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ORIGINAL ARTICLE

Retained versus resected posterior cruciate ligament in mobile-bearing total knee replacement: a retrospective, clinical and functional assessment

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Abstract
Purpose Fully conforming, mobile-bearing total knee replacement (TKR) was initially designed using a posterior cruciate-sacrificing (CS) technique. Rotating-platform TKR that could also be performed retaining the posterior cruciate developed afterwards. The purpose of this study was to compare the clinical and functional outcomes of patients who had either cruciate-retaining (CR) or cruciate-sacrificing (CS) TKR at a minimum follow-up of 2 years with the same prosthetic design.
Methods One hundred and two consecutive TKR (88 patients) were performed at the same institution either with CS (56 TKR—49 patients) or with CR (46 TKR—39 patients) technique. Patients were followed at a minimum of 2 years. Patients were evaluated for articular range of motion, complication rate (infection, loosening) and clinical outcome measures included the pain and functional components of the Knee Society Score.
Results The two groups (CS, CR) were homogeneous. At final follow-up, no significant difference was seen between the two surgical techniques in terms of ROM, pain and functional level, and revision rate.
Conclusions This study showed that for this given mobile-bearing, fully conforming prosthetic design, sacrificing or resecting the PCL does not influence the clinical and functional outcomes at a minimum of 2-year follow-up. Surgeons may indifferently choose one of the two options (CS, CR) according to their preferences.
Level of evidence Case series, level IV.

Keywords Mobile-bearing · Cruciate-retaining · Knee arthroplasty · Posterior cruciate ligament

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Introduction

The role of the posterior cruciate ligament (PCL) in total knee replacement (TKR) is controversial. The published literature has not given a solid base for the decision either to retain or to sacrifice the PCL during primary fixed-bearing TKR due to the lack of a significant difference in outcome between the two groups [1]. However, it has generally been shown that the posterior-stabilized TKR design with post and cam allows for more reproducible outcomes with respect to cruciate-retaining (CR) design, in that it avoids excessive PCL laxity or tightness [1, 2].

The debate over the fate of PCL in TKR has primarily regarded fixed-bearing, primary TKR. Mobile-bearing, fully conforming TKR were initially designed for PCL sacrificing (CS) such as the LCS rotating platform [3] (DePuy, Warsaw, IN). Later on, this design was adapted for PCL retaining (CR), but this implied a change into a "meniscal bearing" tibial insert design (LCS Meniscal Bearing, DePuy, Warsaw, IN) [4]. Successively, another rotating-platform design was made available both with a CS, CR or with a PCL-substituting, posterior-stabilized (PS) [5] design with a femoral cam and a tibial post (PFC Sigma, DePuy, Warsaw, IN) [6]. More recently, other products were released on the market (Table 1).

Mobile-bearing prosthesis has shown comparable results against the same fixed-bearing, CR design and against

Table 1 Non-esaustive list of mobile-bearing prosthetic designs and relative PCL fate

Design	Fate of PCL	References
GKS Prime (Permedica, Merate, Italy)	Retained or sacrificed	Present study
PFC Sigma RP (DePuy, Warsaw, IN, USA)	Retained or sacrificed	[6, 11, 18, 25]
PFC Sigma PS (DePuy, Warsaw, IN, USA)	Substituted	[6, 18]
LCS RP (DePuy, Warsaw, IN, USA)	Sacrificed	[17, 26, 27]
LCS meniscal bearing (DePuy, Warsaw, IN, USA)	Retained	[17, 26, 27]
Innex (Zimmer, Warsaw, IN, USA)	Retained	[14]
E-motion (Braun Aesculap, Tuttlingen, Germany)	Retained or Sacrificed	[2]
Advance (Wright Medical, Arlington, TN, USA)	Retained or Sacrificed	[15]

PCL posterior cruciate ligament, *GKS* global knee system, *PFC* press fit condylar, *RP* rotating platform, *PS* posterior stabilized, *LCS* low contact stress

fixed-bearing PS design [7–9]. The high-conformity polyethylene of the tibial insert determines the anterior–posterior stability and allows for some degree of femoral rollback making the PCL not essential for joint stability. However, it has been hypothesized that retaining the PCL may have an important role in preserving an adequate proprioception and in increasing the articular range of motion by preserving the physiological femoral rollback, thus easing stair-climbing performance [10].

Very few studies in literature explored the possibility to retain or resect the PCL adopting the same knee prosthesis without varying the design of the polyethylene insert and metal components [2, 6, 11]. It is therefore still unclear whether preserving the PCL may provide an improvement in the clinical and functional outcomes.

The aim of this study was to compare the clinical and functional outcomes of the same fully conforming, mobile-bearing prosthetic design either retaining or sacrificing the PCL. It was hypothesized that preserving PCL may improve clinical and functional outcomes.

Fig. 1 GKS Prime (Permedica, Merate, Italy) fully conforming, rotating-platform design

Materials and methods

All patients who had TKR with the GKS Prime® Permedica (Merate, Italy) (Fig. 1) between March 2002 and April 2010 were reviewed (106 patients, 131 TKR). Of these patients, five were died, four were unable to come to a clinical appointment because they were physically or mentally infirm, and two refused our request for a clinical appointment. Patients with a valgus deformity ($n = 4$) and patient with a diagnosis of rheumatoid arthritis ($n = 3$) were excluded from the study. One hundred and two arthroplasties in 88 patients were left for examination. All TKR were performed by the two senior authors (A.G. and A.V.). One surgeon sacrificed the PCL (A.G.); the other surgeon (A.V.) retained the PCL.

The senior surgeons adopted the same technique apart from PCL resection or retention. Midline skin incision and a medial parapatellar arthrotomy were performed. An extramedullary tibial guide was used, and 3–5° of slope were given as a standard. An intramedullary femoral guide was adopted, and the femur was cut with a standard of 5–7° of valgus and 3° of external rotation. Soft tissue balancing was never performed as a routine procedure. The patella was not resurfaced during any of these TKR procedures. Tibial component was always cemented. Femoral component was cemented only when bone was considered osteoporotic. A suction drain was positioned, and the wound was closed in layers applying a slightly compressive dressing.

The two groups underwent the same rehabilitation protocol. On the second postoperative day, the drain was removed and the patients started passive movements with the CPM machine. On the third day, patients were allowed to walk as tolerated with the assistance of a therapist. Skin clips were removed 2 weeks postoperatively.

Postoperative assessment included the KSS Score (Knee and Function), visual analogic score (VAS) and a subjective six-point assessment relating to patient status before intervention (6 = very satisfied, 5 = satisfied, 4 = acceptable, 3 = scarcely satisfied, 2 = unvaried, 1 =

unsatisfied/worsened). Preoperative clinical evaluation was recovered from patients' records. Postoperative clinical evaluation was performed by two residents blinded to treatment (V.C. and C.S.).

Continuous variables are presented as means with ranges and standard deviation (SD). The differences between groups were analysed with the Student's *t* test for continuous variables. Chi-square test and Fisher's exact test were adopted for categorical variables. The level of significance was set at alpha = 0.05. Data were analysed with the SPSS 17.0 statistical software (SPSS Inc., Chicago, US).

Results

Patient demographics are shown in Table 2. The two groups were comparable for all the variables analysed such as age at surgery, gender, BMI, length of follow-up, preoperative range of motion and KSS scoring.

Postoperative outcomes are shown in Table 3. PCL-retaining group obtained an average maximum flexion of 109.8° ± 11.6° (range 85°–145°), an average KSS score knee and function of 78.9 ± 15.4 and 70.6 ± 30.9, respectively, a postoperative average VAS of 2.9 ± 3.1 and a median satisfaction level of 6 (very satisfied).

PCL resection group obtained an average maximum flexion of 112.6° ± 13.6° (range 85°–145°), an average KSS score knee and function of 77.5 ± 16.4 and 68.4 ± 27.7, respectively, a postoperative average VAS of 2.8 ± 2.9 and a median satisfaction level of 5 (satisfied).

There were no statistically significant differences among the two groups for KSS score, range of motion, patient's satisfaction, maximum postoperative flexion and revision rate. In both groups, the increase in KSS score categories averaged around 30 points.

Three cases of revision were documented in the PCL-preserving group (two infections and one aseptic loosening) and two cases in the PCL-sacrificing group (one infection and one aseptic loosening).

Discussion

Posterior cruciate ligament plays a key role in posterior knee stability and in control of the femoral translations. Theoretical advantages of PCL retention in TKR include an

Table 2 Preoperative demographics and clinical status

	PCL retaining ($n = 46$)	PCL sacrificing ($n = 56$)	p value
Age (years)	70.2 ± 7.6	68.6 ± 6.7	n.s.$^{\alpha}$
Gender (M/F)	18/28	17/39	n.s.$^{\beta}$
BMI (kg/m^2)	30.7 ± 4.8	28.8 ± 4.2	n.s.$^{\alpha}$
Mean follow-up (months)	63.9 ± 20	64.1 ± 28.5	n.s.$^{\alpha}$
Side (R/L)	27/19	30/26	n.s.$^{\gamma}$
Femoral cementing (%)	9/46 (19.5 %)	12/56 (21.4 %)	n.s.$^{\gamma}$
Flexion contracture (°)	6.3 ± 9.4 (0–25)	8.1 ± 11 (0–25)	n.s.$^{\alpha}$
Maximum flexion (°)	125.6 ± 9.8 (85–145)	129.1 ± 11.2 (80–150)	n.s.$^{\alpha}$
Total range of motion (°)	118 ± 12.3 (83–146)	115 ± 13.6 (71–143)	n.s.$^{\alpha}$
KSS score knee	45.2 ± 14.7 (17–84)	46.1 ± 15.1 (18–84)	n.s.$^{\alpha}$
KSS score function	39.4 ± 15.3 (0–80)	39.1 ± 17.1 (0–80)	n.s.$^{\alpha}$
VAS	7.7 ± 1.5 (6–10)	8.1 ± 1.9 (5–10)	n.s.$^{\alpha}$

BMI body mass index, *KSS* knee society score, *VAS* visual analogic score

$^{\alpha}$ Student's *t* test, $^{\beta}$ Fisher's exact test, $^{\gamma}$ Chi-square test

Table 3 Postoperative outcome

	PCL retaining ($n = 46$)	PCL sacrificing ($n = 56$)	p value
Flexion contracture (°)	0.8 ± 1.6 (0–10)	0.9 ± 1.9 (0–10)	n.s.$^{\alpha}$
Maximum flexion (°)	109.8 ± 11.6 (85–145)	112.6 ± 13.6 (85–145)	n.s.$^{\alpha}$
Total range of motion (°)	107.9 ± 12 (80–135)	108.2 ± 13.1 (80–145)	n.s.$^{\alpha}$
KSS score knee	78.9 ± 15.4	77.5 ± 16.4	n.s.$^{\alpha}$
KSS score function	70.6 ± 30.9	68.4 ± 27.7	n.s.$^{\alpha}$
VAS	2.9 ± 3.1	2.8 ± 2.9	n.s.$^{\alpha}$
Revised	3/46	2/56	n.s.$^{\gamma}$
Satisfaction[a]	6 (4–6)	5 (4–6)	n.s.$^{\beta}$
Δ KSS score knee	33.6 ± 16.1	31.3 ± 17.2	n.s.$^{\alpha}$
Δ KSS score function	31.1 ± 28.6	29.3 ± 26.4	n.s.$^{\alpha}$

KSS knee society score, *VAS* visual analogic score, *Δ* delta

$^{\alpha}$ Student's *t* test, $^{\beta}$ Fisher's exact test, $^{\gamma}$ Chi-square test

[a] Satisfaction is expressed as median and interquartile range

improved knee function, range of motion (due to increased femoral rollback) stability and strength, a more efficient gait pattern and a reduced interface stress [12]. Although some reports focus on the inconsistency of the results [2] and in a possible increase in knee laxity after PCL-retaining TKR [13], other studies document that PCL does not stretch and remains stable in the postoperative period [14].

The present study analysed clinical and functional outcomes after TKR with a fully conforming, mobile-bearing knee prosthesis either with retention or with sacrifice of the PCL. Results were collected at a minimum follow-up of 2 years and at an average follow-up of 4 years.

Very few studies in literature have looked at the clinical and functional outcomes of patients who underwent TKR with a rotating platform, fully conforming implant either sacrificing or preserving the PCL [2, 6, 11, 15] on the same prosthetic design.

Roh et al. [2] have shown no differences among CR and CS mobile-bearing TKR in terms of clinical outcome and final ROM at 2-year follow-up. However, the authors have highlighted that unpredictable complications all occurred in the CR group and may have been related to PCL laxity or tightness. They have also shown a not physiological kinematic in CR knees, with a paradoxical femoral anterior translation.

Hirsch et al. [6] have compared clinical and functional outcomes after TKR with a CR, CS or a posterior-stabilized prosthetic design. The authors did not find statistically significant differences in terms of clinical outcome. However, they have documented a statistically significant improvement in maximum flexion and ROM for the PS group.

Ishii et al. [4] have shown comparable final ROM with no statistical difference among rotating-platform CS and meniscal bearing CR prosthetic design (in this study the authors adopted two similar prosthetic designs, but not the very same design). Interestingly, the authors have also shown a more variable recovery time for the CR design, with more time needed to achieve the final degrees of flexion.

Again, Misra et al. [11] have shown no differences in the 5-year result of patients who underwent TKR with the same mobile-bearing prosthetic design either with retention or with sacrifice of the PCL. The authors highlighted the trend for a higher percentage of patients with a detectable femoral rollback in the PCL-resected group. The authors postulate that the results may be partially explained by the fact that PCL is histologically abnormal in arthritic knees.

The findings in the above-mentioned studies all suggested that retaining PCL may not play a significant functional role when adopting a fully conforming, rotating-platform knee implant. However, the argument is still debated. The aim of this study was to compare the clinical and functional outcomes of the same fully conforming, mobile-bearing prosthetic design either retaining or sacrificing the PCL. It was hypothesized that preserving PCL could improve clinical and functional outcomes following TKR with a novel knee implant (G.K.S. Prime®, Permedica, Merate, Italy). The hypothesis was rejected in that no significant difference was shown either in the clinical and functional outcomes or in the revision rate among CR and CS groups. Although mobile-bearing implants may reach average flection as high as 120–130° [2, 4, 15, 16], the finding of the present study of an average knee flexion of about 110° is not an uncommon [5, 6, 17]. Moreover, the maximum knee flexion depends on the preoperative flexion, type of adopted prosthesis design, surgical technique, way of measurement, so that a direct comparison among different studies is almost impossible [4].

The postoperative KSS knee and function score varies widely in literature. The findings of our study were average values of 78 for the knee score and 69 for the function score (considering CR and CS groups together). Although not elevated, these values are comparable with those of similar studies in literature [18]. Moreover, although KSS scores increased to limited values, the delta (Δ) KSS knee and function increased of about 30 points (Table 3) as in comparable studies [15].

General revision rate value for primary TKR varies widely in literature. More optimistic reports document a revision rate of 3.4 % at 10 years postoperatively [19]. However, almost the same rate of revision rate (3.8 %) has been reported within 2 years from the implantation [20]. Similarly, according to the Danish register the revision rate after TKR is between 1.3 and 2.3 % after the first postoperative year, between 2.3 and 4.7 % after the second year, and between 4.8 and 6.6 % after the fifth year [21]. There were 5 revisions in the present study (5 %), which is a value in line with the current literature. It has to be underlined that the setting in which patients underwent surgery was a large referral centre, which may have increased the number of revision surgeries due to infection [22]. In similar studies focused on mobile-bearing designs, revision rate of about 5 % was reported: Misra and coworkers reported that out of the 105 knees analysed at 5 years five suffered an aseptic loosening and one had a deep infection requiring revision (5.7 %) [11]. Similarly, out of 90 knees admitted to follow-up, Roh and colleagues reported on one case of deep infection and two cases of knee instability (lax PCL) and one case of polyethylene subluxation (tight PCL) requiring reoperation (4.4 %) [2].

This study has some limitations. Firstly, it is retrospective in nature, and patients lost at follow-up may have influenced the final result. Secondly, in some of the cases the femoral component was cemented and in some others it was press fitted. However, some studies prove that there is

no difference among cemented and non-cemented implants in terms of clinical and functional outcomes at medium-term follow-up [23]. Additionally, radiographic evaluation was not included in the follow-up visit, and therefore updated imaging was not available to couple with clinical data. Lastly, even though the first surgeons A.G. and A.V. adopted the same operative technique and the same surgical steps and procedures (apart from PCL retaining or resecting), the fact that surgeries were carried on by two different operators adds an element of variability that could not be avoided.

This study has also some peculiar strengths. All the procedures were performed by the same group of surgeons and scrub nurses (apart from the first surgeon: either A.G. or A.V.) in the same hospital with the same surgical technique. Patella was never resurfaced. This is an important point as it has been demonstrated that patellar resurfacing may have an impact even on the anterior knee pain, on the overall clinical outcome and reoperation rate [24].

No statistically significant difference ($p > 0.05$) in the clinical and functional outcomes was detected when the G.K.S. Prime® (Permedica, Merate, Italy) fully conforming, mobile-bearing knee prosthesis was implanted either preserving or sacrificing the PCL, with a minimum follow-up of 2 years (average 4 years). In light of these results, surgeons may choose indifferently one of the two options (CS, CR) according to their preferences. However, we now prefer to routinely resect the PCL in that it facilitates the surgical procedure expanding the flexion gap and making the posterior debridement quicker and easier.

Conflict of interest Davide Enea received a Grant (No. 012102) cofinanced by Permedica s.p.a. and the Polytechnic University of Marche. The other authors declare no conflicts of interest.

Ethical standard This work was performed in keeping with the ethical standards of the 1964 Declaration of Helsinki as revised in 2000. All the patients gave their informed consent prior to being included into the study, and the study was authorized by the local ethical committee.

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