The influence of posterior condylar offset on knee flexion after total knee replacement using a cruciate-sacrificing mobile-bearing implant

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We have studied the concept of posterior condylar offset and the importance of its restoration on the maximum range of knee flexion after posterior-cruciate-ligament-retaining total knee replacement (TKR). We measured the difference in the posterior condylar offset before and one year after operation in 69 patients who had undergone a primary cruciate-sacrificing mobile bearing TKR by one surgeon using the same implant and a standardised operating technique. In all the patients true pre- and post-operative lateral radiographs had been taken.

The mean pre- and post-operative posterior condylar offset was 25.9 mm (21 to 35) and 26.9 mm (21 to 34), respectively. The mean difference in posterior condylar offset was +1 mm (-6 to +5). The mean pre-operative knee flexion was 111˚ (62˚ to 146˚) and at one year post-operatively, it was 107˚ (51˚ to 137˚).

There was no statistical correlation between the change in knee flexion and the difference in the posterior condylar offset after TKR (Pearson correlation coefficient r = -0.06, p = 0.69).

The range of movement (ROM) obtained after total knee replacement (TKR) is an important measure of the success of the procedure. Many variables have been investigated to determine their influence on the ROM in TKR.

Some studies have examined the impact of age, gender, diagnosis, body mass index (BMI), and the pre-operative ROM.1-6 Others have focused on a particular design of implant7-11 or surgical technique.12-14 The relevance of the rehabilitation regime has also been evaluated.15-17 Bellemans et al18 have defined posterior condylar offset as the maximal thickness of the posterior condyle projected posteriorly to the tangent of the posterior cortex of the femoral shaft on true lateral radiographs. They demonstrated that restoration of the posterior condylar offset had an important role in maximising the range of flexion after posterior-cruciate-ligament (PCL)-retaining TKR and that a reduction in the post-operative posterior condylar offset had an important role in maximising the range of flexion after posterior-cruciate-ligament-retaining TKR and that a reduction in the post-operative posterior condylar offset correlated with a significant decrease in the final maximum angle of flexion. A reduction of the posterior condylar offset of 3 mm or more resulted in a mean loss of flexion of 29.7˚ compared with TKR in which the posterior condylar offset was restored to within 3 mm. The influence of the posterior condylar offset on knee flexion has also been studied in patients undergoing TKR using a cruciate-sacrificing fixed-bearing prosthesis.19

Our aim was to determine the effect of the posterior condylar offset on knee flexion one year after TKR using a cruciate-sacrificing mobile-bearing prosthesis.

Patients and Methods
We reviewed the clinical and radiological data of 69 patients (26 men, 43 women) who had undergone cruciate-sacrificing mobile-bearing TKR with the low contact stress (LCS) rotating platform (DePuy, Johnson and Johnson, Leeds, United Kingdom). Their mean age was 68 years (38 to 87). The diagnosis was primary osteoarthritis (OA) in 67 patients and rheumatoid arthritis in two. In 55 patients, the mean pre-operative varus deformity was 9˚ (2˚ to 30˚), and in the remaining 14 the mean pre-operative valgus deformity was 13˚ (5˚ to 25˚).

True pre-operative lateral radiographs with complete overlap of the medial and lateral femoral condyles were available for all patients included in the study (Fig. 1). This was a qualifying requirement in order to minimise error in the measurement of the posterior condylar offset. All operations were performed by the senior author (DEB) using the same operating technique with an Insall20 approach to expose the proximal
tibia and resection of both cruciate ligaments. The proximal tibial osteotomy was made perpendicular to the mechanical axis of the limb using an extramedullary guide. With the LCS prosthesis the tibial guide allows a cut of 7° to 11°. We attempted to recreate the patients’ anatomical posterior slope. The anteroposterior (AP) dimension of the lateral femoral condyle was measured using a calliper to determine the appropriate size of the AP intramedullary cutting block. Care was taken to prevent excessive bony resection from the posterior femoral condyles by moving the AP block posteriorly if required. The distal femoral osteotomy was performed using a 5° valgus cutting guide. Ligament-balancing techniques were used and confirmed with spacer blocks to ensure a balanced knee with equal flexion and extension gaps. Any osteophytes at the posterior femoral condyles were removed. The patella was not resurfaced. All the patients were mobilised on the first post-operative day under supervision. Active knee flexion was measured pre-operatively and at one year by an independent single observer (NWT), using a standard hand-held goniometer with 38 cm arms with the patient supine. The lateral femoral condyle was used as the landmark to centre the goniometer with the proximal limb directed towards the greater trochanter and the distal limb towards the lateral malleolus. The amount of knee flexion was measured and recorded to the nearest 5°.

A second independent observer (BMH) measured the pre- and post-operative posterior condylar offset with the values being corrected for magnification as described by Bellemans et al. The difference in the posterior condylar offset before and after surgery was then calculated. The post-operative tibial slope was also measured from the lateral radiographs by measuring the angle between a line drawn parallel to the articular surface and a line drawn perpendicular to the long axis of the tibia (i.e., a line parallel to the length of the tibia on a true lateral radiograph).

Statistical analysis. The relationship between the difference in the pre- and post-operative posterior condylar offset and the change in knee flexion was assessed using a scatterplot graph (Fig. 2) and calculation of Pearson’s correlation coefficient (r). Statistical significance was set at p < 0.05.

Results

The mean pre-operative flexion was 111° (62° to 146°). The mean flexion at one year post-operatively was 107° (51° to 137°). The mean pre-operative posterior condylar offset was 25.9 mm (21 to 35) and after TKR it was 26.9 mm (21 to 34). The mean difference in the pre- and post-operative posterior condylar offset was 1 mm (-6 to +5), i.e., the change in posterior condylar offset ranged from a decrease of 6 mm to an increase of 5 mm. The mean post-operative tibial slope was 6.6° (5° to 9°).

There was no statistical correlation between the posterior condylar offset before and after surgery and the change in the pre-operative range of knee flexion and that measured at one year post-operatively (Pearson correlation coefficient, r = -0.06, p = 0.69; Fig. 2).

Discussion

A TKR is a well-established procedure performed to relieve pain and to improve the ROM in patients with disabling OA. Kinematic studies have shown that 67° of knee flexion is needed for the swing phase of gait, 83° to climb stairs, 90° to descend stairs and 93° to rise from a chair. The minimum knee flexion necessary for daily living is widely agreed to be 90°. Considering these requirements for satisfactory function, the factors which affect ROM should be understood.
Bellemans et al.\(^{18}\) first defined the concept of posterior condylar offset. They demonstrated fluoroscopically that in 72\% of the PCL-retaining TKRs in their study, the maximum active flexion possible was limited by direct impingement of the posterior aspect of the tibial component against the posterior aspect of the femur. This finding was attributed to a number of factors including paradoxical roll forward with flexion, the presence of a high posterior lip on the polyethylene insert and an insufficient posterior slope to the tibial osteotomy. Failure to restore the posterior condylar offset because of excessive resection of the posterior femoral condyles resulted in considerable loss of flexion caused by posterior impingement. When a reduction of 3 mm or more had occurred in the posterior condylar offset there was a mean reduction of flexion of 29.7\(^\circ\) compared with those knees in which the posterior condylar offset had been restored to within 3 mm. Furthermore, they concluded that operating guidelines which rely on anterior referencing can result in excessive bone resection from the posterior femoral condyles because of undersizing of the femoral component.

Kim et al.\(^{19}\) performed a prospective, randomised study comparing the ROM between a standard fixed-bearing prosthesis (Standard NexGen LPS prosthesis; Zimmer, Warsaw, Indiana) in one knee and a high-flexion fixed-bearing prosthesis (NexGen LPS-Flex prosthesis; Zimmer) in the contralateral knee in patients undergoing simultaneous bilateral TKR. In the standard implant group, the posterior condylar offset was decreased by a mean of 1.2 mm compared with the pre-operative value. The restoration of posterior condylar offset was significantly better in the high-flexion implant group, but this finding was not clinically relevant since there was no significant difference in knee flexion between the groups at two years after the initial procedure.

Massin and Gournay\(^{26}\) investigated the potential effects of posterior condylar offset, tibial slope and the condylar roll-back on the range of knee flexion. They demonstrated that a decrease of 3 mm in the posterior condylar offset reduced knee flexion by 10\(^\circ\) before tibiofemoral impingement occurred. Furthermore, a simultaneous decrease in the tibial slope of 5\(^\circ\) reduced the range of flexion by a further 5\(^\circ\). These effects could be reinforced if paradoxical roll-forward was more than 10 mm.

In our study we found no statistical correlation between the difference in posterior condylar offset before and after surgery and the change in knee flexion. In some patients the posterior condylar offset was decreased (1 mm to 6 mm) while in others it was increased (1 mm to 5 mm). The decrease in posterior condylar offset must have resulted from excessive resection of the posterior condyles and the increase from intentional movement of the AP cutting block posteriorly in order to reduce the amount of bone being resected from the posterior condyles. However, within the range of posterior condylar offset in our study (-6 mm to +5 mm), an increase or decrease did not significantly affect the change in knee flexion. Furthermore, the mean difference in posterior condylar offset was only 1 mm (-6 to +5) indicating that it can be restored satisfactorily when using anterior femoral referencing TKR systems provided that care is taken to prevent excessive resection of the posterior femoral condyles.

Our findings are in contrast to those observed by Bellemans et al.\(^{18}\) There may be several reasons for this. First, in the videofluoroscopic part of their study they noted forward sliding of the femur during flexion (paradoxical roll forward). However, in vivo kinematic studies of the low contact stress rotating platform prosthesis have shown almost midline positioning of the femoral component on the rotating platform during deep knee flexion.\(^{27}\) Secondly, the posterior tibial slope in their study was 3\(^\circ\), whereas the coronal tibial cut in the low contact stress technique is intended to produce a posterior slope of 7\(^\circ\), which may also reduce the potential for impingement of the insert against the posterior femoral cortex. The combined effects of condylar roll-forward, reduction in posterior condylar offset and insufficient tibial slope have been demonstrated by Massin and Gournay.\(^{26}\) This may explain why in our study a similar decrease in posterior condylar offset did not result in a significant decrease in knee flexion. In a follow-up study, however, Bellemans et al.\(^{28}\) have shown that when the post-operative tibial slope was compared with maximum flexion, there was a mean gain of flexion of 1.7\(^\circ\) for every additional degree of tibial slope.

In conclusion, when using the low contact stress cruciate-sacrificing rotating platform TKR, we found no correlation between posterior condylar offset and knee flexion one year after operation.

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References


