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Cam impingement of the posterior femoral condyle in unicompartmental knee arthroplasty

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Abstract

Purpose There has been much emphasis on the importance of cam impingement, which is a cause of pain and knee hyperflexion restriction in unicompartmental knee arthroplasty (UKA). This study aimed to correlate cam impingement in the posterior femoral condyle with an α-angle showing the severity of the impingement.

Methods The study groups consisted of 87 knees of 74 patients operated on with phase 3 medial Oxford UKA. Postoperatively, Group A (68 knees, 78.2 %) had no remnant of cam lesion; Group B (19 knees, 21.8 %) had cam lesion remnants. In Group C (18 knees, 20.7 %), which is a subgroup of Group A, cam lesions seen preoperatively were cleaned and not seen postoperatively.

Results The mean increase in active flexion was 20.4° (±7.3°) in Group A, 9.7° (±6.1°) in Group B and 20.8° (±7.3°) in Group C. The difference between Group A and Group B and between Group B and Group C was statistically significant ($p < 0.001$, $p < 0.001$). The mean decrease of α-angle was 11.2° (±4.1°) in Group B, and 31.1° (±3.4°) in Group C. The difference was statistically significant ($p < 0.001$). Mean Oxford Knee Scores were 24 preoperatively, 41 postoperatively in Group A; 22 preoperatively, 38 postoperatively in Group B; and 24 preoperatively, 40 postoperatively in Group C. The differences were not significant.

Conclusions Posterior condylar cam lesion is an impingement which limits hyperflexion and may be an early clinical finding prior to bearing dislocation and wear. The α-angle is a marker showing the severity of this cam lesion. This problem can be overcome using intraoperative fluoroscan views during cam excison and replacing the femoral component in 105° knee flexion.

Level of evidence II.

Keywords Cam · Flexion · Impingement · Unicompartmental knee arthroplasty

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Introduction

Daily activities such as level walking, walking up and down stairs and rising from a chair can be accomplished with approximately 120° of flexion. However, there are activities such as gardening, squatting and kneeling that are important to many patients especially in Japan, and muslim populations that require flexion of 150° or greater [15, 22, 25, 27]. Under the concept of permissible deep flexion, various types of artificial knee joints have been developed.

Unicompartmental knee arthroplasty (UKA) is one of the main treatment options for anteromedial osteoarthritis of the knee. The advantages of this implant include a smaller incision, less soft-tissue injury, minimal bone resection, minimal blood loss, shortened hospital stay, and a faster and better functional recovery with better postoperative knee flexion [7, 11, 16]. Many reports have shown less favourable long-term results or early failures, which require revision total knee arthroplasty or reoperation [4, 13, 14, 20, 24].

Polyethylene wear and dislocation of the mobile-bearing insert are the two main complications seen in Oxford UKA due to impingement [4, 8, 13, 19]. Retrieval studies from mobile-bearing unicompartmental knee replacements have shown that the wear rate and dislocation are increased if the wearing impinges on bone or cement [9, 21]. Thus, cam impingement in the posterior femoral condyle which causes wear and eventual dislocation may be the cause of pain and hyperflexion restriction in the early postoperative period. Cam lesions in the posterior femoral condyle are mainly ignored or cannot be completely cleaned because of the localization.

If the cam lesion in the posterior femoral condyle was cleaned completely, the flexion range of the knee might increase. The severity of the cam lesion may be explained objectively with an angle measurement. In this study, a correlation was made between the angle which describes the severity of the cam impingement and early clinical findings such as pain and hyperflexion restriction. Ways of overcoming cam impingement of the posterior femoral condyle in UKA are also explained in this study.

Materials and methods

Between 2008 and 2011, phase 3 medial Oxford UKA (Biomet, Swindon, United Kingdom) was applied to 87 knees of 74 patients (67 female, 7 male) using 53 cemented and 34 cementless Oxford UKA. All of the indications were anteromedial osteoarthritis of the knee. All operations were performed by the same group of orthopaedic surgeons. The mean follow-up period was 14 (6–40) months. Standard anteroposterior and lateral radiographs of the knee were taken preoperatively and postoperatively in the same way in all patients. In this study, lateral knee radiographs had more importance for the viewing and evaluation of the cam impingement of posterior medial femoral condyle. The medial condyle is seen more magnified than the lateral condyle in lateral knee radiographs because the cassette is positioned at the back of the medial condyle, and the radiograph beam is directed from the lateral side of the knee. This can help to distinguish the two condyles from each other. A bony spur formation in the posterosuperior region of the medial femoral condyle was named as 'cam' which inhibits hyperflexion of the knee. A cam impingement angle (α-angle) was defined. A line parallel to the posterior diaphyseal cortical axis of the femur was put onto the posterior tip point of the posterior condyle. Two lines were drawn from this tip point. The first line was drawn to the starting point of the cam impingement and the second line to the metaphysodiaphyseal junction point of the posterior medial femoral condyle. The angle between these two lines is the 'α'-angle (Fig. 1). A higher α-angle is the cause of earlier impingement in flexion.

The patients were divided into three groups. Group A (68 knees, 78 %) included the knees in which no cam lesion was seen in the postoperative period (Fig. 2), whereas Group B (19 knees, 22 %) consisted of the knees with cam impingement postoperatively. We also compared Group B with a subgroup of Group A consisting of the knees in which the cam lesions seen preoperatively were cleaned and not seen postoperatively (Group C). Group C consisted of 18 knees (21 %). To overcome the excision problem of the cam lesions, two surgical techniques were added in Group C. Firstly, the femoral component was put in 105°-flexion position instead of 90°. To obtain this position, the femoral component peg was drilled in 15°

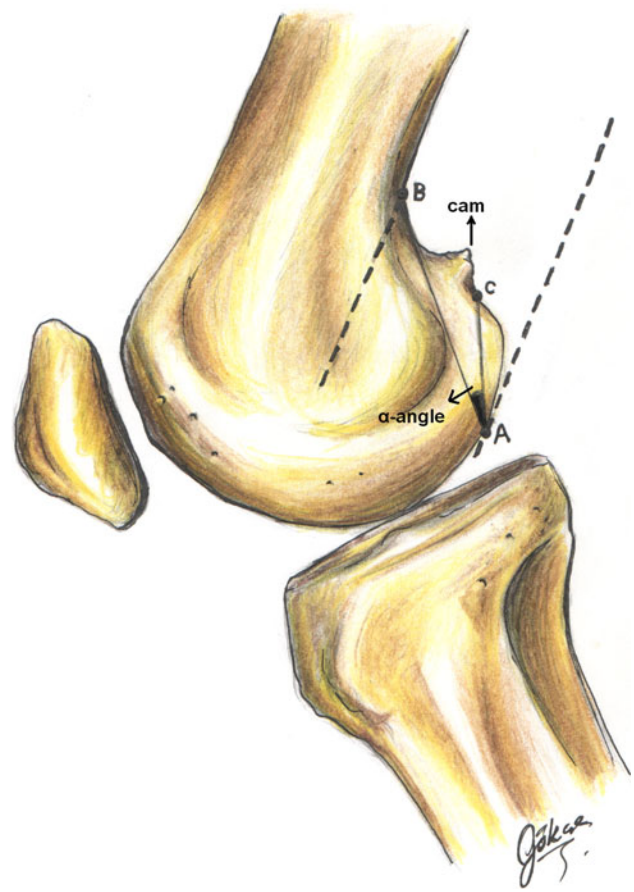

Fig. 1 The method of measuring the 'α-angle'. This drawing shows the sagittal view of a knee with a posterior condylar cam lesion. A line parallel to the posterior diaphyseal cortical axis of the femur is drawn onto the posterior tip point (point *A*) of the posterior condyle. Two lines are drawn from point A. The first line is drawn to the starting point (point *C*) of the cam impingement and the second line to the metaphysodiaphyseal junctional point (point *B*) of the posterior medial femoral condyle. The angle between these two lines is the 'α'-angle

flexional position to the intramedullary femoral guide instead of parallel placement. Secondly, the cam lesion was excised with a curved osteotome which was seen clearly in the intraoperative fluoroscopic view (Fig. 3a–c). In these cases, the gap in 20° of flexion was equalized to the gap in 105° of flexion instead of 90°.

The acceptable range of femoral position in Oxford phase III medial UKA is 0°–15° flexion. We aimed to position in the maximum acceptable flexional position of the femoral components in Group C which is 15°. In this way, we can obtain a longer arc of metal for contact in deep flexion. Also, the femoral components we used were twin pegged which were more stable than one pegged femoral components.

Fig. 2 Postoperative lateral X-ray of a knee with anteromedial osteoarthritis without a cam lesion in Group A

The maximum active flexion and Oxford Knee Score (OKS) were evaluated in the groups. The preoperative and postoperative α-angles in Group B and Group C were also measured from the lateral radiographs with the angle measurement programme found in the picture archiving and communication system (PACS). Then, this angle was correlated with the maximum active flexion of the knees. The flexion range of the knees of all the patients was measured with a goniometer. Clinical investigations of the patients were made by the same surgeon to increase the intraobserver reliability of the study (OKS evaluation, measuring range of active flexion, measuring α angles). Active full flexion was possible in the postoperative twelfth week in all of the patients.

Statistical analysis

The parameters of the patients in the groups were collected and entered into the Statistical Package for Social Sciences (SPSS) computer programme. In statistical analysis, ANOVA and Mann–Whitney *U* test were used to compare the groups.

Results

The mean ages of the patients were 58 years (±4.6), 56 years (±6.7) and 56 years (±5.3), respectively, in Groups A, B and C. Mean body mass indexes (BMI) of the patients were 29.4 (±2.4) in Group A, 30.2 (±2.1) in Group B and 29.8 (±3.1) in Group C. There was no

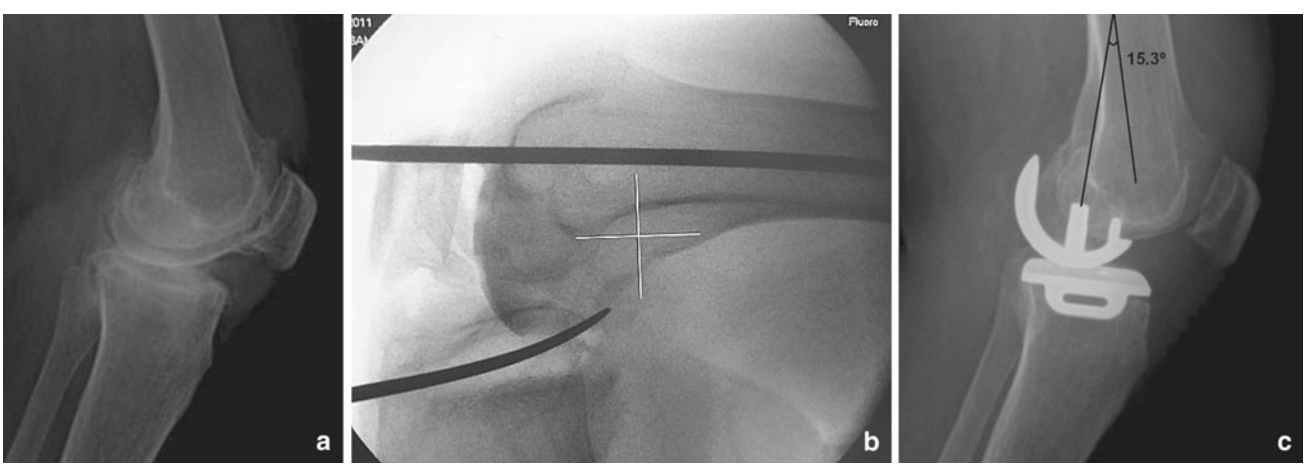

Fig. 3 **a** Preoperative lateral X-ray of a knee with anteromedial osteoarthritis with a cam lesion in Group C. **b** The cam lesion was existed with a curved osteotome as can be clearly seen in the intraoperative fluoroscopic view. **c** The postoperative lateral X-ray of the knee. There was no remnant of the cam lesion, and the femoral component was positioned in 15.3° flexion

significant difference between the groups in terms of age and BMI.

An intraoperative complication in the operation of one patient of avulsion of the median eminencia occured from the origin of the anterior cruciate ligament, and it was fixated with headless screws in the same operation. In another case, a medial tibial plateau fracture was seen in the postoperative third week which had occured in the intraoperative period as a fissure type fracture. It was revised with cannulated screws and total knee arthroplasty. These patients were excluded from this study. There was no infection, bearing dislocation, loosening of the components or any other complications.

The mean flexion contracture was 5° (±4°) preoperatively, which improved to 2° (±2°) postoperatively at the final follow-up in all groups. The mean posterior tibial slope was 6° (±2°) in all groups of the knees. Group A and Group B were compared according to the mean preoperative and postoperative active knee flexion, mean OKS of the patients (Table 1). In Group A, the mean increase in the active motion of flexion was more prominent than in Group B ($p < 0.001$). There was an evident increase in OKS in both groups, but the difference was not significant. Group B and Group C were compared according to the mean preoperative and postoperative active knee flexion, α angle and mean OKS of the patients (Table 2). The mean increase in the active motion of flexion was more significant in Group C compared with Group B ($p < 0.001$). Moreover, the α-angle decreased much more clearly postoperatively in Group C compared with Group B ($p < 0.001$). The OKS of the patients in Groups B and C increased, but the difference was not significant between the groups. The correlation of Groups B and C according to the mean active flexion of the knee and α-angle in the preoperative and postoperative periods is shown in Table 3.

Table 1 The mean preoperative and postoperative active flexion motion and mean OKS of Group A and Group B

	Group A	Group B	*p* value
F-pre	114.4° ± 6.7°	110.8° ± 6.3°	ns
F-post	134.9° ± 7.5°	120.5° ± 5.7°	<0.001
F-inc	20.4° ± 7.3°	9.7° ± 6.1°	<0.001
OKS-pre	24	22	ns
OKS-post	41	38	ns

F flexion, *pre* preoperative, *post* postoperative, *inc* increase, *ns* non-significant

Table 2 The mean preoperative and postoperative active flexion motion, α-angles and mean OKS of Group B and Group C

	Group B	Group C	*p* value
F-pre	110.8° ± 6.3°	111.1° ± 5.3°	ns
F-post	120.5° ± 5.7°	131.9° ± 6.0°	<0.001
F-inc	9.7° ± 6.1°	20.8° ± 7.3°	<0.001
α-pre	33.1° ± 4.3°	31.1° ± 3.4°	ns
α-post	21.8° ± 6.2°	0°	<0.001
α-dec	11.2° ± 4.1°	31.1° ± 3.4°	<0.001
OKS-pre	22	24	ns
OKS-post	38	40	ns

F flexion, *pre* preoperative, *post* postoperative, *inc* increase, *dec* decrease, *ns* non-significant

Discussion

The most important finding of the present study was that cam impingement in the posterior femoral condyle should be removed to increase the range of knee flexion in UKA. Early hyperflexion restriction after UKA is due to cam impingement of the polyethylene insert. As the severity of the cam increases, which is defined as the increase of the α angle, the restriction of the knee hyperflexion is also increased. In studies by Pandit et al. [19] and Kendrick et al. [8], it was clearly shown that the rates of polyethylene wear and dislocation increased with the presence of impingement in UKA. Although the clinical knee scores do not show any significant differences, impingement may play a role in future wear and bearing dislocations.

Banks et al. showed the mean range of flexion during kneeling and lunge in a comparative kinematic study of unicondylar and bi-unicondylar knee replacements. Mean flexion was 135° during kneeling and 133° during lunge which shows the effectiveness of unicondylar knee replacements in gaining a significant range of active knee flexion in daily activities [2]. There are many factors that affect the postoperative range of flexion in the knees. Two main factors are the posterior condylar offset which is defined as the projection of the posterior arc of the femoral component from the posterior cortex of the femur, and the posterior slope of the tibial surface. Small posterior condylar offset and small posterior tibial slope decrease the range of flexion in the knees [3, 5, 23, 26]. In the current study, the tibial slope was approximately the same and did not effect the difference of the flexion ranges between the groups. 'Posterior condylar cam' lesion, which is a bony spur formation located in the posterosuperior part of the medial femoral condyle, was defined in this study. In flexion of the knees with posterior condylar cam lesions the posterior femoral impingement starts earlier, and the range of flexion is limited if the posterior condylar offset is smaller. The "α-angle" is the marker of the starting point of this posterior condylar impingement. If the α-angle is higher, the posterior impingement starts earlier, and flexion is much more limited. Another factor that limits the range

Table 3 The correlation of mean α-angle and mean active flexion in the preoperative and postoperative periods of Group B and Group C

	Group B pre	Group B post	Group C pre	Group C post
α-angle	33.1° ± 4.3°	21.8° ± 6.2°	31.1° ± 3.4°	0°
Flexion	110.8° ± 6.3°	120.5° ± 5.7°	111.1° ± 5.3°	131.9° ± 6.0°

pre preoperative, *post* postoperative

of flexion is the soft-tissue impingement seen in patients with a high BMI. In the demographic data of the patients, in the current study, there were no statistical differences in terms of BMI. Therefore, BMI was not accepted as a cause of hyperflexion restriction.

Pandit et al. [19] reported mean knee flexion as 133° at the end of a 5-year follow-up of patients undergoing phase 3 OUKA. In other studies, with phase 3 OUKA, the mean knee flexion increased from 117° to 131°, from 106.4° to 117.4° and from 128.8° to 130.4°. The results of the current study are similar in Group A and in Group C where there was no remnant of posterior condylar cam lesion. However, in Group B, the active range of flexion was found to be 120° which was lower than the other groups.

Cam lesions in the posterior femoral condyle are mainly ignored or cannot be completely cleaned because of the localization. A smaller size of femoral component will result in more remnants of cam lesion. Ascertaining the most suitable femoral component can be achieved with preoperative templating, although this is not enough to fully excise the cam lesion. To overcome the cam impingement problem, two surgical tricks can be used. Firstly, under intraoperative fluoroscopic views, the cam lesion can be completely excised with a curved osteotome. Secondly, the femoral component can be placed at 105° flexion of the knee. In this way, 15° of extra femoral surface can be provided in the posterior femoral condyle, which increases the deep flexion. White et al. placed the femoral components at 105° flexion of the knee instead of 90° during twin-peg phase III Oxford medial unicompartmental knee replacements as was done in the current study for Group C knees; thus, a longer arc of metal for contact in deep flexion was obtained. The 2-year results reported no meniscal bearing dislocation or revision in 108 knees, and the median range of flexion was 130° [28]. Moreover, this surgical technique provides a greater congruency between meniscal bearing and the femoral component, which may be beneficial for stress distribution and surface wear.

The reported OKS of Oxford UKA patients has been 41.3, 40.2, 38.3, 39 and 42 in different studies [9, 12, 18, 19]. In the present study, the OKS of the patients was similar to those in the literature. The OKS for the patients in the current study showed that good function can be maintained in Oxford UKA even when there is posterior condylar cam impingement and flexion is limited.

In phase 3, Oxford UKA is a mobile-bearing UKA. High wear rates have been reported for fixed-bearing components, and a mobile-bearing component can minimize polyethylene wear [1, 6, 10, 17]. Posterior condylar cam lesion is a barrier in hyperflexion. Mobile-bearing UKA is normally placed posteriorly while flexing the knee, but a cam lesion causes impingement, and thus, the mobile bearing is forced to go anteriorly. This lesion blocks the knee during active motion of hyperflexion. If hyperflexion is forced, the polyethylene wear of the mobile-bearing may start, and with more force, it may dislocate anteriorly. Choy et al. [4] reported rates of bearing dislocations greater than component loosening with 5.3 % of bearing dislocation in a 22.6-month-follow-up period of 166 Oxford UKA, most of which were anteriorly dislocated. In a study by Pandit et al., the results of 1,000 cases were reported, and it was concluded that the most common reason for further surgical intervention was the progression of arthritis in the lateral compartment (0.9 %), followed by dislocation of the bearing (0.6 %) and revision for unexplained pain (0.6 %) [19]. If the bearing is functionally normal without impingement, the wear rate is less than 0.03 mm/year [21]. Kendrick et al. [9] found the mean annual wear rate of the polyethylene bearing to be 0.045 mm/year. In another study by Kendrick et al., the wear rates of mobile-bearings were categorized into 3 groups. In the first group with no abnormal macroscopic wear and a normal articular surface, the wear rate was 0.01 mm/year. In the second group with abnormal macroscopic wear and normal articular surfaces with extra articular impingement, the wear rate was 0.05 mm/year. In the last group, abnormal macroscopic wear and abnormal articular surfaces with intraarticular impingement were seen, and the wear rate was 0.12 mm/year [8]. Thus, it can be seen that the wear rate increases if impingement occurs.

A limitation of the present study is that only short-term findings are reported. Long-term follow-up would allow for the observation of whether cam impingements increase the rates of wear or bearing dislocation. Another limitation is that it is a retrospective study as more objective results may be obtained from prospective studies.

Advanced surgical techniques and instruments may be produced to overcome the cam lesion of the knee. More attention may be needed in the preoperative evaluation of the patients according to the cam lesion in the posterior femoral condyle, not only in UKA, but also in total knee arthroplasty and arthroscopic surgery of posterior horn lesions of the medial meniscus.

Conclusion

Posterior condylar cam lesion is an significant cause of impingement which limits hyperflexion of the knee. The α-angle can be used as a good marker of the severity of the cam lesion. As this impingement is caused by the push force of the cam lesion on the polyethylene bearing, the repetitive contact of these structures may be a cause of further wear and dislocation of the bearing.

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