

Intentionally Increased Flexion Angle of the Femoral Component in Mobile Bearing Unicompartmental Knee Arthroplasty

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Purpose: The purpose of this study was to determine the results of mobile bearing unicompartmental knee arthroplasty (UKA) with an intentionally increased flexion angle of the femoral component in patients requiring high flexion.

Materials and Methods: We investigated 45 knees treated by UKA. Clinically, we measured the range of motion (ROM) and the American Knee Society (AKS) score preoperatively and at final follow-up and investigated complications. Radiologically, we measured the flexion angle of the femoral component, the posterior slope angle of the tibial component, the femorotibial angle and mechanical axis of the limb postoperatively.

Results: The ROM was increased from 123° preoperatively to 139° at the final follow-up. The AKS knee and function scores increased from 59 and 68, respectively, preoperatively to 94 and 96, respectively, at the final follow-up. The flexion angle of the femoral component was 9.1°, and the posterior slope angle of the tibial component was 8.6°. There was one case of bearing dislocation in the largest femoral flexion angle case.

Conclusions: The results might reflect the positive effect of an increased flexion angle of the femoral component up to 10° on ROM in mobile bearing UKA, which would contribute to better quality of life after UKA especially in populations requiring deep knee flexion.

Keywords: Knee, Arthroplasty, Unicompartmental, Flexion angle, Femoral component, Range of motion

Introduction

Better range of motion (ROM) following knee arthroplasty is an important factor with regard to better clinical outcomes¹⁻³. In Asian cultures, highly flexed knee positions are required more frequently than in other cultures because of cultural or religious reasons^{1,3-5}. Theoretically, unicompartmental knee arthroplasty (UKA) has the benefit of increasing ROM compared to total knee

arthroplasty (TKA)⁶⁻⁸; however, high flexion can also increase the rate of complications such as dislocation of the polyethylene bearing in mobile bearing systems^{4,5}. Currently, improved operative techniques and new implants have been developed to permit higher knee flexion and to minimize complications⁹⁻¹¹.

In general, increased flexion angle of femoral components may permit higher flexion³. However, as the angle increases, the risk of dislocation can also increase due to subsequently increased flexion gap with abnormal gap balancing in mobile bearing systems^{4,12}. Given these facts, the Oxford group suggested a flexion angle of the femoral component between 5° extension and 10° flexion for mobile bearing UKA¹³. Many articles regarding mobile bearing UKA have reported the mean flexion angle of the femoral component ranged between 0.8° extension and 2.1° flexion in their series¹³⁻¹⁶. Those angles are close to neutral 0° flexion and far from the 10° flexion of acceptable limit suggested by them. Nonetheless, we could not find any clinical report presenting beyond 2.1° of average femoral component flexion angle in mobile bearing UKAs.

Received June 23, 2017; Revised August 21, 2017;

Accepted September 18, 2017

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The purpose of this study was to determine the effects of mobile bearing UKA in patients requiring high flexion knees, receiving about 10° of flexion angle of the femoral component which is the nearest numerical value as acceptable limit in flexion angle of the femoral component suggested by the Oxford group¹³. We hypothesized that the intentionally increased angle of the femoral component close to 10° of flexion would increase the postoperative ROM (Fig. 1) without increasing the rate of bearing dislocation or additional complications. To support the hypothesis, we compared our findings with those presented in the literatures on flexion angles of the femoral component in mobile bearing UKA.

Materials and Methods

We retrospectively investigated 43 patients (45 knees) treated by UKA using Oxford phase 3 (Biomet, Bridgend, UK) components. The mean follow-up period was 51 months (range, 23 to 75 months), except one patient due to death from lung cancer. There were 7 males and 35 females with a mean age of 61 years (range, 48 to 78 years). Written informed consent was obtained from all patients before this institutionally approved study was initiated. The preoperative diagnosis was medial unicompartamental osteoarthritis of the knee in all cases. The operation was performed by a senior author in all cases.

We assessed the preoperative magnetic resonance imaging scans in all patients to verify the status of cruciate ligaments, menisci and degenerative changes in the cartilaginous lesions. All patients had varus deformities and flexion contractures less than 15° with ROM greater than 100° preoperatively⁶. Patients with

asymptomatic degenerative changes of the patellofemoral joint were included^{6,8}. We excluded patients with anterior or posterior instability and those with grade 2 degenerative lesions in the lateral compartment according to the Kellgren and Lawrence classification^{6,8}.

For the operation, about 8 cm longitudinal incision was made at about 1 cm medial to the proximal part of the patella. After opening the joint, without everting the patella, we removed all osteophytes and verified the status of intraarticular structures such as cartilage, anterior cruciate ligament and menisci. Next, we performed a medial tibial cut perpendicular to the tibial mechanical axis using a tibial saw guide aimed at about 7° of the posterior tibial slope angle. We then performed an excision of the anterior part of the medial meniscus. Then we drilled a hole at 1 cm anterior to the anteromedial corner of the intercondylar notch, inserted an intramedullary (IM) rod and positioned a femoral drill guide based on the IM rod. From a sagittal view, the uppermost surface of the drill guide had been recommended parallel to the IM rod, however, we positioned the drill guide at about 10° flexed to the IM rod using a goniometer in the lateral view. Then we cut the posterior side of the medial femoral condyle using a cutting guide based on the drill guide with about 10° flexion. We measured the flexion and extension gap using a filler gauge and matched the gap by gradual milling of the distal femoral condyle. After checking the balanced flexion and extension gap with a trial implant inserted, we fixed the real tibial and femoral components with bone cement and inserted the mobile bearing polyethylene. All patients performed ankle-pumping exercises and active motion exercises on the day of operation as well as passive motion

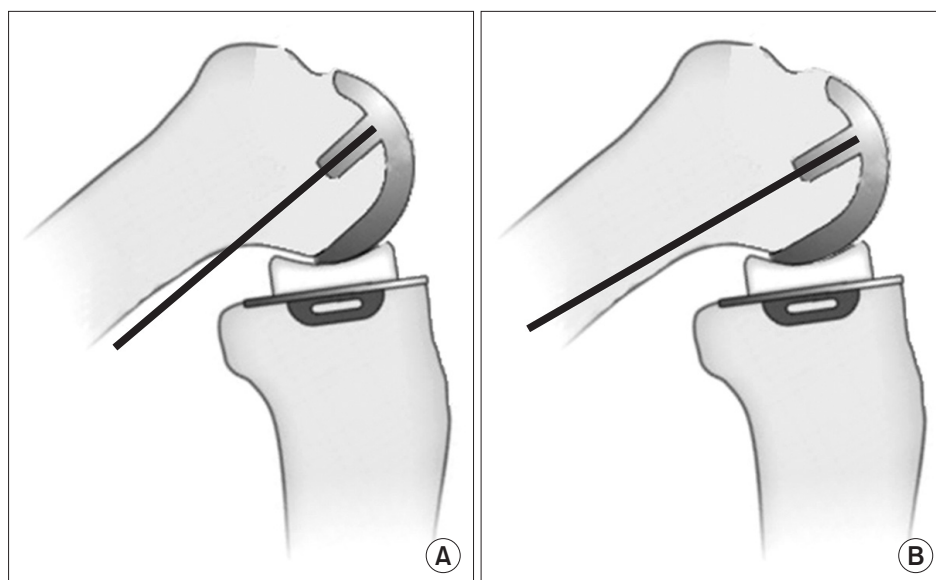


Fig. 1. Illustrations showing different sagittal positions of the femoral component. Flexed position of the femoral component can increase posterior contact surface and range of motion. (A) Neutral position. (B) Flexed position.

exercises from postoperative day one. We educated patients on crutch ambulation and allowed pain-free distance ambulation. Outpatient follow-up was performed at 6 weeks, 3 months, 6 months, and 1 year postoperatively and then once every year. Radiologically, we measured the femorotibial angle pre- and postoperatively as well as the mechanical axis. Furthermore, we measured the flexion angle of the femoral component and posterior slope angle of the tibial component on postoperative radiographs. Clinically, we measured the American Knee Society (AKS) score and ROM preoperatively and at the latest follow-up and investigated complications including polyethylene bearing dislocation at the last follow-up.

Results

The mean preoperative femorotibial angle was 2.5° valgus (range, 4.8° varus to 8.1° valgus), which was corrected to 6.0° valgus (range, 0.2° valgus to 12.8° valgus) postoperatively, with the mean preoperative mechanical axis of 4.8° varus (range, 12.0° varus to 3.1° valgus) corrected to 0.7° varus (range, 6.7° varus to 6.9° valgus). The average flexion angle of the femoral component was 9.1° (range, 5.0° to 15.3°), and the average posterior slope angle of the tibial component was 8.6° (range, 4.6° to 10.0°).

The average AKS knee score increased from 59 (range, 52 to 70) preoperatively to 94 (range, 70 to 100) and the average AKS function score increased from 68 (range, 40 to 70) to 96 (range, 80 to 100) at the last follow-up. The average ROM was increased from 123° to 139° and the flexion contracture decreased from 4.7° to 0° at the last follow-up (Table 1).

There was one case of bearing dislocation. It developed at post-

operative 6 weeks in a patient with 15.3° of flexion of the femoral component which was the largest flexion angle among our series. Consequently, it was converted to TKA. There was no other additional postoperative complication such as infection or early implant loosening till the last follow-up.

Discussion

The principal finding of this study was that a better ROM was achieved with an intentionally increased flexion angle of the femoral component in mobile bearing UKA. To achieve satisfactory clinical outcomes with UKA, it is crucial to determine the proper position of components¹⁷⁻¹⁹. Radiologically, the femoral component's varus/valgus angle or mediolateral distance in the coronal plane is important because of impingement or edge loading on the polyethylene bearing especially in fixed bearing UKA^{14,15}. However, there has been little knowledge about the sagittal positioning of the femoral components, and much contention exists surrounding the normal ranges of femoral component flexion and extension angles¹³.

In the current study, we hypothesized that the postoperative ROM would increase after UKA performed with the target femoral component angle of 10° as suggested by the Oxford group as the acceptable high flexion angle of the femoral component¹³. We conjectured that increasing the flexion angle of femoral components would facilitate better flexion of the knee joints through gradual but stable widening and lengthening of the articular surface in contact with the posterior surface of the femoral component and bearing during deep knee flexion (Fig. 1). Up to now, existing literatures have reported average flexion angle of the

Table 1. Comparison of Previous Studies about Component Angles, Range of Motion (ROM) and Dislocation

Study	Flexion angle of femoral component (°)	Posterior tibial slope (°)	ROM (°)		No. of dislocations (%)
			Preoperative	Postoperative	
Shakespeare et al. ¹⁶⁾	-0.2 (-10 to 15)	5.7 (-5 to 10)	N/A	N/A	N/A
Vorlat et al. ²³⁾	N/A	N/A	N/A	N/A	4 (2.6)
Gulati et al. ¹⁵⁾	-0.8 (-9.9 to 9.6)	5.1 (0.8 to 13.1)	N/A	N/A	0 (0)
Clarius et al. ¹⁴⁾	2.1 (-10 to 19)	6.1 (0 to 14)	115 (80 to 150)	130 (100 to 155)	N/A
Pandit et al. ²²⁾	N/A	N/A	117 (25 to 145)	130 (85 to 152)	6 (0.6)
Choy et al. ⁴⁾	N/A	N/A	135 (95 to 150)	150 (140 to 165)	10 (5.3)
Kim et al. ²⁵⁾	N/A	N/A	129 (120 to 135)	133 (127 to 150)	3 (2.4)
Lim et al. ⁵⁾	N/A	N/A	129 (120 to 135)	133 (127 to 150)	12 (3)
Kim et al. ¹³⁾	1.2 (-12 to 20)	N/A	N/A	N/A	N/A
Current study	9.1 (5.0 to 15.3)	8.6 (4.6 to 10.0)	123 (90 to 140)	139 (125 to 145)	1 (2.3)

Values are presented as mean (range).

N/A: not available.

femoral components between 0.8° extension and 2.1° flexion¹³⁻¹⁶. Therefore, we intended to evaluate the postoperative ROM of the knee with an intentionally increased flexion angle of the femoral component of about 10° and compare with previous reports.

The postoperative ROM documented in previous Western articles using the Oxford phase 3 ranges from 130° to 133°^{8,14,20}. Among Asian studies, Lim et al.⁵ reported 133° of postoperative ROM compared to 129° of preoperative ROM, and Kim et al.²¹ reported 133.5° as a mean postoperative ROM. The average postoperative ROM in the current study (139°) was in agreement with the results of these previous articles. However, there was no information on the flexion angle of the femoral component in those studies^{5,8,20,21}. Therefore, we could not compare with those studies in term of radiographic flexion angle of the femoral component.

There were few articles reporting the femoral component angle in the sagittal plane. To the best of our knowledge, only one article by Clarius et al.¹⁴ reported a relationship between flexion-extension angles of the femoral components and clinical scores in UKA using Oxford phase 3 implants. They inserted femoral components with an average 2.1° of flexion and there was no difference in clinical scores between the properly implanted group and the outlier group according to the guidelines proposed by the Oxford group¹⁴. In all the other reports with Oxford phase 3, the radiographic mean flexion angle of the femoral components was considerably lower than that in the current study¹⁴⁻¹⁶ (Table 1). Among these, comparison on the postoperative ROM was possible only with the study of Clarius et al.¹⁴: postoperative knee flexion was greater in our study compared to the study with a different flexion angle of the femoral component. This might indicate the positive effect of the increased flexion angle of the femoral component on postoperative ROM.

Although an increased flexion angle of the femoral component may allow a better ROM of the knee joint³, bearing dislocation can occur due to the increased flexion gap resulting from gradual widening of the flexion gap in deep flexion⁴. In the current study, the flexion angle of the components was aimed at about 10°, which is the maximum permissible angle according to the Oxford group recommendation¹³, and there was no dislocation observed up to this angle. We experienced one case of bearing dislocation, but it was an exceptional case with 15.3° of flexion of the femoral component; this was far beyond our target angle and was the largest flexion angle in our series. So, we carefully suggest that the risk of bearing dislocation can increase in case of overly greater flexion angle of the femoral component.

The incidence of bearing dislocation in mobile bearing UKA

was 0.6% to 2.6% in recent studies²²⁻²⁵. However, considering these results were all from the Western countries, it has limited applicability to Asian countries where kneeling and cross-legged positions are required much more frequently. Indeed, the studies in East Asia reported dislocation rates of 3% to 5.3%^{4,5}, which might suggest the influence of different lifestyles on the rate of dislocation in different populations. On the other hand, Lim et al.⁵ reported the non-anatomical bearing resulted in a higher rate of dislocation in the early period than the anatomical bearing (3.2% vs. 2.8%). Similarly, Choy et al.⁴ also suggested the impact of non-anatomical bearing on dislocation in their series. Therefore, we think the non-anatomic type of bearing could be considered as one of the causative factors of bearing dislocation.

The newly designed Microplasty (Zimmer Biomet, Bridgend, UK), the twin peg Oxford partial knee, adopted the extra peg, lengthened the posterior flange and the arc by 15° and consequently increased the contact with a bearing at high knee flexion¹¹. Although White et al.¹¹ reporting the new twin peg design with a 5.4° of flexion angle of the femoral component did not demonstrate an increase in the actual ROM compared to the conventional one peg design, we anticipate an increased postoperative ROM in the twin peg design model with an intentionally increased flexion angle of about 10° based on our results.

The limitations of our study include a relatively small number of cases (45 knees) without a comparison group; therefore, we could not compare with knees with a neutral flexion angle of the femoral components in a single surgeon series. On the risk of dislocation, other related factors such as the angle of posterior tibial slope or the tension of medial ligamentous structures were not investigated thoroughly. However, the degree and range of posterior tibial slope were similar among patients included in the current study and the operation technique was the same in all cases since it was a single surgeon's series. Last, the follow-up period was relatively short for arthroplasty, and therefore further investigation with a longer term follow-up would be required.

Conclusions

We think that the technique of intentionally increasing the femoral component flexion angle to about 10° in mobile bearing UKA may produce a better ROM without increasing the incidence of bearing dislocation. This would contribute to better quality of life after UKA especially in the population demanding deep knee flexion.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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