Posterior cruciate ligament retaining versus posterior cruciate ligament substituting knee arthroplasties: a four-decades-old debate

NP Sachinis*

Abstract
Introduction
The ways of treating the posterior cruciate ligament have been a matter of excessive debate during the past years. Between retaining, sacrificing and substituting studies have been mainly focused among posterior cruciate ligament retaining and posterior cruciate ligament substituting designs and techniques. Most studies report mostly these critical outcomes of a successful total knee arthroplasty: survivability and range of motion/flexion, along with other scores that demonstrate the quality of life and mobility of the patient. Also, there have been studies that analyse the histology of posterior cruciate ligaments in arthritic knees, and ones that study the biomechanical behaviour of posterior cruciate ligament retaining and posterior cruciate ligament substituting arthroplasties. The aim of this review is to discover the advances that have been made during the past years in terms of establishing the differences between cruciate retaining and substituting designs. Also, the review explores these differences and their true impact on patients and implant survival rate.

Conclusion
In terms of survival, both types of implants so far have shown almost excellent durability even on long-term follow-ups of 10 and more years. The difference between these two implants that has been revealed by recent meta-analyses is in the range of motion where, paradoxically for some researchers, the posterior cruciate ligament substituting designs provide more flexion and range of motion. Histological analyses reveal that most posterior cruciate ligaments in arthritic knees are under a degenerative process. Future comparing properly randomized trials could possibly reveal how these small differences in flexion and the degeneration of posterior cruciate ligament affect the lives of patients who have undergone a posterior cruciate ligament retaining or posterior cruciate ligament substituting knee arthroplasties.

Introduction
Since the introduction of the total condylar prosthesis (TCP) (Zimmer, Warsaw, IN) in 1974 and the first study which followed up the patients having that specific prosthesis*, many more implants coming as evolutions have been produced. The post-cam mechanism, which comes as a substitute for the excised posterior cruciate ligament (PCL), has been part of the Genesis I and II Posterior Stabilized (Smith & Nephew, Memphis TN) implants, the P.F.C. Sigma Cruciate Substituting (Depuy Johnson & Johnson, New Brunswick, NJ), the Maxim Posterior Stabilized (Biomet, Warsaw, IN) and other posterior cruciate ligament substituting (PCLS) designs. However, the posterior cruciate ligament retaining (PCLR) implants have also sustained through time and are still on the market (Figure 1).

For the patient with a non-functional PCL, only a PCLS design can be used. In patients with a PCL that is estimated as efficient than the design that will be implemented depends on the preference and training of the orthopaedic surgeon. The latter category is the one where most studies have been analysing the outcomes of the PCLS and PCLR designs. Most of the papers published in international literature so far about these knee replacement prostheses are clinical trials with either a cohort of patients or one specific design or groups where both types are used4,5. What could be argued is that there is a difficulty in determining which patients have or are prone in having a deficient PCL in the next sort post-operative years, sometimes even inside the operating room; therefore, the implant decision is based on rather subjective criteria.

The outcomes that are of most importance for a successful knee arthroplasty are survival, range of motion (ROM) and knee flexion4,6. Other factors that may contribute to the effectiveness of the replacement and the well-being of the patient are stability, the ability to climb stairs, complications and subjective factors included in the WOMAC and SF36 forms. Logically, one element should be expected to have a direct impact on others; per se the ROM and flexion, or the stability, should influence the ability to squat, kneel and climb stairs. They could also affect the score of questionnaire forms, even the survival of an implant in relation with the patient’s demands. The aim of this review is to discover the advances that have been made during the past years in terms of establishing the differences between cruciate retaining and substituting designs. Also, the review explores these differences and their true impact on patients and implant survival rate.

Licensee OA Publishing London 2013. Creative Commons Attribution Licence (CC-BY)

Review

Competing interests: none declared. Conflict of Interests: none declared.

All authors contributed to the conception, design, and preparation of the manuscript, as well as read and approved the final manuscript. All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

Discussion
The author has referenced some of his own studies in this paper. These referenced studies have been conducted in accordance with the Declaration of Helsinki (1964), and the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

Survival
It is a fact that above all, a successful replacement is based on its capability to endure through time. Revision surgery can happen mostly due to the wear of polyethylene, loosening of components and change of position, increased stiffness, infection and fracture. Either by measuring the overall durability of a replacement or its radiological integrity or the clinical survivability, numerous studies have shown favourable results for both designs. Even for older designs, the results have almost always been most favourable. Mokris et al. studied a cohort of 105 Genesis I knee replacements, where no revisions were reported during a mean follow-up period of 4.25 years. On the same prosthesis, Laskin followed 56 PCLR and 44 PCLS Genesis I arthroplasties at an average follow-up of 11.2 and 10.4 years, respectively. Analysis demonstrated 96% survival in the group of patients in whom the PCL was retained and 97% in the group of patients in whom the PCL was sacrificed. Ishii et al. analysed data from 82 primary Genesis I total knee arthroplasties (TKAs) (53 PCLR and 29 PCLS) and also found survival as high as 97.6% after 7 years. A previous study by the author included a group of patients that had undergone a Genesis I PCLR prosthesis and non-resurfacing of the patella, and achieved a 96.69% survival rate after an average 12.6 year follow-up period. Newer models of the same company have also achieved a 5-year survival as high as 98% (Figure 2).

Other studies analysing models from different companies have also shown excellent results. Bistolfi et al. followed 179 TKAs for an average of 13.5 years where the Press Fit P.F.C implant was applied with cement technique. They observed that the cumulative average survival rate at 15 years (the endpoint being failure with revision) was 90.6% ± 2% standard deviation. Arthur et al. studied 171 Sigma Press Fit Condylar total knee replacements. Eight knees (3.4%) were revised, five for infection and three in order to change the polyethylene insert. The survival at 10 years with an endpoint of revision for any reason was found to be 95.9%, and when only a revision for aseptic failure was analysed, it was as high as 98.7%.

What can be understood from all the studies above is that so far most designs have been successful, despite retaining or sacrificing the PCL. However, if that is an established fact then

Licensee OA Publishing London 2013. Creative Commons Attribution Licence (CC-BY)

why do we still keep comparing these two different designs?

Range of Motion/Flexion
ROM of the knee plays a very important role in one’s daily activities. For patients with a western culture, a range of 90°–95° is essential for stair climbing and other routine actions.1 High knee flexion needs can rise up to 111°–165° for people with non-western cultures, who desire sitting cross-legged or kneeling on a regular basis. Therefore, it is necessary to find an implant that best serves these needs without compromising longevity.

There have been several reports in the past, which state that a higher ROM and knee flexion would be obtained by using a PCLR implant, with standard flexion designs.2–4 An intact PCL on normal knees is needed not only for preventing pathological posterior translation of the tibia specially on flexion, but also for enhancing posterior femoral roll back (PFR).25 PFR has been found to increase knee flexion and quadriceps strength by the elongation of the lever arm during active knee extension25.

On arthritic knees that have undergone TKA with PCLR prosthesis, these advantages have not been confirmed. Many kinematic studies have observed paradoxical femoral movement or reverse axial rotation in existing CR-type prostheses26–30 and inferior results also have been reported in the comparison studies of PS-type prostheses.1,2,6,31

Two meta-analysis reports have been done so far in the English literature in order to investigate studies that have compared PCLS and PCLR designs, and tried to strengthen the results in order to produce an answer as to which implant has shown improved post-operative outcomes and longevity.1,2,6,31 Jacobs et al.4 on a systematic Cochrane framework review found and studied eight randomized control trials. Two of them compared PCL retention against sacrifice, five against substitution and one had all three treatment options. The only statistical difference that could be found after analysis was that the PCLS group had 8° higher ROM when compared to the PCLS group. However, the study findings were heteroge-
knees and compared them with four cadaver specimens with light and electron microscopy. They demonstrated that the PCLs from the arthritic knees had more deteriorating changes and also that age ≥60 years was linked with reduced collagen diameter. Mullaji et al. studied 45 osteoarthritic knees and compared them histologically and radiologically. They found that irrespective of the radiological grade and severity of deformity, most PCLs had moderate degenerative changes.

On a young and active patient, keeping the PCL in a TKA sounds logical, particularly for the proponents of keeping knee anatomy as normal as possible. However, even patients under 55 years of age do have arthritic knees where the PCL may be already under a degeneration progress. Therefore, keeping the PCL with all the above findings entails the risks of PCL future rupture or deficiency, which could produce pain and decrease of daily activities.

Conclusion
The query still remains that if both designs have been in the market for so many years, one of them would have rationally dominated over the other by providing better results, or the cheaper, or easier-to-use product would have prevailed. More and more studies support that a PCLs implant may have better outcomes than a PCLR one. However, these advantages have yet to be proved great in clinical terms. Orthopaedic surgeons should still use the prosthesis with which they have more experience with and which most consistently provides good results for their patients. All clinical and meta-analysis studies suggested that even after four decades of research, more high-quality, randomized controlled studies needed that report comparable data on clinical aspects of knee replacements such as stair-climbing ability, stability, proprioception and pain relief. Only then there can be a clear statement about which prosthesis is clearly superior to the other and better for a patient’s knee.

References

Licensee OA Publishing London 2013. Creative Commons Attribution Licence (CC-BY)