Mid-term results of lateral unicompartmental mobile bearing knee arthroplasty

A MULTICENTRE STUDY OF 363 CASES

Aims
The aim of this independent multicentre study was to assess the mid-term results of mobile bearing unicompartmental knee arthroplasty (UKA) for isolated lateral osteoarthritis of the knee joint.

Patients and Methods
We retrospectively evaluated 363 consecutive, lateral UKAs (346 patients) performed using the Oxford domed lateral prosthesis undertaken in three high-volume knee arthroplasty centres between 2006 and 2014. Mean age of the patients at surgery was 65 years (36 to 88) with a mean final follow-up of 37 months (12 to 93).

Results
A total of 36 (10.5%) patients underwent revision surgery, giving a survival rate of 90.1% at three years (95% confidence intervals (CI) 86.1 to 93.1; number at risk: 155) and 85.0% at five years (95% CI 77.9 to 89.9; number at risk: 43). Dislocation of the mobile bearing occurred in 18 patients (5.6%) at three years (95% CI 1.0 to 16.4; number at risk: 154) and in 20 patients (8.5%) at five years (95% CI 1.0 to 27.0; number at risk: 42). There were no significant differences in the dislocation rate between the participating centres or the surgeons. We were not able to identify an effect of each surgeon’s learning curve on the dislocation rate of the mobile bearing. The clinical outcome in patients without revision surgery at final follow-up was good to excellent, with a mean Oxford knee score of 40.3 (95% CI 39.4 to 41.2), a mean Tegner activity score of 3.2 (95% CI 3.1 to 3.3) and a mean University of California, Los Angeles score of 5.7 (95% CI 5.5 to 5.9).

Conclusion
Our data, which consists of a high number of patients treated with mobile bearing UKA in the lateral compartment, indicates a high revision rate of 15% at five years with dislocation of the mobile bearing being the main reason for implant failure. Despite the good functional and clinical results and the high patient satisfaction in our study group, we therefore discontinued using mobile-bearing lateral UKA in favour of a fixed-bearing component.

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allows distraction of the lateral compartment in flexion of up to a mean of 6.7 mm, compared with 2 mm in the medial compartment.\textsuperscript{13,14} Furthermore, the anatomical shape of the tibial condyle in the medial compartment is flat, whereas the lateral tibial condyle is convex. Additionally, in high flexion, the centre of the femoral condyle in the medial compartment stays central on the tibial plateau, whereas the lateral femoral condyle subluxes posteriorly and inferiorly off the back of the tibial plateau.\textsuperscript{15}

In order to address these critical specifications, the Oxford domed lateral mobile-bearing UKA (Biomet Inc., Warsaw, Indiana) was introduced with a spherically convex, domed tibial plateau and a biconcave mobile bearing, ensuring fully congruent contact in all positions throughout flexion with the advantage of an increased bearing entrapment (7 mm) (Fig. 1).\textsuperscript{13,16}

To date, clinical studies on the Oxford domed tibia device have demonstrated a dislocation rate of 0% and 6.6% and a survival rate between 90% and 98%, with a mean follow-up of between 1.7 and four years.\textsuperscript{8,13,17-20} Most of these studies include a relatively small number of patients from a single centre, a short follow-up and/or data reported by the developer-centre. Therefore, we performed this independent study to assess the mid-term results of lateral UKA with the Oxford domed lateral prosthesis. As the indication for lateral UKA is far less common than medial UKA, we performed a multicentre study in high-volume centres to include a high number of consecutively treated patients.

**Patients and Methods**

All consecutively treated patients who underwent lateral UKA with the Oxford domed lateral prosthesis between November 2006 and January 2014 in the participating hospitals (University Hospital of Heidelberg, Vulpius Clinic Bad Rappenau, Diakonie Clinic Paulinenhilfe Stuttgart) were included in this study with a minimum follow-up of 12 months. All operations were carried out by five well trained surgeons (PRA, MC, TG, MH, JM) with extensive experience in UKA. The demographics of the study group are summarized in Table I.

The primary indication was severe osteoarthritis of the lateral compartment with full thickness articular cartilage loss (‘bone on bone’) or avascular necrosis of the femoral
condyle. In all patients, the anterior cruciate ligament and the medial and lateral collateral ligaments were functionally intact, the valgus deformity was manually correctable and there was no evidence of osteoarthritis in the medial compartment. Osteoarthritis of the patellofemoral joint was not considered to be a contraindication unless there was deep eburnation or bone grooving on the medial facet of the patella. Rheumatoid arthritis, fixed valgus deformity, previous osteotomy, or a flexion deformity > 15° were considered to be a contraindication.

All procedures were performed using the minimally invasive surgical technique through a small lateral parapatellar approach without dislocation of the patella, internal rotation of the tibial plateau, anatomical positioning of the femoral component to avoid a change in the height of the joint line and selection of bearing thickness in full extension, as previously described by the developer. All components were secured with cement (Refobacin Bone Cement R; Biomet, Berlin, Germany). Full weight-bearing was allowed postoperatively.

All patients were contacted by telephone for a structural interview to assess the state of the implant, possible reasons and circumstances for revision surgery and patient-related outcome measures. These included the Oxford Knee Score (OKS), the University of California at Los Angeles (UCLA) score, the Tegner activity score, the Short-Form 36 score (SF-36) and subjective parameters such as pain level or satisfaction with the prosthesis. The physical-related dimensions of the SF-36, such as physical functioning, role physical, bodily pain and general health were summarized as the physical component score (PCS); the mental-related dimensions, such as vitality, emotional well-being, social functioning and emotional functioning were summarized as the mental component score. Patients who could not be contacted by telephone were sent a questionnaire to complete the corresponding questions. In case of revision surgery, additional information was gathered from treating hospitals or general practitioners. The mean postoperative pain level was measured by use of a numeric ratings scale (NRS) from 0 to 10. To detect any influence on the complication rate due to the learning curve by each individual surgeon, we stratified all procedures from first to last, summarized these procedures into five operation groups (operation 1 to 15, 16 to 30, 31 to 50, 51 to 100 and > 100) and compared the complication rate of these groups.

Statistical analysis. Data were recorded and analyzed using SPSS version 17.0 (SPSS Inc., Chicago, Illinois) and Graphpad Prism version 5.0 (Graphpad Software, San Diego, California). The empirical distribution of continuous variables was described using mean and SD. Kaplan-Meier survivor-
ship analysis, with 95% confidence intervals (CI), was performed with the use of the endpoints revision for any reason (defined as operations in which at least one of the components was changed), re-operations, aseptic revision and dislocation of the bearing. Differences between the hospitals or operation groups were tested for significance with use of the log-rank test. Differences in the dislocation rate of the surgeons were tested with use of the Fisher’s exact test. We considered p-values < 0.05 to be significant.

The institutional review board of the University of Heidelberg approved all procedures (S-265/2014) and the study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all participating patients.

**Results**

Between November 2006 and January 2014, 363 lateral UKAs were performed using the Oxford domed lateral prosthesis in 346 patients with a mean age of 65 years (36 to 88). Patient demographics are summarized in Table I. A total of nine patients (nine knees) refused to participate in this study and ten patients (ten knees) were lost to follow-up (2.7%). From the remaining 327 patients (344 knees), eight patients (eight knees) died and 36 patients (36 knees) underwent revision surgery (Fig. 2). The mean follow-up was 37 months (12 to 93) (Table I and Fig. 2).

Altogether, there were 36 patients (36 knees) for whom revision surgery was undertaken (10.5%), defined as removal or exchange of at least one of the components. From these, six patients (six knees, 1.7%) acquired more than one revision procedure. Postoperative infection occurred in three patients (three knees, 0.9%). The first patient had multiple lavages with cultures positive for methicillin-resistant Staphylococcus (S.) aureus and final bearing exchange one month after primary surgery without need of further revision thereafter. The second patient required a two-stage revision due to an infection with S. aureus two months after primary surgery with removal of the UKA and implantation of a semiconstrained prosthesis two months later. The third patient also required a two-stage revision 22 months after primary surgery with final implantation of a bicondylar unconstrained prosthesis.

Additionally, 18 patients (18 knees, 5.2%) underwent a removal of the UKA and implantation of a TKA for various reasons: in five patients (five knees), the reason was a recurrent dislocation of the mobile bearing, six patients (six knees) had progression of osteoarthritis in the medial compartment, three patients (three knees) complained about an instability of the knee joint, three patients (three knees) reported unexplained knee pain, and one patient (one knee) was revised because of loosening of the femoral component.

In 20 patients (20 knees, 5.8%), a dislocation of the mobile bearing occurred. In one patient, there was a spontaneous repositioning of the bearing without need of revision surgery. All other patients had to be revised. In six patients (six knees, 1.7%), more than one revision was performed because of recurrent dislocations after the initial treatment. In total, five patients (five knees) were revised to a bicondylar knee arthroplasty (as described above), in five patients (five knees) there was an exchange of the mobile bearing, and nine patients (nine knees) had a revision to a fixed bearing tibial component.

Kaplan-Meier survival analysis at three years with revision for any reason as the endpoint was 90.1% (95% CI 86.1 to 93.1; number at risk: 155); the five-year survival rate was estimated at 85.0% (95% CI 77.9 to 89.9; number at risk: 43).

Kaplan-Meier survivorship curve with 95% confidence intervals (CI) for revision for any reason as the endpoint. The three-year survival rate was estimated at 90.1% (95% CI 86.1 to 93.1; number at risk: 155); the five-year survival rate was estimated at 85.0% (95% CI 77.9 to 89.9; number at risk: 43).

Inverted Kaplan-Meier plot using dislocation of the bearing as the endpoint. The cumulative incidence of dislocation was 5.6% (95% confidence intervals (CI) 1.0 to 16.4; number at risk: 154) at three years and 8.5% (95% CI 1.0 to 27.0; number at risk: 42) at five years.
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The Kaplan-Meier survivorship curve with 95% confidence intervals (CI) for revision for any reason except dislocation of the bearing as the endpoint. The three-year survival was estimated at 95.1% (95% CI 91.5 to 97.1; number at risk: 152); the five-year survival was estimated at 92.4% (95% CI 87.1 to 95.5; number at risk: 41).

Table II. Bearing-dislocation rate in relation to each surgeon. The table demonstrates the bearing-dislocation rate, the number of procedures of each surgeon and the procedure number in which a bearing-dislocation occurred. Independent of the number of procedures performed by each surgeon, bearing-dislocation still occurred. There were no statistically significant differences between the surgeons in the Fisher’s exact test (p > 0.05).

<table>
<thead>
<tr>
<th>Surgeon no.</th>
<th>Procedures, n</th>
<th>Bearing-dislocations, n (%)</th>
<th>Procedure no. with a bearing dislocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48</td>
<td>1 (2.1)</td>
<td>44</td>
</tr>
<tr>
<td>2</td>
<td>119</td>
<td>10 (8.4)</td>
<td>6, 10, 25, 28, 45, 84, 95, 96, 102, 106</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>4 (8.7)</td>
<td>3, 6, 27, 46</td>
</tr>
<tr>
<td>4</td>
<td>120</td>
<td>4 (3.3)</td>
<td>23, 79, 91, 120</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>1 (2.1)</td>
<td>5</td>
</tr>
</tbody>
</table>

Table III. The number of dislocations, the total number of operations, the cumulative dislocation rate after Kaplan-Meier and the number at risk by operation group (all surgeons). There is no statistically significant difference in the dislocation rate between any of the operation groups in the log-rank test (p > 0.05), indicating that bearing dislocation is independent to the learning curve.

<table>
<thead>
<tr>
<th>Operation group (all surgeons)</th>
<th>Dislocations, n</th>
<th>Total operations, n</th>
<th>Cumulative dislocation rate after Kaplan-Meier, n (at risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 15 operations</td>
<td>5</td>
<td>71</td>
<td>4.3 (67) 5.9 (53) 7.7 (50) 7.7 (45) 7.7 (25) 7.7 (15)</td>
</tr>
<tr>
<td>16 to 30 operations</td>
<td>4</td>
<td>60</td>
<td>3.4 (58) 5.2 (53) 5.2 (43) 7.6 (33) 7.6 (15) N/A</td>
</tr>
<tr>
<td>31 to 50 operations</td>
<td>3</td>
<td>74</td>
<td>1.4 (88) 2.7 (50) 2.7 (35) 2.7 (21) N/A N/A</td>
</tr>
<tr>
<td>51 to 100 operations</td>
<td>5</td>
<td>100</td>
<td>4.0 (95) 5.1 (74) 5.1 (28) 5.1 (14) N/A N/A</td>
</tr>
<tr>
<td>&gt; 100 operations</td>
<td>3</td>
<td>39</td>
<td>7.7 (36) 7.7 (5) N/A N/A N/A N/A</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>344</td>
<td>3.8 (322) 5.2 (230) 5.6 (154) 6.3 (108) 8.5 (42) 8.5 (15)</td>
</tr>
</tbody>
</table>

N/A, not applicable

with revision except for bearing dislocation was 95.1% (95% CI 91.5 to 97.1; number at risk: 152) and 92.4% (95% CI 87.1 to 95.5; number at risk: 41) at five years (Fig. 5). There were no statistically significant differences in the dislocation rate between all participating centres or between all five surgeons.

In addition, we could not detect a learning curve. Independent of the number of prostheses of each surgeon, dislocation of the bearing still occurred with a similar frequency throughout the period of record (Table II). There were no statistically significant differences in the dislocation rate between any of the operation groups. Cumulative dislocation rate for the first 15 procedures for all surgeons at two years was 5.9%, compared with 7.7% for those implants after the performance of > 100 procedures (Table III).

Patients without revision surgery achieved a good to excellent clinical outcome with a mean OKS of 40.3 (95% CI 39.4 to 41.2) at final follow-up. The mean Tegner activity score was 3.2 (95% CI 3.1 to 3.3) and the mean UCLA score was 5.7 (95% CI 5.5 to 5.9). In all, 240 patients (250 knees, 90%) were satisfied or highly satisfied with the outcome. The mean postoperative pain level, measured with a NRS was on a low level with a mean value of 2.2 (95% CI 1.9 to 2.5). In the eight dimensions of the SF-36, our patients achieved high mean scores (Fig. 6). In the summarized physical-related dimensions (PCS), patients achieved...
a statistically significant higher mean score than a matched reference population of patients with osteoarthritis in the t-test (p = 0.03).

**Discussion**

A large analysis of data from a national joint registry compared the mid-term survival rates of medial and lateral UKA performed in England and Wales.\(^2\) At five years, the survival rate of 2052 lateral UKA was 93.0%, which did not differ significantly from the survival rate of 93.1% for medial UKA. In addition, there was no statistically significant difference in the survival rate of lateral prosthesis with a fixed bearing device compared with those with a mobile bearing device. Nevertheless, no information is given about the kind of prosthesis used in their report.

The clinical results and patient-reported outcome measures in the present study are good to excellent, comparable with those previously reported for lateral or medial Oxford UKA, and are better than those reported for TKA.\(^1\)\(^,\)\(^2\)\(^,\)\(^7\) In our series, the mean OKS was 40.3 at final follow-up, which is consistent with previously published data at 20 to 48 months with mean scores ranging from 40 to 42 points.\(^13\)\(^,\)\(^17\)\(^,\)\(^18\) Additionally, the level of activity measured by the activity scores after Tegner and the UCLA score was on a similar level to previously reported data.\(^2\)\(^,\)\(^2\)\(^8\) High scores in the SF-36 demonstrated a good quality of life for patients following lateral UKA with the Oxford domed tibia knee system. Overall satisfaction in our patient cohort was high, with 90% being satisfied or highly satisfied with their knee function. In three patients, revision surgery was performed with conversion to TKA due to unexplained pain outside the participating centres. Revision for unexplained pain is considered to be undertaken more readily than after TKA.\(^2\)\(^9\) Even when up to 20% of patients are dissatisfied with the result after TKA,\(^2\)\(^7\) revision surgery is less common in these patients compared with dissatisfied patients after UKA. In a review published by Murray et al,\(^2\)\(^9\) it was stated that, due to the fact of a relatively easy revision surgery in UKA, the threshold for revision is much lower than it is for TKA. In patients with a postoperative OKS of < 20, the chance for revision surgery in patients after UKA is about 60%, compared with 10% in patients after TKA.\(^2\)\(^9\)

In our study, the overall survival rate with revision for any reason as the endpoint was 90.1% at three years and 85.0% at five years. These rates are lower than those reported by Baker et al\(^2\)\(^6\) for mobile bearing lateral UKA in their registry study but are similar to those previously published by independent centres for the Oxford domed lateral prosthesis. Marson et al\(^1\)\(^9\) demonstrate a survival rate of 90% after 2.9 years in 15 patients, Schelfaut et al\(^1\)\(^8\) demonstrate a survival rate of 92% after 1.7 years in 25 patients.
and Altuntas et al\textsuperscript{17} demonstrate a slightly higher survival rate of 97\% after 2.2 years in a series of 64 patients. In the first designer series of 98 implants, Pandit et al\textsuperscript{13} demonstrate a survival rate of 98\% after 2.3 years. These excellent results were confirmed by Weston-Simons et al\textsuperscript{20} in a series of 265 implants with a survival rate of 92\% after 8 years.

The most important finding of our study is that the main reason for revision surgery was bearing dislocation. The cumulative dislocation rate was 5.6\% at three years and 8.5\% at five years, which is slightly higher than previous reported results which range from 0\% to 6.6\% over a period of 1.7 years to eight years.\textsuperscript{8,13,17-20} The reason for dislocation is still not well understood. In a previous study, Streit et al\textsuperscript{8} were able to show that increasing the joint line elevation can be caused by two intraoperative mechanisms: overmilling of the distal femur as an attempt to equalize and balance the flexion and extension gaps; and overstuffing of the lateral compartment by choosing the bearing thickness in slight flexion instead of full extension.\textsuperscript{8} Regarding the number of procedures done by each surgeon after which a bearing dislocation occurred, we could not detect a learning effect for each surgeon throughout the observation period. Furthermore, there was no significant difference in the dislocation rate between any of the operation groups. Independent to a surgeon’s experience and even after the performance of a relatively high number of lateral UKA, bearing dislocation still exists.

The survival rate at three years with revision except for dislocation of the bearing was 95.1\% in our series, demonstrating that UKA in the lateral compartment can be seen as a safe procedure if the main reason for revision could be diminished by the use of a fixed bearing device. As described above, Baker et al\textsuperscript{26} demonstrate similar survival rates for fixed and mobile bearing lateral UKA at five years. Similar to our study, one of the main reasons for revision surgery for mobile bearing devices was dislocation of the bearing, whereas the main reason for revision surgery for fixed bearing devices was unexplained pain.\textsuperscript{26} In addition, further studies have demonstrated high survival rates for fixed bearing devices in lateral UKA with survival rates ranging from 92\% at ten years\textsuperscript{30} to 100\% at five\textsuperscript{31} and 12 years.\textsuperscript{32}

In conclusion, this study demonstrates that bearing dislocation still remains the main reason for revision of lateral UKA, even with the Oxford domed lateral implant. We found a dislocation rate comparable with the previous design of the Oxford prosthesis.\textsuperscript{12} We did not observe a learning curve influencing the rate of bearing dislocation. Therefore, we assume that surgical experience is not the main cause of bearing dislocation, which seems likely to be the result of multiple factors.

As a consequence of our findings and despite the good functional and clinical results and the high patient satisfac-

\textbf{Take home message:}

- Dislocation of the bearing remains the main reason for revision surgery in lateral UKA with a mobile bearing prosthesis with a dislocation rate of 8.5\% after five years.
- We could not observe a learning curve influencing the rate of bearing dislocation.
- As a consequence of the presented data we discontinued to apply mobile bearing lateral UKA in favour of a fixed bearing device.

\textbf{Supplementary material}

A table showing a summary of complications in patients can be found alongside the online version of this article at www.bjj.boneandjoint.org.uk

\textbf{References}


Author contributions:
T. Walker: Interpreting the data, Drafting and writing the manuscript.
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T. Bruckner: Statistical analysis of the data.
M. R. Streit: Interpreting the data, Drafting the manuscript.
G. Mohr: Collecting the data.
P. R. Aldinger: Designing the study, Interpreting the data.
M. Clarius: Designing the study, Interpreting the data.
T. Gotterbarm: Designing the study, Interpreting the data, Drafting and writing the manuscript.

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