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Complications - Other

# Epidemiology of Bearing Dislocations After Mobile-Bearing Unicompartmental Knee Arthroplasty: Multicenter Analysis of 67 Bearing Dislocations

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ABSTRACT

*Background:* This study investigated the epidemiology and causes of bearing dislocations following mobile-bearing unicompartmental knee arthroplasty (MUKA) and determined whether the incidence of primary bearing dislocations decreases as surgeon experience increases.
*Methods:* We retrospectively reviewed the bearing dislocations following MUKAs performed by 14 surgeons with variable experience levels. Causes of bearing dislocations were determined based on the surgical records, radiographs, and operator's suggestion. Using a chi-squared test, the incidence of bearing dislocation was compared between the first 50, the second 50, and the next 100 unicompartmental knee arthroplasties (UKAs) of each surgeon's cohort.
*Results:* There were 67 (3.6%) bearing dislocations from 1853 MUKAs. The mean time to bearing dislocations after index MUKAs was 33 months (range, 1-144 months); 55% of the bearing dislocations occurred within 2 years after the index MUKAs. Primary bearing dislocations (n = 58) were the most common, followed by secondary (n = 6) and traumatic dislocations (n = 3). There was no significant difference in the incidence of bearing dislocation between the first 50 and second 50 UKAs for each surgeon. Two surgeons showed a significant decrease in bearing dislocations in their second 100 UKAs, while the other surgeons did not show a difference between their first 100 and second 100 UKAs.
*Conclusion:* Most bearing dislocations after MUKAs were related to technical errors such as component malposition or gap imbalance. This study did not confirm that the incidence of bearing dislocations decreases as the number of cases increases.
*Level of Evidence:* IV, Case series.



Bearing dislocation is one of the early complications occurring after mobile-bearing unicompartmental knee arthroplasty (MUKA). A reported incidence of bearing dislocation after MUKA is 0%-5.3%, being more frequent in Asian patients than in Western patients [1–10]. In particular, the incidence of bearing dislocation has been reported to be higher in Korean patients than in other Asian populations with similar activities of living [3,4,11–14]. Although possible explanations for the higher incidence of bearing dislocation in Asian population have been suggested, the exact causes remain undetermined.

Poor surgical techniques are related to primary bearing dislocation as defined by the Oxford group [15]. Such poor techniques include component malalignment, flexion-extension gap imbalance, iatrogenic medial collateral ligament (MCL) injury, and impingement by remnant cement [5,10,16–19]. To prevent technical errors, surgeons should be aware of technical pitfalls and tips. In addition, optimal usage of unicompartmental knee arthroplasties

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(UKAs) is important to improve and maintain good surgical skills. As revision rates decrease with both increasing surgeon experience (UKAs/surgeon/year) and usage (percentage of primary knee arthroplasty that are UKAs) [20], it is expected that the incidence of bearing dislocations after MUKAs decreases as the surgeon's experience increases.

To identify the cause of the higher incidence of bearing dislocation in the Asian population, it is necessary to know the epidemiology of this specific complication. However, there is little information about the epidemiology of bearing dislocations after MUKAs. The purpose of this study is to investigate the epidemiology and common causes of bearing dislocations after MUKA. A secondary purpose is to determine whether the incidence of primary bearing dislocations decreases as a surgeon's experience increases. As primary bearing dislocations are related to surgical technical errors, we hypothesized that the incidence of primary bearing dislocation would decrease as the number of cases increases.

## Methods

After obtaining institutional review board approval, we retrospectively reviewed cases of bearing dislocations following MUKAs performed at 8 hospitals by 14 orthopedic surgeons with variable experience levels (Table 1). All surgeons were knee joint specialists and their primary practice was arthroplasty (more than 10 years' experience). All primary MUKAs were selected based on the indications recommended by the Oxford group [15,21], and they were performed using a minimally invasive approach between 2002 and 2016 with Oxford medial partial knee implants (Oxford Phase 3; Zimmer Biomet, Warsaw, IN) in all patients. Available data on patient demographics, clinical and radiographic outcomes, intraoperative findings at the time of the revision surgery for bearing dislocation, and recent follow-up were collected from medical records in each hospital.

The causes of bearing dislocations were categorized into primary, secondary, and traumatic according to the Oxford group classification [15]. We developed 4 bearing dislocation modes for the subanalysis of primary bearing dislocations: mode 1, component malposition (femoral or tibial component, Figs. 1 and 2), which was assessed using the radiographic criteria by the Oxford group [15,22]; mode 2, flexion-extension gap imbalance (Fig. 3); mode 3, intraoperative MCL injury, which was determined by surgical note or hypervalgus alignment on the postoperative radiographs; and mode 4, bearing impingement by the cement or bone, which was determined by surgical note or postoperative radiographs (Fig. 4). The causes and modes of bearing dislocations were determined by consensus among 4 independent MUKA users (knee surgeons more than 7 years' experience of MUKA) based on the surgical records and radiographs. The gap imbalance was considered a cause of bearing dislocation, if there were no component malposition, no intraoperative MCL injury, and impingement. If the exact causes were not determined by 4 MUKA users, the surgeon's suggestion about bearing dislocation modes was taken.

To determine whether the incidence of bearing dislocation decreases with an increase in the number of procedures that each surgeon performs, we compared the incidence of bearing dislocation between the first 50 UKAs and the second 50 UKAs of each surgeon's cohort. This analysis was performed only for surgeons who performed UKAs in more than 100 cases. Second, we also compared the incidence of bearing dislocation between the first 100 UKAs (early experience) and the second 100 UKAs (late experience) of each surgeon's cohort. This analysis was performed only for surgeons who performed UKAs in more than 200 cases.

Continuous variables were presented as mean and standard deviation, whereas categorical variables were described using frequency and percentages. The chi-squared test was used for the comparison of the incidence of bearing dislocation between early and late surgeon experience and for the comparison of the incidence of recurrent bearing dislocations between the anterior and posterior bearing dislocation (SPSS version 12.0; IBM, Armonk, NY). Significant difference was set at $P < .05$.

## Results

A total of 67 (3.6%) bearing dislocations from 1853 MUKAs were analyzed (Table 2). The mean time to bearing dislocations after the index MUKA was 33 months (range, 1-144 months). Most (55%) of the bearing dislocations occurred within 2 years after the index MUKA (Table 3). Primary bearing dislocations (n = 58, 87%) were the most common, followed by secondary (n = 6, 9%), and traumatic (n = 3, 4%) bearing dislocations. For primary bearing dislocations, the most common bearing dislocation mode was component malposition (n = 34, 59%, 18 femoral, 16 tibial), followed by flexion-extension gap imbalance (n = 20, 34%), intraoperative MCL injury (n = 2, 3%), and bearing impingement (n = 2, 3%). Secondary bearing dislocations were caused by chronic MCL laxity (2 cases), femoral component loosening (2 cases), bearing wear (1 case), and bearing fracture (1 case).

The median number of MUKAs performed by all surgeons at the time of the first bearing dislocation was 14 (range, 1-47). Most surgeons (9 of 14) have experienced bearing dislocations in more than 2 cases. There was no significant difference in the incidence of bearing dislocation between first 50 UKAs and second 50 UKAs for each surgeon (Table 4). Two surgeons (S10, S11) showed a significant decrease in bearing dislocations in their second 100 UKAs, while the other surgeons (S12, S13, S14) did not show a difference between their first 100 UKAs and their second 100 UKAs.

Reoperations for the first bearing dislocation included 52 bearing exchanges and 15 conversions to total knee arthroplasty (TKA). The causes for conversion to TKA were 7 component malalignment, 5 gap imbalance, 2 femoral component loosening, and 1 MCL insufficiency. Of the 52 bearing exchanges, 13 (25%) redislocations (8 anterior, 2 posterior, 3 medial) occurred. The mean time interval between the first and second dislocations was 15 months (range, 1-44 months). Bearing sizes of index UKAs with redislocation were 3 mm (n = 2), 4 mm (n = 8), 5 mm (n = 1), 6 mm (n = 1), and 7 mm (n = 1). At the time of bearing exchange, there were 1-mm increase (n = 4), 2-mm increase (n = 6), and 3-mm increase (n = 2). Further subanalysis of the bearing exchange group showed that anterior dislocation was significantly higher in redislocations (anterior 62%, posterior 15%, medial 23%; $P = .039$).

**Table 1**
Total Experience and the Incidence of Bearing Dislocation for Each Surgeon.

| Surgeon | Total Number of MUKA Cases | Incidence of Bearing Dislocation, N (%) | Caseload (UKAs/y) | Usage (%UKA/ TKA + UKA) |
|---|---|---|---|---|
| Surgeon 1 | 14 | 3 (21%) | <12 | <20% |
| Surgeon 2 | 17 | 1 (6%) | <12 | <20% |
| Surgeon 3 | 32 | 2 (6%) | <12 | <20% |
| Surgeon 4 | 37 | 1 (3%) | >12 | <20% |
| Surgeon 5 | 41 | 1 (2%) | >12 | <20% |
| Surgeon 6 | 44 | 1 (2%) | >12 | <20% |
| Surgeon 7 | 51 | 4 (8%) | >12 | <20% |
| Surgeon 8 | 95 | 1 (1%) | >12 | <20% |
| Surgeon 9 | 164 | 2 (1%) | >12 | <20% |
| Surgeon 10 | 200 | 4 (2%) | >12 | <20% |
| Surgeon 11 | 225 | 11 (5%) | >12 | >20% |
| Surgeon 12 | 240 | 6 (3%) | >12 | >20% |
| Surgeon 13 | 284 | 11 (4%) | >12 | >20% |
| Surgeon 14 | 409 | 19 (5%) | >12 | >20% |

MUKA, mobile-bearing unicompartmental knee arthroplasty; UKAs, unicompartmental knee arthroplasties; TKA, total knee arthroplasty.

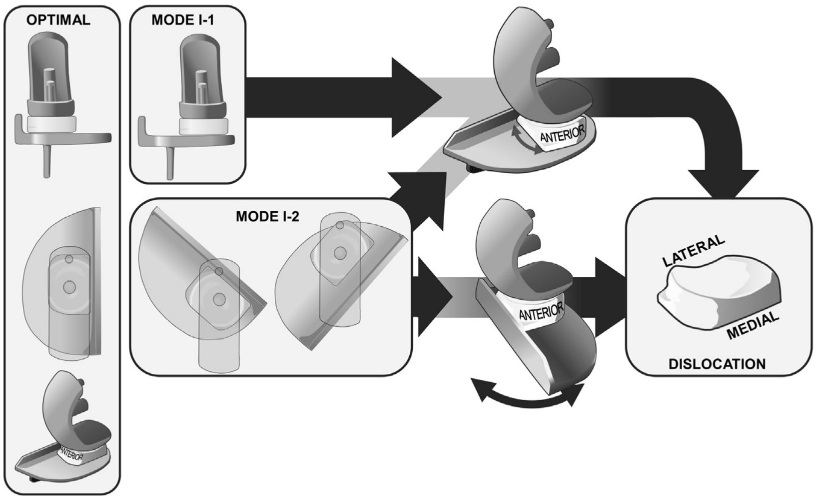


**Fig. 1.** Bearing dislocation mechanism by component malposition (mode 1). In mode 1-1, a wide coronal gap between the bearing and lateral wall of the tibial component can result in bearing rotation. This phenomenon can occur in rotatory malrelationship between the bearing and tibial plate (mode 1-2). In both cases, the femoral component over the bearing can be dissociated by the relatively short medial and lateral bearing rim (compared with the anterior and posterior bearing rim). The bearing spinning phenomenon was reported in previous studies.

## Discussion

This multicenter study investigated the epidemiology and common causes of bearing dislocations following 1863 MUKAs. The incidence of bearing dislocations in our multicenter analysis was 3.6%, which was similar to that previously reported from a single-center analysis in our country [3,4,14]. Most (87%) bearing dislocations were primary dislocations as defined by the Oxford group. The most common bearing dislocation mode for primary bearing dislocations was component malposition, followed by flexion-extension gap imbalance. Most bearing dislocations occurred early after the index MUKA, suggesting that the causes were related to technical surgical errors.

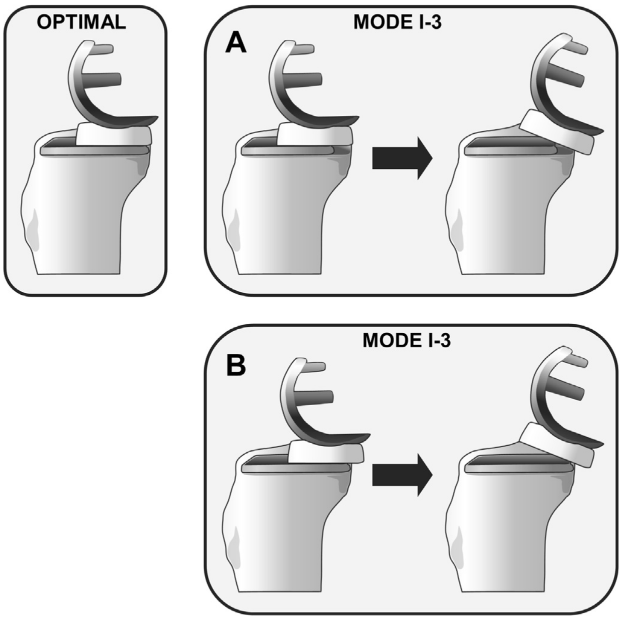


**Fig. 2.** Bearing dislocation mechanism by component malposition (mode 1). In mode 1-3, the posterior portion of the bearing can become unsupported by the tibial component through 2 possible mechanisms. First (A), the undersized or too anteriorly placed tibial component can cause posterior falling of the bearing in deep knee flexion. Second (B), the physiologic or pathologic anterior translation of the proximal tibia relative to the femur (eg, anterior cruciate ligament insufficiency, generalized ligamentous laxity) during deep knee flexion can cause the same situation.

As primary bearing dislocations are related to surgical errors, it is important to know the common surgical errors during MUKA for prevention. In our cohort, there was a similar group of surgical errors. We categorized such errors into 4 modes, which reflect primary reason for bearing dislocation. Mode 1 was designated as component malposition. Cho et al [23] reported 1 case of bearing dislocation due to an abnormal flexion position of the femoral component. According to Clarius et al [19], care should be taken with respect to the medial position of the femoral component, as a deviation could cause the inlay to slide medially, leading to soft tissue irritation and eventually bearing spinning and dislocation. Mode 2 was designated as flexion-extension gap imbalance due to inappropriate bone cut, and improper soft tissue tension. Mode 3 was defined as intraoperative MCL injury that could or could not be identified during surgery. In this mode, an unusually thick bearing may be inserted for fear of bearing dislocation, resulting in postoperative valgus limb alignment. Mode 4 was designated as bearing impingement by the cement, bone, or component. Bozkurt et al [24] suggested that posterior condylar cam lesion is an impingement that limits hyperflexion and may be an early clinical finding before bearing dislocation and wear. Bearing dislocation can occur due to combination of several causes in many cases. Our suggested modes reflect not a single cause but primary reason of a combination of multifactorial causes leading to bearing dislocation. In addition, they may help surgeons understand the complex mechanism of bearing dislocation phenomenon and prevent surgical errors during MUKA.

A wide space between the medial margin of the femoral component and the lateral wall of the tibial component is a well-known risk factor for bearing spinning. However, we observed that component malposition in the sagittal or axial plane can also be a risk factor for bearing dislocation. Therefore, component malposition was subdivided into coronal, rotational, and sagittal malposition. Component malposition in the coronal plane occurs when the femoral or tibial component is situated too medial or too lateral, respectively, to the other component. The coronal plane for

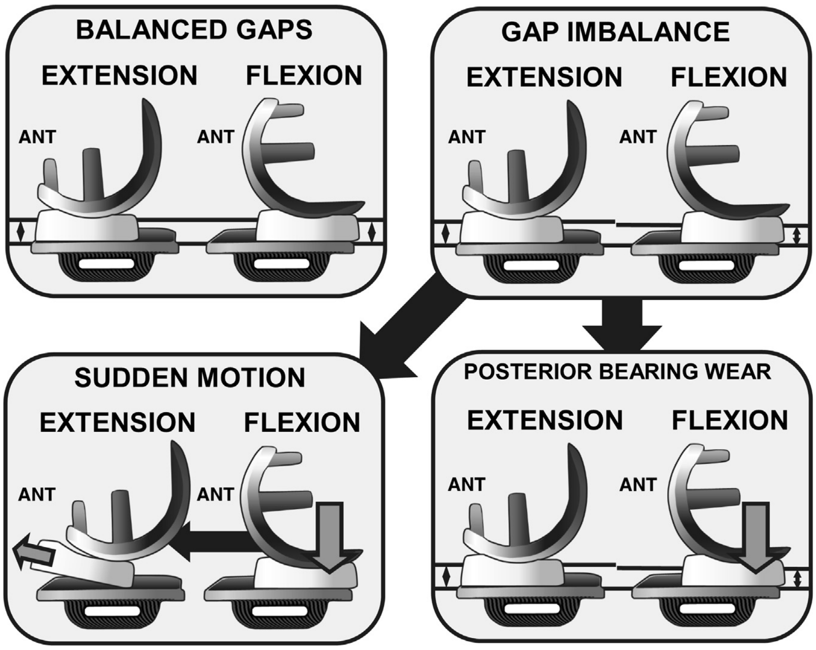


**Fig. 3.** In balanced flexion-extension gap, the anterior-posterior translation of the bearing during knee flexion-extension motion is not problematic (left superior inbox). However, flexion-extension gap imbalance (ie, the extension gap is wider than the flexion gap; right superior inbox) can cause bearing dislocation. During sudden knee motion from flexion to extension (left inferior inbox), the bearing can suddenly spring out from the femorotibial articulation. Chronically, tight flexion gap can cause posterior bearing wear (right inferior inbox). This wear lowers the posterior bearing rim, resulting in anterior bearing dislocation. EXTENSION, extension of knee joint; FLEXION, flexion of knee joint; ANT, anterior.

component malposition results in a wide space for bearing spinning, leading to bearing dislocation. Component malposition in the sagittal plane occurs when the posterior portion of the bearing is uncovered by more than half of the tibial component. An undersized tibial component to the medial articular surface or a too anterior placement of the tibial component leads to an overhanging bearing on the tibial component during deep flexion. When more than half of the bearing part overhanging occurs posteriorly, bearing dislocation may occur posteriorly. Component malposition in the axial plane mainly occurs when the rotational alignment of the tibial component does not match that of the femoral component. As the bearing follows the femoral component, a serious rotational mismatch between the femoral and tibial components can result in bearing maltracking on the tibial component leaving

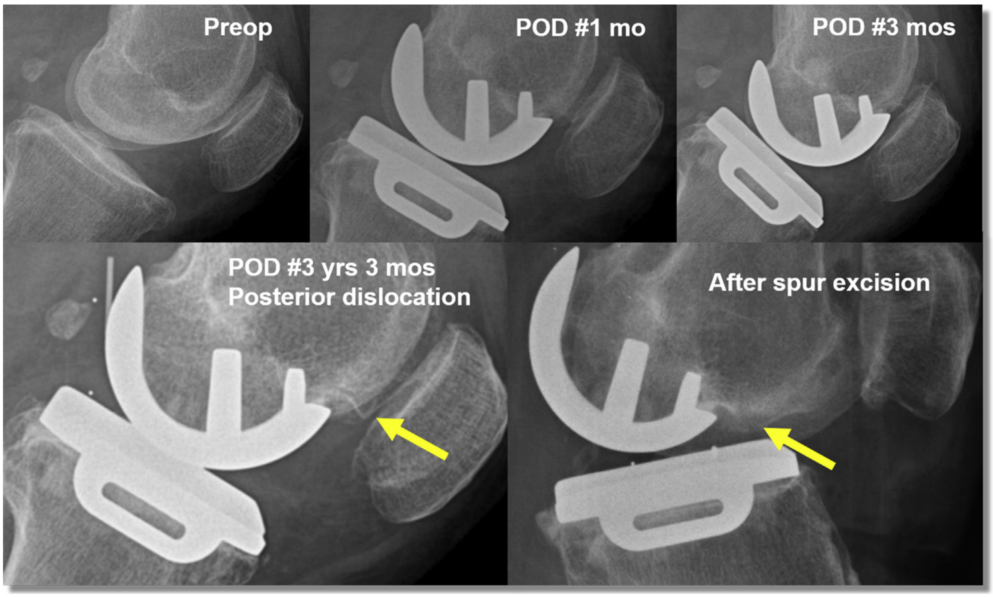


**Fig. 4.** A case of anterior bony impingement of the bearing. There is an obvious bony spur (yellow arrow) anterior to the femoral component at 3 years and 3 months postoperatively. This spur is not visible during the immediate postoperative periods (at 1 and 3 months after index surgery). Following posterior bearing dislocation, bearing exchange and spur resection were performed. No further bearing dislocation event occurred.

**Table 2**
Demographics of 67 Bearing Dislocation Patients.

| Variable | Bearing Dislocation Cases (N = 67) |
|---|---|
| Age (y) | 64 ± 8 (range, 48-80) |
| Sex (male/female) | 5/62 |
| Body mass index (kg/m$^2$) | 27 ± 3 (range, 19-35) |
| Diagnosis | 60 OA, 7 osteonecrosis |
| Operated side (right/left) | 28/39 |
| Dislocation direction | |
| Anterior/posterior/medial | 36/28/3 |
| Microplasty (yes/no) | 17/50 |
| Femoral component | |
| Single peg/twin pegs | 39/28 |
| Extra-small/small/medium | 38/26/3 |
| Tibial component | |
| AA/A/B/C/D | 14/22/22/8 (1 missing data) |
| Bearing thickness (mm) | |
| 3/4/5/6/7/8/9 | 19/32/7/5/2/0/1 (1 missing data) |

OA, osteoarthritis.

space for bearing spinning. When bearing overhanging or bearing impingement by the tibial implant owing to bearing maltracking occurs, the bearing dislocates.

Improper size of components can be another mode of bearing dislocation, although the present study did not include a component size as a mode of bearing dislocation. Because the small symmetric single-radius components may not match the anatomy of the medial femoral condyle exactly, extra-small or small femoral components with single peg are difficult to place correctly on the femoral condyle, which may lead to component malposition or wide space for a meniscal bearing to spin out. In our study, 18 of 38 patients with an extra-small size femoral component had a height more than 154 cm, which was not appropriate for an extra-small size femoral component according to a guide to the size of femoral component based on the height and gender [15]. However, it is unclear whether the size of femoral components was underestimated for these 18 patients, as postoperative radiographic evaluation did not show undersize of femoral components. Further study will be needed to investigate whether extra-small size component would be a risk factor of bearing dislocation.

Some authors suggest that the performance of deep knee flexion activities may be a predisposing factor for bearing dislocation, because the incidence of bearing dislocation has been reported to be higher in Asian populations experiencing deep knee flexion activities [9,10]. Theoretically, 2 factors could possibly increase the risk of bearing dislocation in patients performing deep knee flexion activities, namely tight flexion gap and component malposition in the sagittal plane. Tight flexion gap may decrease the normal posterior translation of the meniscal bearing, increase the lift-off of the meniscal bearing's anterior portion, and increase the wear of the meniscal bearing's posterior edge with deep knee flexion. All of

**Table 3**
Time From Index Unicompartmental Arthroplasties to Bearing Dislocations in 67 Cases.

| Time from surgery | Cumulative Number of Bearing Dislocations, N (%) |
|---|---|
| 6 mo[a] | 15 (22) |
| 1 y | 26 (39) |
| 2 y | 37 (55) |
| 3 y | 43 (64) |
| 4 y | 47 (67) |
| 5 y | 53 (79) |
| 6 y | 57 (85) |
| 7 y | 62 (93) |
| 8 y | 64 (96) |
| 12 y | 67 (100) |

[a] Follow-up period after index unicompartmental knee arthroplasties.

**Table 4**
Comparisons of the Incidence of Bearing Dislocations.

| Surgeon | First 50 UKAs | Second 50 UKAs | Second 100 UKAs | *P* Value[b] (50 vs 100) | *P* Value[c] (100 vs 200) |
|---|---|---|---|---|---|
| S9[a] | 1 | 1 | | 1.000 | |
| S10 | 1 | 3 | 0 | .307 | .043 |
| S11 | 5 | 6 | 0 | .749 | .001 |
| S12 | 2 | 3 | 3 | .646 | .471 |
| S13 | 2 | 4 | 5 | .400 | .756 |
| S14 | 2 | 3 | 5 | .646 | 1.000 |

UKAs, unicompartmental knee arthroplasties.
[a] Surgeon number in Table 1.
[b] *P* value, comparisons between first 50 UKAs and second 50 UKAs for each surgeon.
[c] *P* value, comparisons between first 100 UKAs and second 100 UKAs for each surgeon.

these factors decrease the bearing entrapment between the femoral and tibial components, resulting in a predisposition to bearing dislocation. Furthermore, a greater posterior translation of the meniscal bearing with deep knee flexion may predispose to overhanging on the tibial implant, leading to a fall from the tibial component in cases of component malposition in the sagittal plane. However, the higher incidence of bearing dislocation is limited to the Korean population, whereas the incidence of bearing dislocation in other Asian countries is similar to that in Western countries [11–13]. In addition, our study showed that most bearing dislocations in our cohort were related to technical surgical errors and that only 3 cases of bearing dislocations were due to component malposition in the sagittal plane. Therefore, whether deep knee flexion activities could lead to a predisposition for bearing dislocation remains unclear.

Appropriate MCL tension is very important to prevent bearing dislocation [25]. Bearing dislocations due to MCL laxity have been reported in the literature [13,26,27]. In our study, 2 cases of bearing dislocations were due to chronic MCL laxity; however, the cause of the chronic MCL laxity could not be exactly explained. A possible cause could be an undetected intraoperative partial MCL injury with progressive MCL stretching (laxity) caused by overcorrection from varus to valgus alignment. During bone cutting (especially the horizontal cutting of the tibia), the MCL could be injured as a result of insufficient protection. Minimal or partial MCL injury may be underestimated intraoperatively. In this situation, surgeons perceive that MCL tension seems to be normal at the time of surgery. However, the injured MCL can progressively stretch with time beyond its normal length. Overcorrection can accentuate the MCL stretch, leading to joint distraction [28,29]. Therefore, surgeons should be careful to preserve the MCL to avoid overcorrection after surgery.

As MUKAs require precise surgical technique, the surgeon's experience is associated with clinical outcomes and occurrence of complications [20,30–32]. However, it is not yet determined that a surgeon's experience influences the incidence of bearing dislocation. A previous meta-analysis showed no difference in the annual or absolute revision rate for bearing dislocation although the experience or usage of UKAs increased [20]. Our study showed that the incidence of bearing dislocations in the first 50 UKAs of each surgeon was not significantly different from the second 50 UKAs, which means that it does not decrease as experience increases up to 100 UKAs. We also found that 3 of 5 surgeons had similar incidence of bearing dislocation between the first 100 UKAs and the second 100 UKAs. Although high-volume surgeons are less likely to experience primary bearing dislocations, they can occur at any experience level owing to many variables.

Treatment options for bearing dislocations include bearing exchange, UKA component exchange, and conversion to TKA. As treatment differs according to the underlying causes, identifying the causes of bearing dislocation is exceedingly important for the decision on the proper treatment of the bearing dislocation. In our study, 52 bearing dislocations were treated with bearing exchange, whereas others were managed by conversion to TKA. Of 52 patients, 13 (25%) had redislocation after bearing exchange, implying that the bearing exchange alone did not properly correct the underlying causes. In general, there are 3 possible scenarios for the underlying causes of bearing dislocations: correctable, uncorrectable, and undetermined causes. If the underlying cause of bearing dislocation is correctable during reoperation, bearing exchange can be the preferred option after the cause has been corrected. In these cases, redislocation does not theoretically occur. If the underlying cause of bearing dislocation is uncorrectable during reoperation, redislocation is likely to occur after bearing exchange alone. In these cases, conversion to TKA could be the proper treatment to prevent reoperation. When a definite cause of bearing dislocation cannot be determined, bearing exchange may fail because the underlying cause is not corrected. It would be better to perform conversion to TKA as a definitive treatment.

This study has several limitations. First, it was difficult to identify the exact cause of the bearing dislocation in 3 patients owing to inadequate radiographs and insufficient data on the gap balance status, retrieved bearing, and MCL tension from the surgical records. In these cases, the surgeon's opinion was a high priority in determining the cause. However, a recall bias can be another limitation. Second, although we collected a large volume of cases from 14 surgeons, the incidence of bearing dislocation in this study may not represent the true incidence because several high-volume MUKA surgeons in our country did not participate in this study. However, our data were collected from a heterogeneous group of surgeons with variable experiences. This means that our results can be applied to surgeons of any experience level. Third, most MUKAs in this study were performed before the introduction of the Microplasty instrumentation system (Oxford Microplasty; Zimmer Biomet). Koh et al [33] previously reported that the Microplasty instrumentation system consistently placed the femoral and tibial components in more contiguous and convergent positions. Such changes in position decreased the risk of bearing dislocations by reducing the available space for bearing rotation. As component malposition was the most common cause in our study, the use of the Microplasty instrumentation system would help decrease the incidence of bearing dislocation by decreasing the component malposition. This system is currently used in our country. Therefore, the current incidence of bearing dislocations may be lower than that indicated in this study. Fourth, for the analysis of the sum of all cases in 5 surgeons, there was significant decrease in the incidence of bearing dislocations between the first 100 UKAs and the second 100 UKAs (31 vs 13, $P = .006$). However, this result may be biased by 1 surgeon (S11) who showed a dramatic decrease in bearing dislocations for the second 100 UKAs (11 vs 0). When we compared the incidence of bearing dislocation excluding this surgeon, there was no difference in the incidence of bearing dislocations between the first 100 UKAs and the second 100 UKAs (20 vs 13, $P = .213$). Further investigation will be required. Finally, all primary bearing dislocations may have gap imbalance with or without component malposition, ligament laxity, etc. So, we intended to use the term "mode," which reflects not a single cause but multifactorial relationship. We designated primary reason causing gap imbalance as a specific mode. However, as not all component malpositions or gap imbalance lead to bearing dislocation, other factors may still exist. Despite these limitations, we believe that this study provides valuable information for both inexperienced and experienced surgeons performing MUKAs regarding bearing dislocation.

## Conclusions

Most bearing dislocations following MUKAs in our cohort were primary bearing dislocations and 55% of them occurred within 2 years after MUKA. Femoral or tibial component malposition was the most common mode of primary bearing dislocations. This study shows that surgeon's experience does not decrease the incidence of bearing dislocation, reflecting the quality of the operative procedure is the more determining factor.

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