to analyse the comparative outcomes of both techniques starting from the study of the interaction of several factors and not just the model of implant CR or PS.

The objective of this study was to analyse the clinical results of patients with PS or CR models and the interaction of certain factors (age, sex, BMI, prior deformity and use of navigation).

2. MATERIALS AND METHODS

From a multicenter study of 6 Spanish hospitals were collected epidemiological, clinical and radiographic data from a series of 415 TKA of the same model (APEX®, OMNI LifeScience, East Taunton, Massachusetts, USA.), with a minimum follow-up of 12 months. In 298, the CR model was implanted and the PS in 117. Data for this study were obtained through a questionnaire specifically for this study, collected through a computer network and centralized for analysis. The scales used were Western Ontario and McMaster Osteoarthritis Index (WOMAC), American Knee Score (AKS) [6] and Short Form 12 Health Survey version 2 (SF-12 v2) than showed the clinical, functional and well-being outcomes. The data were collected in the preoperative study, at one month, at 3 and 12 months, between type of technique and preoperative deformity, sex, age, and BMI, showed that prior deformity and BMI influenced more on results than the use of one model or another. Navigation improved the results in the three scales, although these cases started with lower scores.

**Conclusion:** Analysis of results of TKAs based exclusively on the use of PS or CR models is insufficient. Characteristics of the patient, previous deformity and navigation aid influence more on the results than using one model or another.
months after surgery. Patient consent was obtained, and the ethics committee of the hospital's research approved the study. Ahlbäck radiological classification [7] was used in the preoperative study and to graduate the patella femoral joint Outerbridge [8] classification was used.

All patients had osteoarthritis of the knee and had followed a conservative treatment without success. The average age of the series was 71 years (SD 7.8); 127 were men and 288 women. The mean BMI was 31.7 (SD 4.8); normweight were 6.8%, 32.8% overweight and obesity and morbid obesity 60.2%. 46% of patients had a grade 2 of Ahlbäck on preoperative radiographs and 29.9% grade 3 and 4. The affection of the patella femoral joint was severe in 10.9%. In 294 cases (70.8%) frontal deformity of the mechanical axis of the knee was greater than 3º, of which 13.5% were valgus and 57.3% varus.

In 158 cases (38.5%) surgical navigation was used for arthroplasty implant. In all instances, it was used the navigation system Total Knee Surgetics®(PRAXIM SA, La Tronche, France) version 7.9. Staff as the first surgeon had implanted 84.1% of TKA, and residents implanted the rest.

In the WOMAC scale (subscale pain) the average preoperative score was 13.8. In the stiffness subscale, it was 5.5 and 48.7 in functional capacity. In the preoperative AKS scale, a mean level of 28.9 was observed in the knee subscale and 42.4 in functional. The SF 12 showed a preoperative score of 26.3 on the physical subscale and 42.5 in the mental subscale.

We used a system of data collection designed for this purpose by a SQL database. We performed a descriptive analysis of all variables. Quantitative variables were described as means and standard deviations, qualitative variables with frequencies. The General Linear Model was used as Analysis of Variance Repeated Measurements in the results, considering as inter-subject variables the measurements of the scales and subscales at two points in measuring: preoperative and one year after surgery. The inter-subject variables were type of arthroplasty model (PS or CR), prior deformity, sex, age, BMI and use of navigation. It studied the effects and interactions with the correction of Greenhouse Geisser. P values less than 0.05 was considered significant. Data analysis was performed using SPSS version 22 for Windows.

3. RESULTS

The average age of patients carrying the PS model was 71.6 years and 70.9 the group with CR model (p=0.407). There was also no significant differences between both groups with respect to gender (p = 0.449), BMI (p = 0.369), preoperative radiograph of the knee according to Ahlbäck scale (p = 0.610) nor the joint affection of the patella (p = 0.076) (Table 1).

In cases without femoral-tibial deformity or with preoperative deformity of less than 3º, PS model was used in 14.9%. With deformity higher than 3º this model was used in 33% (p<0.001). CR group was navigated in 28.1% and PS in 63.2% (p<0.001). Staff surgeons used more PS models than training surgeons (30.2% vs. 16.7%) (p=0.016).

In the overall series, a statistically significant improvement (p <0.001) was observed in all subscales analyzed at 12 months after surgery (Fig. 1). By analysing independently the results of the PS and CR models, it was noted that PS models showed better results (Table 2) with increments in all subscales (Fig. 2).

When studying the interaction between type of technique (CR vs. PS) and preoperative deformity, it was observed that there was no different evolution in SF12 in the mental subscale (p = 0.905), but it was maintained for physical subscale (p = 0.039); Regarding the AKS (knee and function subscale) it was observed that there was not different evolution by type of technique (p = 0.196 and p = 0.072 respectively). Analysing the WOMAC it was noted that there was interaction between the subscale pain and functional capacity (p = 0.012 and p = 0.029 respectively), but not with the rigidity (p = 0.185). These results show that the previous deformity modified the evolution in the three scales more than the use of PS or CR models (Table 3).

By introducing along with the type of implant (PS or CR) and preoperative deformity the interactions with gender, age, and BMI, it was observed that in the three subscales of WOMAC, the type of implant or the gender did not modify the evolution, but the prior deformity, BMI, and age did. In the two subscales of AKS neither
gender nor age nor type of implant modified the evolution, but it the BMI and preoperative deformity did. In the mental subscale SF 12 the evolution, BMI, and deformity were modified while the BMI, age and preoperative deformity were modified in the physical subscale. Therefore in the three scales analysed the BMI and deformity modified the results while the age affected the WOMAC score and the SF-12 in their physical subscale (Table 4).

Comparing the results of the cases with or without navigation we found that both the WOMAC and the AKS score and SF12 was higher in the cases with navigation (p>0.001), although these cases had started with lower scores (Fig. 3). By studying the interaction between navigation and implant type (PS or CR) we observed that navigation improved the results in the three scales to a greater extent than the kind of implant.

### Table 1. Preoperative status of both groups

|                     | CR    |     | PS    |     | Total |     | P value |
|---------------------|-------|-----|-------|-----|-------|-----|---------|
|                     | n     | %   | n     | %   | n     | %   |         |
| Gender              |       |     |       |     |       |     |         |
| Male                | 88    | 29.5% | 39    | 33.3% | 127  | 30.6% | 0.449   |
| Female              | 210   | 70.5% | 78    | 66.7% | 288  | 69.4% |         |
| BMI                 |       |     |       |     |       |     |         |
| Normal weight       | 20    | 6.7% | 8     | 6.8% | 28   | 6.8%  | 0.540   |
| Overweight          | 102   | 34.3% | 34    | 29.1% | 136  | 32.9% |         |
| Obesity             | 163   | 54.9% | 67    | 57.3% | 230  | 55.6% |         |
| Morbid obesity      | 12    | 4.0% | 8     | 6.8% | 20   | 4.8%  |         |
| Ahlback’s Grade     |       |     |       |     |       |     |         |
| I                   | 63    | 21.2% | 24    | 20.9% | 87   | 21.1% | 0.610   |
| II                  | 133   | 44.8% | 57    | 49.6% | 190  | 46.1% |         |
| III                 | 62    | 20.9% | 19    | 16.5% | 81   | 19.7% |         |
| IV                  | 32    | 10.8% | 10    | 8.7% | 42   | 10.2% |         |
| V                   | 7     | 2.4% | 5     | 4.3% | 12   | 2.9%  |         |
| Outerbridge Grade   |       |     |       |     |       |     |         |
| I                   | 68    | 22.9% | 23    | 20.0% | 91   | 22.1% | 0.076   |
| II                  | 35    | 11.8% | 25    | 21.7% | 60   | 14.6% |         |
| III                 | 162   | 54.5% | 54    | 47.0% | 216  | 52.4% |         |
| IV                  | 32    | 10.8% | 13    | 11.3% | 45   | 10.9% |         |
| Age                 |       |     |       |     |       |     |         |
| Mean(SD)            | 70.85 (7.94) | 71.57 (7.66) | 71.06 (7.85) | 0.407 |
Fig. 2. Differences between CR and PS models after one year follow-up
* Absolute values in increases for WOMAC scores

Table 2. Results of the subscales according to models CR vs PS

| Score                  | CR Pre-operative | CR 1 year | CR Increase* | PS Pre-operative | PS 1 year | PS Increase* |
|------------------------|------------------|-----------|--------------|------------------|-----------|--------------|
| AKS Knee Score         | 31.26            | 77.87     | 46.61        | 23.41            | 77.64     | 54.22        |
| AKS Function Score     | 43.76            | 86.21     | 42.45        | 39.18            | 90.71     | 51.53        |
| WOMAC Pain             | 13.48            | 3.02      | 10.46        | 14.93            | 2.10      | 12.83        |
| WOMAC Stiffness        | 5.35             | 1.33      | 4.02         | 5.89             | 0.87      | 5.02         |
| WOMAC Function         | 47.18            | 12.93     | 34.25        | 53.10            | 9.32      | 43.78        |
| SF-12 Physical Component | 26.55           | 46.06     | 19.51        | 25.22            | 49.82     | 24.60        |
| SF-12 Mental Component | 42.85            | 53.03     | 10.18        | 41.68            | 55.44     | 13.75        |

*Absolute values in increases for WOMAC scores

Table 3. Results about the previous deformity and technique type

| Score                  | <=3º Preoperative | >3º Preoperative | Total Preoperative | <=3º 12 months | >3º 12 months |
|------------------------|-------------------|------------------|-------------------|----------------|--------------|
| AKS Knee               | 37.60             | 28.55            | 31.26             | 76.19          | 78.58        |
| PS                     | 38.00             | 21.01            | 23.41             | 78.25          | 77.53        |
| Total                  | 37.67             | 25.92            | 28.87             | 76.54          | 78.22        |
| WOMAC Function         | 45.26             | 43.13            | 43.76             | 79.74          | 88.97        |
| PS                     | 42.50             | 38.63            | 39.18             | 84.17          | 91.78        |
| Total                  | 44.79             | 41.56            | 42.37             | 80.50          | 89.95        |
| WOMAC Pain             | 12.68             | 13.90            | 13.48             | 3.93           | 2.52         |
| PS                     | 13.39             | 15.24            | 14.93             | 3.00           | 1.92         |
| Total                  | 12.78             | 14.34            | 13.87             | 3.79           | 2.33         |
| WOMAC Stiffness        | 4.92              | 5.58             | 5.35              | 1.79           | 1.08         |
| PS                     | 4.61              | 6.14             | 5.89              | 1.61           | 0.73         |
| Total                  | 4.88              | 5.76             | 5.50              | 1.77           | 0.97         |
| WOMAC Function         | 44.01             | 48.87            | 47.18             | 17.05          | 10.73        |

*Absolute values in increases for WOMAC scores
4. DISCUSSION

It is recognized in the literature that some clinical situations such as absence or ineffectiveness of PCL, gross deformities or some types of instability, should preferably be treated with models of TKA type PS. However, in knees without those alterations the decision to use PS or CR models depends on individual factors of the surgeon as training, school or previous experience. It is known that the PCL has different types of mechanoreceptors for proprioception and kinesthesia so it would be preferable its conservation, but on the other hand the sacrifice of this ligament helps to make a correct ligament balance in knees with severe deformities or contractures.

From the published literature, it is difficult to know whether or not the PCL conservation modifies the results of the TKA. Although no statistical differences have been found in the clinical assessment of both techniques, it seems the greater frequency of radiolucent lines in PS models indicate differences in the kinematics of the knee [9], differences that have not been confirmed in the literature. Even an explicit indication of the PS models such as rheumatic inflammatory processes is under discussion since no differences were observed in the evolution using either technique [10].

Several meta-analyses have been published analyzing the results published in the literature (Table 5). Bercik et al. [5] who reviewed the results of 1256 TKAs, found no differences in the frequency of complications although the PS models provided better postoperative motion. However, both models had similar clinical results and the authors are not inclined to recommend one type or another. Another meta-analysis [11] analyses the results of 8 previous works. As in the earlier study the range of motion was greater in PS models, with significant differences, authors do not recommend either type. Verra et al. [12] studied 20 articles, which include 2347 TKAs with a minimum follow-up of 1 year. The PS models showed greater motion in flexion, although only of 2º of average. Also the subscale function of the AKS was slightly higher in PS models, but the other parameters were similar. The authors report a poor quality of the studies and also make recommendations regarding the use of either model. Recently, Li et al. [13] have analysed eight studies that bring together nearly 1000 TKA. It was also found an increased postoperative motion in the PS models, but the results were similar in terms of pain, score in the knee, complications and implant survival. In a recent article comparing the results of both techniques using the same arthroplasty model with an average follow-up of over 12 years [14] it was found that PS had better clinical outcomes and motion although implant survival was similar. Other studies have also noted the improved motion obtained with PS models that reach an average of 8-10º [15] especially in flexion, but certainly this difference has no clinical relevance.

| Score          | Preoperative | 12 months | PS <=3º | PS >3º | Total <=3º | Total >3º | Total |
|----------------|--------------|-----------|---------|--------|------------|-----------|-------|
| SF12 Physical  | 45.11        | 54.68     | 53.10   | 15.83  | 8.03       | 9.32      |       |
| SF12 Mental    | 28.29        | 24.52     | 25.22   | 45.84  | 50.74      | 49.82     |       |
|                | 28.29        | 25.53     | 26.20   | 43.30  | 48.74      | 47.05     |       |

Table 4. P values for the interactions of the implant type, preoperative deformity, gender, age and BMI with the results of AKS, WOMAC and SF12 (preoperative to 1 year)

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and does not conspicuously alter the functional and clinical outcomes. A flexion greater than 90° is hardly used by patients in their daily lives [16] and may, however, increase the risk of aseptic subsidence. Other factors that have been discussed in the literature as the stability of components [17], early emigration [18] or kinematics in gait [19-21] haven't shown any differences between either model. In our study, we found that in the overall series, there was a statistically significant improvement in all scales analyzed at 12 months postoperatively. When the results of the PS and CS models were independently tested, it was noted that the former had better outcomes with increases in all subscales, both in terms of pain, function or well-being.

It can, therefore, be argued that the PS models offer better knee motion and better scores on pain and function both in literature and in our study. However, the simple comparative analysis of the use of CR or PS is confusing. It is essential to analyze other individual factors jointly as interactions may mask the results. In our work, we have seen that in the three scales analysed the BMI and deformity modify the results as the age affects the WOMAC scale score and the SF-12 in their physical subscale. That means that the prior deformity and BMI are more important to the results than using PS or CR models. If we analyse the differences in the results considering the navigation, we also find that the use of computer-assisted surgery is more important than the type of implant PS or CR. We did not find in the literature an interaction of the effect of a procedure depend on the combination of multiple factors. The simplistic view of the effect of a given factor on the outcome is not useful for clinical practice because patients have different preoperative situations, they are operated with or without navigation and by surgeons that are little or very experienced.

The strength of our study is based on the use of the same model of TKA, only different in terms of conservation or not of the PCL. The results of a given arthroplasty model can be evaluated from observational multicenter studies using similar criteria of inclusion and evaluation of outcomes. These studies, which allow us to analyse a large number of cases from various hospitals and surgeons with different experience, show the real behaviour of a model of TKA. Other studies that show only the results of centers of excellence or from the own implant designers only provide a partial information and subject to distorting factors. Multicenter studies, like ours, have the added value of providing a more comprehensive and representative view of the fact that single-center studies. But also they have drawbacks as potential bias arising from the participation of different surgeons with different techniques. Given the difficulties of conducting randomized studies and randomized surgery we used methods of analysis to control the confounding factors in observational studies. Given the difficulties of conducting randomized studies in surgery we used methods of analysis to control the confounding factors in observational studies. The study of various interactions as in our work, can add significant benefits to observational studies and shows how the results can be masked if only one factor is analysed separately. As limitations, we may note, on the one hand, the short time evolution of our series. The major limitation of our study is the short follow-up. However, it is known that the clinical and functional results of the TKAs are stabilized at 6 months so that an assessment at one year can be considered as definitive [12]. Furthermore, although a similar questionnaire was followed with a uniform methodology differences cannot be ruled out between surgeons to record patient data, entering personal perceptions.

| Author          | Year | Studies | TKAs | Results                              | CR vs PS advantages |
|-----------------|------|---------|------|--------------------------------------|---------------------|
| Jacobs et al.   | 2005 | 8       | 576  | More range motion in PS              | No                  |
| Bercik et al.   | 2013 | 12      | 1265 | More range motion in PS              | No                  |
| Li et al.       | 2014 | 8       | 963  | More range motion in PS              | No                  |
| Verra et al.    | 2015 | 20      | 2347 | More range motion in PS              | No                  |
5. CONCLUSION

Our study does not ensure that the PS or CR models are superior in terms of clinical and functional outcomes of the TKA. Although a first approximation meant that PS models contributed better results, by studying the interactions of other factors it has been shown that the type of implant alone was not responsible for this difference.

ACKNOWLEDGEMENT

Pablo Miguel Roza for control and centralization of data collection.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
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