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Revision from unicompartmental knee arthroplasty to total knee arthroplasty: An analysis of 118 cases at midterm follow-up

Marius Jonathan Ibach[1] | **Oscar Torney**[1] | **Christoph E. Horn**[1] | **Alexander Frenzel**[2] | **Christoph Hubertus Lohmann**[3] | **Jonas Sina**[4] | **Daniel Schrednitzki**[5] | **Andreas Matthias Halder**[1] | **Nils Meißner**[1]

[1]Department of Orthopaedic Surgery, Sana Hospital Sommerfeld, Kremmen, Germany

[2]Department of Orthopaedics, Carl-Thiem-Klinikum Cottbus, Cottbus, Germany

[3]Department of Orthopaedic Surgery, Otto-von-Guericke University, Magdeburg, Germany

[4]Clinic for Orthopaedic Surgery, Hand Surgery and Traumatology, City Hospital Zurich, Zurich, Switzerland

[5]Department of Orthopaedic and Trauma Surgery, Sana Hospital Lichtenberg, Berlin, Germany

Correspondence

Nils Meißner, Department of Orthopaedic Surgery, Sana Hospital Sommerfeld, Waldhausstr 44, Kremmen, Germany.
Email: nils.meissner@sana.de

Abstract

Purpose: Aseptic failure of unicompartmental knee arthroplasty (UKA) often requires revision to a total knee arthroplasty (TKA). However, outcomes following revision from UKA to TKA remain controversial. The purpose of this study was to analyze a large cohort of revisions from UKA to TKA, with emphasis on implant survivorship, clinical outcomes and radiographic results.

Methods: We retrospectively reviewed 118 aseptic revisions from UKA to TKA performed at a single surgical center between 2016 and 2022. Of these, 50 were required due to progression of osteoarthritis (42%), and 44 for aseptic loosening (37%). The mean age was 67 years, 65% were female, and the mean body mass index was 31 kg/m^2. Tibial stem extensions were used in 30% of cases, augments in 9%, and a constrained implant in a single patient. The mean follow-up was 6 years (range, 2.7–10.9).

Results: The 8-year survivorship free of any re-revision and reoperation was 94% and 92%, respectively. Progression of osteoarthritis was associated with reduced odds of re-revision (odds ratio [OR]: 0.09; $p = 0.025$) and reoperation (OR: 0.20; $p = 0.04$). Knee Society Function Scores (KSS-F) improved from 53 to 82 ($p < 0.001$), with no correlation to implant type, demographics or radiographic patella height. At final follow-up, the mean Oxford Knee and Forgotten Joint Scores were 33 and 54, respectively. The mean modified Insall-Salvati Ratio was 1.56 preoperatively compared to 1.52 at last follow-up ($p = 0.07$).

Conclusion: Aseptic revision from UKA to TKA provides excellent midterm implant survivorship, clinical outcomes, and radiographic results, particularly when performed for the progression of osteoarthritis.

Level of Evidence: Level IV.

KEYWORDS

implant survival, patella height, patient-reported outcomes, revision total knee arthroplasty (TKA), revision unicompartmental knee arthroplasty (UKA)

Abbreviations: BMI, body mass index; CI, confidence interval; FJS, Forgotten Joint Score; KSS, Knee Society Score; KSS-F, Knee Society Function Score; mISR, modified Insall-Salvati ratio; OKS, Oxford Knee Score; OR, odds ratio; PACS, Picture Archiving and Communication System; PE, polyethylene; PROM, patient-reported outcome measure; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty.

INTRODUCTION

Unicompartmental knee arthroplasty (UKA) provides superior function and fewer perioperative complications compared to total knee arthroplasty (TKA) for patients with isolated compartment knee osteoarthritis or osteonecrosis [1, 20, 21, 25, 38]. Yet, annual revision rates are estimated to be two times as high after UKA compared to TKA [2]. In contrast to TKA, the predominant reasons for revision of a UKA are aseptic loosening and progression of osteoarthritis, with fewer than 5% of cases due to periprosthetic joint infection [16, 33]. As a result, treatment guidelines should consider the outcome of subsequent aseptic revision from UKA to TKA [18].

However, prior evidence remains inconclusive whether the risks and benefits of revision from UKA to TKA resemble those of primary TKA or rather those of revision TKAs [28]. Prior reported revision rates after revision from UKA to TKA vary widely, with data from high-volume single centres tending to outperform those from national registries and smaller cohorts [4, 19, 23, 24, 26, 31]. In addition, comparisons of patient-reported outcomes (PROMs) are complicated by a wide range of different instruments, as well as varying rates of primary implant and revision components used [20, 22]. Therefore, this study aimed to analyze implant survivorship, clinical outcomes and radiographic results in one of the largest available subsets of aseptic revisions from UKA to TKA.

PATIENTS AND METHODS

After obtaining local ethics committee approval (2024-133-BO-ff), all patients who underwent aseptic revision from UKA to TKA between January 2015 and March 2022 at a single medical center, with a minimum follow-up of 2 years, were reviewed. A total of 144 revisions were identified in 140 patients. Of these, 22 cases (15%) were excluded due to loss to follow-up. Additionally, patients who underwent revision of a lateral UKA or bicompartmental UKA to TKA were excluded (four cases; 3%). The final cohort included 118 aseptic medial UKA to TKA revisions.

The most common indications for aseptic revision from UKA to TKA were progression of osteoarthritis (42%), aseptic loosening (37%) and persistent pain (9%, Table 1). The mean age at the time of surgery was 67 years (range: 43–91 years), 77 (65%) were female, and the mean body mass index (BMI) was 31 kg/m^2 (range: 18–48 kg/m^2). At the time of revision from UKA to TKA, additional patella resurfacing was performed in seven patients (6%). The mean follow-up was 5.6 (range: 2.7–10.9) years. The mean time from primary UKA to revision was 5 years (range: 0–23 years).

Predominantly, patients were revised to primary TKA implants (n = 117, 99%), and one patient required a revision to a constrained implant (n = 1, 1%). The most frequently used implants were Innex (Zimmer Biomet; 65 cases, 55%), followed by Persona (Zimmer Biomet; 43 cases, 36%), Nexgen (Zimmer-Biomet; 8 cases, 7%) and Legion (Smith & Nephew; 2 cases,

TABLE 1 Demographic and surgical factors.

Characteristic	*N* = 118[a]
Age, years	67 (43–91)
Sex	
Female	77 (65%)
Male	41 (35%)
BMI, kg/m^2	31 (18–48)
Implant	
Innex	65 (55%)
Persona	43 (36%)
Nexgen	8 (7%)
Legion	2 (2%)
Polyethylene thickness, mm	
10	76 (64%)
12.5	19 (16%)
12	11 (9%)
11	8 (7%)
15	2 (2%)
9	1 (1%)
14	1 (1%)
Aseptic failure mode	
Progression of osteoarthritis	50 (42%)
Aseptic loosening	44 (37%)
Persisting pain	10 (9%)
Tibial fracture	8 (7%)
Malalignment	3 (3%)
Onlay dislocation	3 (3%)
Tibial stem	35 (30%)
Tibial stem length, mm	
105	17 (14%)
30	12 (10%)
100	4 (3%)
60	2 (2%)
135	1 (1%)
Augment	10 (9%)
Patella resurfacing	7 (6%)
Follow-up, years	5.6 (2.7–10.9)

Abbreviation: BMI, body mass index.
[a]Mean (Min–Max); *n* (%)

2%). Of the 118 cases, 35 cases (30%) required a tibial stem extension, with the most common lengths at 105 mm (17 cases, 48%) and 30 mm (12 cases, 34%). In 10 cases (9%), augments were utilized. Three patients died 2, 5 and 10 years after revision from UKA to TKA due to sepsis, secondary to pneumonia ($n = 2$) and urinary tract infection ($n = 1$), respectively. All of these were unrelated to the revision surgery.

Surgical technique and perioperative protocol

All surgeries were performed by board-certified orthopaedic surgeons using the technique previously described by Ibach et al. [13]. Patients received no specific prehabilitation protocol, except for oral instructions to maintain a balanced diet and engage in daily movement, if possible. All patients underwent preoperative laboratory analysis (complete blood count, electrolytes, coagulation, infection panel [4]), periprosthetic infection exclusion (EBJIS criteria) and blood typing. A medial parapatellar approach was used for all patients, and implants were assessed for loosening on both the tibial and femoral sides. Following histological and microbiological sampling, the implant, cement and residual debris were removed. Subsequently, the joint line was restored using cemented TKAs, with revision components (augments and stems) applied as planned by the surgeon. No robotic technology or cones were utilized. Fast-track perioperative management included immediate weight bearing, perioperative tranexamic acid, periarticular ropivacaine, opioid-sparing pain management and a 4-week course of low molecular weight heparin. Post-discharge, all patients underwent a 3-week inpatient or outpatient rehabilitation protocol.

Statistical analysis

Continuous variables were evaluated for normality using the Shapiro–Wilk and Kolmogorov–Smirnov tests. If the null hypothesis of normality was rejected, non-parametric statistical tests were employed. In all other cases, the *t* test was utilized. Revisions were defined as surgery where at least one component was exchanged. Reoperations included all revisions, as well as surgeries without component exchange. Clinical outcomes were assessed using the Knee Society Function Score (KSS-F) [34, 35]. These were collected preoperatively and at the last clinical follow-up visit. Poor outcomes were defined as a KSS-F of less than 60 [11]. We also collected Oxford Knee Score (OKS) and Forgotten Joint Score (FJS) at the last follow-up [14]. Revisions and reoperations were considered as time-to-event outcomes and analyzed using the Kaplan–Meier method. Log-rank and chi-square statistics were used to evaluate binary associations between revisions or reoperations and sex, age, BMI and indication. Due to low event counts, Firth's penalized likelihood was used in the Cox regression analysis. Fisher's exact, Student's *t* test or chi-square test were used to analyze associations between clinical outcomes and baseline characteristics and surgical factors. Due to the limited number of events, a multivariate survival analysis was not conducted. All statistical tests were two-sided, and statistical significance was defined as $p < 0.05$. All statistical analyses were conducted using R Statistical Software (version 4.3.1; R Foundation for Statistical Computing).

Radiographic analysis

True lateral radiographs of the knee were analyzed for changes in patella height and tendon length. Patellar height was evaluated using the modified Insall-Salvati ratio (mISR), following the methodology established by Grelsamer and Meadows [8]. Radiographic evaluations of patellar tendon anatomy were performed before revision and at the last follow-up. Two orthopaedic surgeons (M.J.I. and O.T.) independently measured the mISR and patella length. In addition, perioperative primary UKA radiographs in patients revised for aseptic loosening were analyzed, using previously described methodology to check for erroneous indication/implantation [9, 10, 12]. Measurements were conducted using IntelliSpace PACS, Version 4.4 (Philips).

RESULTS

Implant survivorship

The survivorship free of any re-revision was 96.5% at 2 years (95% confidence interval [CI]: 93.2–99.9), 94.4% at 5 years (95% CI: 90.0–98.9) and 94.4% at 8 years (95% CI: 90.0–98.9; Figure 1).

There were six (5%) patients who required a re-revision following revision from UKA to TKA, with a median time to re-revision of 2 years (range, 17–57 months). Reasons for re-revision included aseptic loosening ($n = 2$), disease progression in the patellofemoral compartment ($n = 2$) and arthrofibrosis ($n = 2$). Revision from UKA to TKA for progression of osteoarthritis was associated with 11-fold lower odds of re-revision compared to the rest of the cohort (OR: 0.09; 95% CI: 0–0.78, $p = 0.025$; Table 2). Neither age, sex, BMI, nor aseptic loosening at revision from UKA to TKA was associated with an increased risk for re-revision.

The survivorship free of any reoperation was 94.0% at 2 years (95% CI: 89.8–98.4), 91.9% at 5 years (95% CI: 86.8–97.2) and 91.9% at 8 years (95% CI: 86.8–97.2; Figure 2).

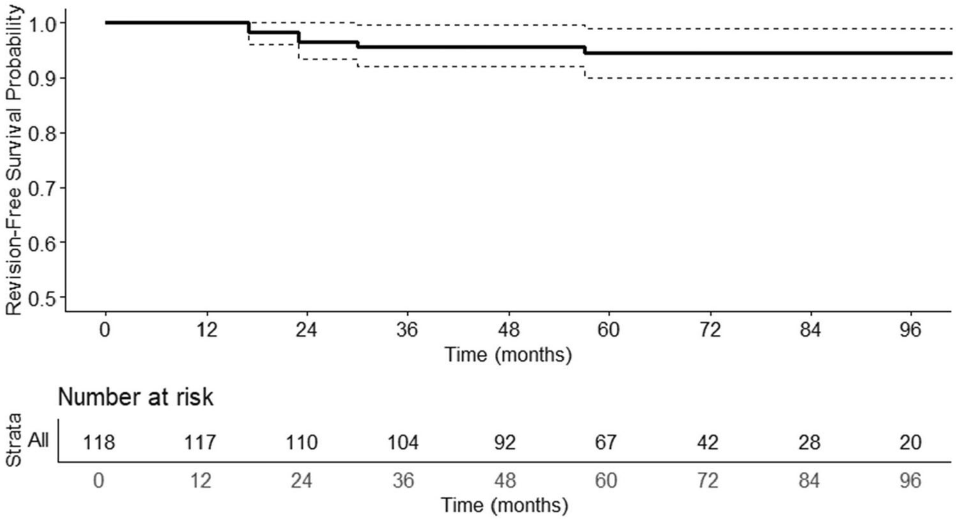

FIGURE 1 Kaplan–Meier curve showing survivorship free of any re-revision for all patients.

TABLE 2 Risk factors for any revision.

	Group	Survival (95% CI)	*p* log-rank	*p* Chi	Odds ratio (95% CI)	*p* (firth penalized)
Age	>65	94.0% (87.6–100.0)	0.826	1	0.93 (0.19–4.57)	0.93
	≤65	94.7% (88.9–100.0)				
Sex	Male	94.2% (86.6–100.0)	0.866	1	1.07 (0.20–5.94)	0.97
	Female	94.6% (89.6–99.9)				
BMI	>30	95.2% (90.0–100.0)	0.834	1	1.15 (0.13–14.34)	0.93
	≤30	95.1% (88.6–100.0)				
Progression of osteoarthritis	POA	100.0% (100.0–100.0)	0.026*	0.070	0.09 (0.00–0.78)	0.025*
	Other	90.0% (82.6–98.0)				
Aseptic loosening	AL	97.2% (93.5–100.0)	0.123	0.296	3.43 (0.47–39.42)	0.153
	Other	89.2% (79.5–100.0)				

Abbreviations: AL, aseptic loosening; BMI, body mass index; CI, confidence interval; POA, progression of osteoarthritis.
*Significant at $\alpha = 0.05$.

There were three (3%) reoperations within three months of revision from UKA to TKA without component exchange. Two patients underwent reoperation for wound dehiscence with delayed wound healing. Additionally, one patient required manipulation under anaesthesia for limited range of motion. Revision from UKA to TKA for progression of osteoarthritis was associated with fivefold lower odds of reoperation compared to the rest of the cohort (OR: 0.20, 95% CI: 0.02–0.94, $p = 0.04$; Table 3). Neither age, sex, BMI, nor aseptic loosening at revision from UKA to TKA was associated with reoperation.

Clinical outcomes

The mean preoperative KSS-F was 53 (range: 0–80) and improved to 82 (range: 0–100) at last follow-up ($p < 0.001$; Figure 3).

Thirteen patients (11%) reported poor clinical outcomes (KSS-F ≤ 60) at the last follow-up. There was no statistically significant association between poor clinical outcomes and BMI, age, sex, indication, patella resurfacing, implant type, stem use, PE thickness >12 mm or augment use (all $p > 0.1$). The mean OKS and FJS at last follow-up were 33 (range: 5–48) and 54 (range: 20–100), respectively.

Radiographic results

The mean mISR was 1.56 preoperatively compared to 1.52 at last follow-up ($p = 0.07$). The change in the mISR was not significantly associated with a KSS-F below 60 (OR: 0.32, 95% CI: 0.01–4.91, $p = 0.51$). When stratifying patients into three groups based on the directionality of mISR change (decreased,

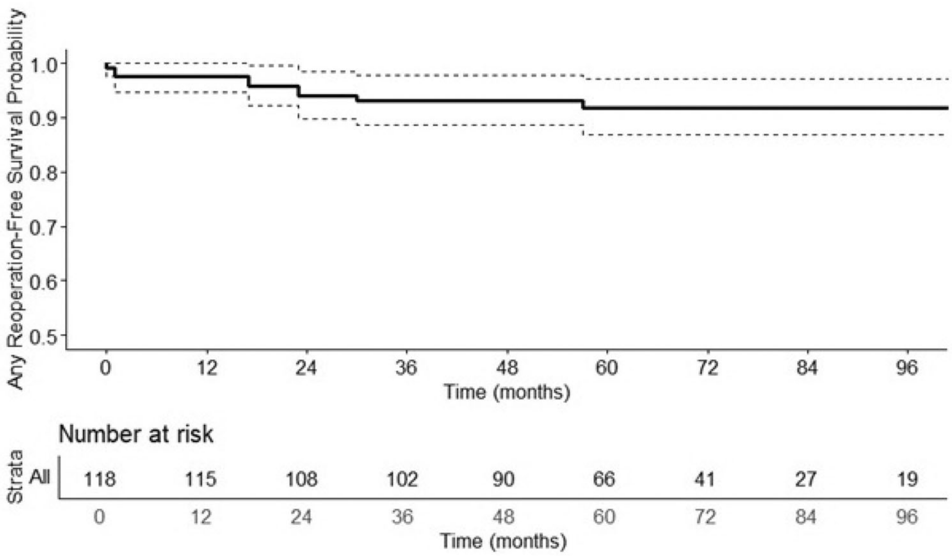

FIGURE 2 Kaplan–Meier curve showing survivorship free of any reoperation for all patients.

TABLE 3 Risk factors for any reoperation.

Variable	Group	Survival (95% CI)	*p* log-rank	*p* Chi	Odds ratio (95% CI)	*p* (firth penalized)
Age	>65	90.8% (83.3–99.0)	0.956	1	1.18 (0.24–6.29)	0.83
	≤65	92.9% (86.5–99.9)				
Sex	Male	94.2% (86.6–100.0)	0.37	0.648	1.94 (0.35–20.03)	0.48
	Female	90.8% (84.5–97.5)				
BMI	>30	90.9% (82.8–99.9)	0.712	0.982	0.75 (0.13–4.27)	0.68
	≤30	93.7% (87.9–99.9)				
Progression of osteoarthritis	POA	98.1% (94.4–100.0)	0.040*	0.085	0.20 (0.02–0.94)	0.040*
	Other	86.9% (78.7–95.9)				
Aseptic loosening	AL	95.9% (91.4–100.0)	0.057	0.14*	3.55 (0.71–23.14)	0.075
	Other	84.6% (73.7–97.2)				

Abbreviations: AL, aseptic loosening; BMI, body mass index; CI, confidence interval; POA, progression of osteoarthritis.

*Significant at $\alpha = 0.05$.

unchanged or increased), there was no significant association with a KSS-F below 60 ($p = 1.00$).

Perioperative radiographs from the time of primary UKA were available in 25 out of 40 (63%) patients, who were later revised for aseptic loosening. Of these, five cases (5/25, 20%) showed neither an indication nor an implantation error. In 20 cases, we identified at least one potential cause of failure across two groups: indication errors (9/20; 45%) or technical errors with tibial implantation (16/20; 80%). Indication errors included absence of medial bone-on-bone osteoarthritis ($n = 8$) and presence of lateral/patellofemoral osteoarthritis ($n = 1$). With respect to technical errors during tibia component implantation, malpositioning (oversize, $n = 6$; valgus, $n = 4$) and tibial cut errors (excessive resection, $n = 10$; insufficient resection, $n = 1$) were the most frequent.

DISCUSSION

In this large cohort of aseptic revisions from UKAs to TKAs, we found excellent 8-year survivorship free of any re-revision and reoperation, when using almost exclusively primary TKA implants. Notably, implant survival was significantly better for revisions from UKA to TKA due to progression of osteoarthritis compared to other indications. Patient-reported outcomes demonstrated generally good functional results, although 1 out of 10 patients reported severe limitations.

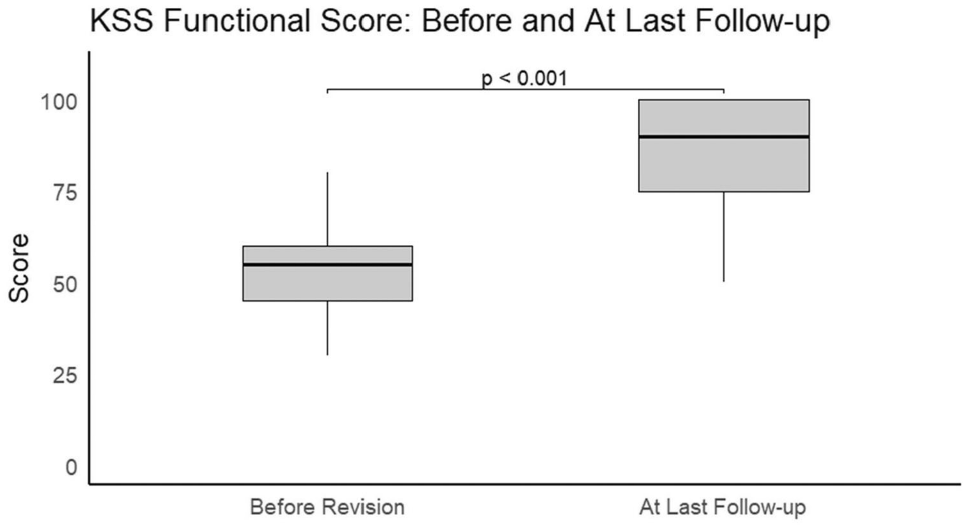

FIGURE 3 Patient-reported outcome measures—Knee Society Function Score (KSS-F).

Poor function was not associated with radiographic patella shortening, demographic parameters or revision components used.

Leta et al. reported a re-revision rate of 12% at a median follow-up of 4 years after revision from UKA to TKA, using data from the Norwegian Arthroplasty Registry [19]. Similarly, El-Galay et al. found a re-revision rate of 10% at comparable follow-up using Danish nationwide data [5]. In their study, midterm re-revision rates were also lower in high-volume centres. In support of this finding, a single-centre analysis of 175 revision UKAs to TKAs by Sierra et al. demonstrated a significantly lower re-revision rate of 4.5% at a mean follow-up of 6 years, comparable to the results of this study [31]. Recently, Nwanko et al. reported a re-revision rate of 2.6% at 4 years in a large series of over 400 UKA to TKA revisions [26]. Thus, merging our results with prior data supports the hypothesis that UKA to TKA in high-volume tertiary care centres exhibits lower re-revision rates compared to nationwide registries, and more closely resembles aseptic revision rates after primary TKA than revision from TKA to TKA [32].

While El-Galaly et al. described a caseload effect as well as an adverse effect of male gender and young age on implant survival, their study did not demonstrate a relationship between the failure mode of UKA and the revision risk following UKA to TKA in the Danish registry [5]. A recent analysis of 413 UKAs to TKAs by Nwanko et al. could also not demonstrate an effect of aseptic failure mode on revision risk after UKA to TKA [26]. Conversely, our results suggest that the progression of osteoarthritis, thus the natural biologic course of the disease, may be a more easily correctable cause of failure compared to other indications for UKA to TKA, leading to lower re-revision rates. In contrast to El-Galaly, we did not find an association between sex or age and re-revision risk [5]. However, interpreting risk factor estimates remains challenging due to the low event counts across all studies. For example, in their report of 413 aseptic UKAs to TKAs, Nwanko et al. report only 11 (2.7%) re-revisions [26]. Combining data from tertiary centres with high caseloads could thus help in further exploring the effect of aseptic UKA failure modes on re-revision risk following UKA to TKA.

Regarding clinical outcomes, patient-reported outcomes of our cohort indicate a high degree of satisfaction with the revision from UKA to TKA, with scores equal to or even superior to those previously published [3, 7, 15, 22, 24, 27, 28, 30, 31]. Although poor outcomes were rare in this study, 1 in 10 patients reported a KSS-F score below 60, indicating severe limitation. However, we found no association between such poor outcomes and demographic or surgical factors, including BMI, age, sex, indication, patella resurfacing, implant type, stem or augment use or PE thickness. We could also not demonstrate an association between radiographic changes in patella height and clinical outcomes, in line with the hypothesis that patella shortening does not cause poor functional results in revision UKA to TKA [13]. This observation contrasts with data on primary TKAs, showing that post-operative patella shortening may correlate with restricted movement and pain, particularly with extensive infrapatellar fat pad resection [29, 36, 37].

With around 30% of cases, revision component use, including stems and augments, was comparable to prior studies of revision UKA to TKA, albeit much more frequent compared to primary TKA [3, 12]. Nevertheless, patient satisfaction, as measured by PROMs in this study, approached data from randomized controlled trials on primary TKA. In combination with the reported low re-revision rate, these findings challenge the hypothesis that UKA to TKA resembles revision TKA to TKA more than primary TKA [6, 17, 24]. In a subgroup analysis of patients revised for aseptic loosening with available radiographs, 80% demonstrated either inappropriate indication and/or technical errors at the time of the primary UKA. This finding supports the notion that optimal patient selection and surgical technique may prevent a high number of early UKA failures.

This study has several strengths and limitations. First, it represents one of the largest series of revisions from UKA to TKAs published from a single center. Second, internal validity is enhanced compared to registry data through a highly standardized approach within a single institution. Finally, combining implant survival data, PROMs and radiographic evaluation results in a comprehensive and highly representative snapshot of clinical practice in a high-volume surgical center. Nevertheless, observational studies can only demonstrate associations and do not allow for causal inferences. In the absence of randomization, patient selection may introduce bias through hidden confounders. Key limitations include the absence of a control such as primary TKA or revision TKA to TKA and a loss to follow-up of 15%. In a worst-case scenario analysis, counting all lost-to-follow-up cases as failures, yields re-revision and reoperation rates of 20% and 22%, respectively. Furthermore, preoperative OKS and FJS were not available. Additionally, due to the low number of events, meaningful multivariable analysis of re-revision risk was not feasible. Accordingly, while revision for progression of osteoarthritis was associated with reduced odds of re-revision, this result should be interpreted with caution. Finally, external validity is limited by potential differences in patient selection, as well as surgical technique and patient care, between centres.

In conclusion, this study demonstrates that aseptic revision from UKA to TKA in a high-volume tertiary care center is associated with favourable midterm implant survivorship, satisfactory clinical outcomes, and good radiographic outcomes, which are superior to those reported in nationwide registries. Both revision rates and clinical outcomes resemble previously published data on primary TKAs more than revision TKAs. This information may support patients and orthopaedic surgeons in choosing primary UKA over TKA, with the reassurance that, if revision becomes necessary, favourable outcomes can still be achieved in the majority of cases.

AUTHOR CONTRIBUTIONS

Marius J. Ibach: Conceptualization; formal analysis; investigation; data collection; visualization; writing—original draft; writing—review and editing. **Oscar Torney**: Data collection; writing—review and editing; formal analysis; investigation. **Christoph E. Horn**: Data collection; writing—review and editing. **Alexander Frenzel**: Data collection; writing—review and editing. **Christoph H. Lohmann**: Writing—review and editing. **Jonas Sina**: Writing—review and editing. **Daniel Schrednitzki**: Writing—review and editing. **Andreas M. Halder**: Writing—review and editing; supervision. **Nils Meißner**: Conceptualization; data collection; supervision; writing—review and editing.

CONFLICT OF INTEREST STATEMENT

Andreas M. Halder and Daniel Schrednitzki have received speaker and consultant honoraria from ZimmerBiomet. Andreas M. Halder and Nils Meißner have received research funding from the German Innovation Fund. Nils Meißner has received research funding from the German Society for Orthopaedics and Trauma and Aesculap AG. Christoph H. Lohmann has received funding for presentations and study support from Implantec GmbH, Austria; MathysMedical, Switzerland; and W. Link GmbH Co. KG, Germany. Andreas M, Halder is the 2nd Vice President and Board Member of the European Knee Society. Christoph H. Lohmann is the president of the German Society for Orthopaedics and Trauma. The remaining authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data are not publicly available due to privacy and ethical restrictions.

ETHICS STATEMENT

The investigation received approval from the local ethics committee (2024-133-BO-ff) prior to the start of the study. Informed consent was obtained from all participants included in the study.

ORCID

Marius Jonathan Ibach https://orcid.org/0009-0003-5113-1887
Oscar Torney https://orcid.org/0000-0003-4348-532X
Christoph Hubertus Lohmann https://orcid.org/0000-0002-2962-2183
Jonas Sina https://orcid.org/0000-0001-7798-3306
Daniel Schrednitzki https://orcid.org/0000-0003-2696-1769
Andreas Matthias Halder https://orcid.org/0000-0001-8901-5898
Nils Meißner https://orcid.org/0000-0002-7321-219X

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