

Bicruciate retaining

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Abstract: Total knee replacement (TKR) is a procedure used to treat knee arthropathy. Patients’ dissatisfaction is still relevant (literature reports dissatisfaction rates as high as 40%). The anterior cruciate ligament is usually removed while performing a total knee arthroplasty, thus changing knee biomechanics. As patients’ mean age to surgery is decreasing, bicruciate retaining models, which preserve normal biomechanics, may be useful in increasing patients’ outcomes. Limited data concerning bicruciate retaining arthroplasty is available; although clinical results are encouraging, there are concerns regarding surgical exposure, anterior cruciate integrity evaluation, and implant fixation.

Keywords: Bicruciate retaining; knee; replacement

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Total knee replacement (TKR): the need for bicruciate retaining implants

TKR is a widespread surgical procedure performed to relieve patients from pain mainly due to osteoarthritis. The 2014 annual report from the American Joint Replacement Registry shows a constantly decreasing mean age at the time of surgery (66.1 vs. 66.7 from the previous report, and 66.8 in 2012). Once considered a surgical procedure dedicated to the elderly, it’s now more often being performed in younger and more active patients. The risk of unsatisfying results after TKR is still present; Dunbar *et al.* (1) report data from the Swedish Knee Registry, from the National Joint Registry of England and Wales, and from the Ontario Joint Replacement Registry. Surprisingly, the data from three different countries showed constant rates of dissatisfaction of about 18%. Although literature reports studies in which unsatisfying results are more frequent, from 20% to 40% (2-4). Patients with a higher risk of dissatisfaction are females, with a pathology of more recent onset and duration, such as avascular necrosis, or patients with pain at rest (5).

Anterior cruciate ligament (ACL), although considered the main anteroposterior stabilizer of the knee, is usually sacrificed during TKR. This determines an alteration in the prosthetic knee kinematics, leading to the loss of the “screw home” and rolling back mechanisms. With both ACL and

posterior cruciate ligament (PCL) present, on flexed knee, the tibia is internally rotated. During knee extension, due to the difference in condyle morphology, the lateral condyle finishes its articular surface, and is contrasted by the ACL. The larger medial condyle rolls posteriorly, aided by the PCL. This brings the tibia in external rotation. With an ACL sacrificing TKR, paradoxical motion occurs (6,7), with the tibia subluxed anteriorly in extension and the femur translated anteriorly during flexion, thus leading to impingement and loss of flexion. In PCL sacrificing knee replacements, the PCL is substituted by a cam-post mechanism. As the ACL is deficient, the tibia is translated anteriorly during extension, thus leading to a possible impingement of the anterior cam on the posterior stabilizing box, increasing wear of the anterior post and consequently to failure (8).

Bull *et al.* (9) report a constant tibial external rotation both in extension and in flexion in ACL sacrificing TKR; roentgen stereophotogrammetric studies show constant alteration in articular kinematics both with cruciate retaining and cruciate sacrificing prostheses (10-12).

Bicruciate retaining implants: kinematics

Bicruciate retaining prosthesis (BCR), since its development by Gunston in the middle 1960s, was designed as a model

to allow for more physiological movement of the knee, and throughout the years it evolved in materials and conception; it may still be a satisfying solution in younger patients with more demanding activities, as it preserves normal biomechanics (13,14). Saving both cruciate ligaments leads to improved performance, as documented by gait analysis and stair climbing (15). New BCR models allow greater range of motion (ROM) than older designs, as they are capable of more rollback in the lateral compartment and have more flexion. Fluoroscopic analysis confirms near normal kinematics in BCR knee replacements, with limited anterior and posterior translation, as in normal knees (13,14). Pritchett *et al.* (16) compared different types of implants in patients undergoing bilateral staged TKR. BCR showed normal kinematics, and patients who had undergone staged bilateral knee replacement preferred them to posterior cruciate-retaining and mobile bearing prosthesis, although there was no statistical difference in terms of pain score, ROM, knee score, or function score. There was no preference in BCR prosthesis over medial pivot (MP) ones. This study, along others (17,18) illustrates the limited utility of health outcome questionnaires such as Oxford-12 or Knee Society Score to assess patients' satisfaction. As suggested by Pritchett, the patients seem to prefer a prosthetic model with anterior/posterior stability (as BCR or MP) preventing paradoxical motion. Another reason for BCR preference over other models may be the superior proprioception due to ACL preservation

Clinical results

In 1979, Cracchiolo published a study in which geometric and polycentric prosthetic models were compared with a mean 3.5 years follow up. Failure rates were 11% for the polycentric model and 16% for the geometric. A higher failure rate was seen in males, and in patients affected by osteoarthritis (19).

Buechel *et al.* (20) compared implants including a bicruciate retaining meniscal bearing, a posterior-retaining meniscal bearing, and a cruciate sacrificing, rotating platform tibial component mated to the same femoral and rotating patellar components with a mean follow up of 6 years. Survivorship did not differ in the three groups (survivorship for bicruciate retaining was 100% in this series).

Pritchett (16), on a series of 201 knees, demonstrated that, while comparing BCR and posterior-stabilizing total knee arthroplasties, 89.1% of patients preferred the former.

Limited data are available when considering a follow up

of at least 10 years. Cloutier (21) reports a survival rate of 95%; Sabouret (22) examined 32 knees with a mean follow up of 22 years, with a survivorship of 80% with the hermes-2C prosthetic model. At the time of surgery ACL had been preserved even when it had a partially degenerative appearance as long as anterior drawer and Lachmann tests were normal. Townley (23) on a 426 series with a mean follow up of 11 years found excellent or good outcomes in almost 90% of the patients.

Not all studies report positive results, however. In a prospective study with a follow up of 3-year, Jenny *et al.* (24) didn't find any difference in flexion, X-ray findings, and functional scores between BCR and a ACL-sacrificing prosthetic model (93 knees).

Migaud *et al.* (25) retrospectively studied 68 Cloutier prosthetic implants (in 38 that ACL was preserved): the main factor Causino anterior translation was an increase in tibial slope: a 10 degrees increase in posterior tibial slope caused a rise in anterior tibial translation by 5.6 mm in weight bearing situation. When ACL was preserved, the translation was lower but no statistical difference was found. Moreover, ACL sparing didn't increase ROM or Hospital for Special Surgery (HSS) score.

Surgical technique and implant characteristics

Bicruciate retaining prostheses's design has caused some concerns throughout the years. The tibial component is horseshoe-shaped, with a thinner central area (the "tibial bar") at potential risk of breaking. In order to prevent this from happening, the implant would have to be made thicker, thus increasing invasivity on the bone, and potentially endangering ACL. Tibial fixation has also been a concern; the area of contact between the tibial component and the bone is small, as there's no chance of central stabilization; bone fixation is supported by small pegs or fins. Pritchett (26) reports a series of BCR TKRs with a 23-year follow up; survival rate (89%) was similar to posterior sparing or posterior-stabilized implants (16,27,28). In this series, the main reason for failure was polyethylene wear. The encouraging data regarding survivorship may be due to the preservation of knee kinematics that may be decrease mechanical stress on the components.

Another challenge when performing BCR TKR is surgical exposure, as it is made more challenging by the presence of both cruciate ligaments, potentially affecting the quality of implantation. It may be difficult for the surgeon to recreate natural anatomy, such as varus and posterior tibial

slope. As suggested by Bellemans (29). Tibial component overhang must be avoided, as femoral component over the central bone block; the joint line must be recreated carefully to preserve cruciate ligaments' functionality.

Anterior cruciate ligament (ACL) integrity

In order for BCR prosthesis to work properly, both cruciate have to be intact. Mont *et al.* (30) have described different ACL histopathologic alterations in osteoarthritic knees, mostly present in elderly patients, with higher BMI, and more advanced osteoarthritis. Even in the presence of a macroscopically present ACL, it may be hard to define its functionality: Johnson (31) evaluated 200 patients at the time of surgery. Lachmann test alone, performed under anesthesia, was ineffective at predicting ACL functional integrity (33% sensitivity). The Lachmann test was then combined with MRI scans, which showed ACL presence. The sensitivity and specificity of the combined tests were 93.3% and 99%, respectively.

Conclusions

Bicruciate retaining TKAs are fascinating surgical option to treat active and younger patients as it have proved to preserve normal knee kinematics. However, the difficult surgical technique and concerns regarding prosthetic design and fixation have made the choice for this implant less attractive. Results from previous studies have shown encouraging results concerning patients' satisfaction when compared to other designs and a survivorship similar to ACL sacrificing prosthesis. Studies with long term follow-up on BCR replacements are still scarce; with more data available, development of new techniques and designs may lead to an increase in its usage.

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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