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Unicondylar knee arthroplasty demonstrating a significant increased risk for aseptic revisions compared to unconstrained and constrained total knee arthroplasty: An analysis of aseptic revisions after unicondylar and primary total knee arthroplasty of the German Arthroplasty Registry

Josina Straub[1] | Dominik Szymski[1] | Nike Walter[1] | Yinan Wu[2] | Oliver Melsheimer[2] | Alexander Grimberg[2] | Volker Alt[1] | Arnd Steinbrueck[2,3] | Markus Rupp[1]

[1]Department for Trauma Surgery, University Hospital Regensburg, Regensburg, Germany

[2]Deutsches Endoprothesenregister gGmbH (EPRD), Berlin, Germany

[3]Orthopädisch Chirurgisches Kompetenzzentrum Augsburg (OCKA), Augsburg, Germany

Correspondence

Markus Rupp, Department of Trauma Surgery, University Medical Centre Regensburg, Franz-Josef-Strauss Allee 11, Regensburg 93053, Germany.
Email: markus.rupp@ukr.de

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None

Abstract

Purpose: Due to ageing population, the implantation rate of total knee arthroplasties (TKAs) is continuously growing. Aseptic revisions in primary knee arthroplasty are a major cause of revision. The aim of the following study was to determine the incidence and reasons of aseptic revisions in constrained and unconstrained TKA, as well as in unicondylar knee arthroplasties (UKAs).

Methods: Data collection was performed using the German Arthroplasty Registry. Reasons for aseptic revisions were calculated. Incidence and comparison of aseptic revisions were analysed using Kaplan–Meier estimates. A multiple χ^2 test with Holm's method was used to detect group differences in ligament ruptures.

Results: Overall, 300,998 cases of knee arthroplasty with 254,144 (84.4%) unconstrained TKA, 9993 (3.3%) constrained TKA and 36,861 (12.3%) UKA were analysed. Aseptic revision rate in UKA was significantly increased compared to unconstrained and constrained TKA ($p < 0.0001$). In constrained TKA, a 2.0% revision rate for aseptic reasons were reported after 1 year, while in unconstrained TKA 1.1% and in UKA, 2.7% of revisions were identified. After 7 years in constrained TKA 3.3%, in unconstrained TKA 2.8%, and in UKA 7.8% sustained aseptic revision. Ligament instability was the leading cause of aseptic revision accounting for 13.7% in unconstrained TKA. In constrained TKA, 2.8% resulted in a revision due

Abbreviations: AJRR, American Joint Replacement Register; ASA, American Society of Anesthesiologists risk classification; BMI, body mass index; BVMed, German Medical Technology Association; EPRD, Endoprothesenregister Deutschland (German Arthroplasty Registry); HR, hazards ratio; ICD-10, 10th International Classification of Diseases; ICPM, International Classification of Procedures in Medicine; NJR, National Joint Registry; OPS, Operation and Procedure Code 301 system; PMPC, polyethylene such poly-2-methacryloyloxyethyl phosphorylcholine; TKA, total knee arthroplasty; UKA, unicondylar knee arthroplasty.

Josina Straub and Dominik Szymski share joint first authorship.

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to ligament instability. In the UKA, the most frequent cause of revisions was tibial loosening, accounting for 14.6% of cases, while progression of osteoarthritis accounted for 7.9% of revisions. Ligament instability was observed in 14.1% of males compared to 15.9% of females in unconstrained TKA and in 4.6% in both genders in UKA.

Conclusion: In patients with UKA, aseptic revision rates are significantly higher compared to unconstrained and constrained TKA. Ligament instability was the leading cause of aseptic revision in unconstrained TKA. In UKA, the most frequent cause of revisions was tibial loosening, while progression of osteoarthritis was the second most frequent cause of revisions. Comparable levels of ligament instability were observed in both sexes.

Level of Evidence: Level III, cohort study.

KEYWORDS

aseptic revision, constrained, knee arthroplasty, register study, unconstrained, unicondylar

INTRODUCTION

Knee arthroplasty is the preferred treatment for patients with end-stage gonarthritis. It is one of the most commonly performed orthopaedic procedures worldwide [10]. Based on historical data provided, the incidence rate of knee arthroplasty will increase annually in the future [24]. By 2040, the incidence rate of total knee arthroplasty (TKA) in Germany will increase from 245 TKA's per 100,000 inhabitants in the year 2016 to 379 [24]. In the United States, in the time between 2012 and 2021, a total of 1,485,482 knee arthroplasty were performed [1]. An increase of 12.0% of partial and total knee arthroplasty was observed over the investigated 11-year period from 150,504 in 2008 up to 168,479 procedures in 2018 [27]. The most common treatment for patient with gonarthritis is unconstrained TKA with a proportion of 80%–90% of all TKA [16]. Unicondylar knee arthroplasty (UKA) accounted for 2.9% in 2017 and increased to 4.2% in 2021 of all primary knee arthroplasties reported to American Joint Replacement Register [1]. However, UKA account for only 5%–10% of knee arthroplasty procedures and go along with a threefold increase in revision rates compared to TKA [16]. A trend towards UKA revisions in patients younger than 65 years could be observed with an increase of 34.2%–47.8% between 2008 and 2018, however, patients 65 years of age or older represented the largest cohort with 65.8% of the unicondylar revision cases in 2008 [26]. While excellent outcomes following TKA have been demonstrated with implant survivorship exceeding 90%, the procedure is not without complications and can lead to revision surgery [18]. Reasons for revisions can either be septic or aseptic reasons [3, 5]. The analysis of failed TKA in the United States healthcare system demonstrated infection being the most common reason for revision (20.4%), followed by aseptic loosening (20.3%) [3]. Focusing on the aseptic reasons for revision requires mentioning progressing secondary osteoarthritis in case of UKA [16], aseptic loosening or ligament instability [16, 23]. Faschingbauer and Reichel mentioned aseptic loosening as the most common reason for aseptic revision in knee arthroplasty with 28% [8]. The problem of wear has decreased significantly in the last few years due to the use of improved polyethylene such poly-2-methacryloyloxyethyl phosphorylcholine—grafted highly cross-linked polyethylene [8, 15]. However, surgical techniques are an aseptic reason for implant-associated instability [8]. Ligament instability is the fourth common reason for revisions in primary knee arthroplasty, especially after trauma or severe deformity [5, 8]. Compared to men, women suffer ligament ruptures two to eight times more frequently and anatomical, hormonal, and biomechanical variables are thought to be the reason for an increased knee laxity and higher risk of ligament rupture in women [2, 6, 9, 19].

Therefore, aim of the present study was to (1) analyse aseptic revision rates and reasons after unconstrained and constrained primary TKA, as well as UKA. In addition, (2) an analysis of ligament instability for aseptic revisions in unconstrained, and constrained TKA and UKA patients for both genders were performed. We hypothesised that unicondylar arthroplasties would exhibit a higher likelihood of aseptic failure.

MATERIALS AND METHODS

Data collection

The study was approved by the Ethics Committee of the University of Kiel (ID: D473/11) and conducted according to the Declaration of Helsinki. This study

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examines the aseptic revisions of unconstrained and constrained TKA, as well as UKA in patients with primary gonarthritis based on the 'German Arthroplasty Registry' (EPRD). Implantations of arthroplasties in Germany have been documented since 2012 in the EPRD in collaboration with the statutory health insurance funds (AOK Bundesverband GbR, Verband der Ersatzkassen e.V vdek), the German Medical Technology Association and several participating hospitals. Over 2 million procedures are included in the registry and approximately 70% of all hip and knee arthroplasties performed in Germany are covered in the registry by 2022 [7]. Cross-validation of data provided by the surgeons is carried out by inclusion of two participating health insurance associations (AOK-B, vdek), which approximately covers hereby 65% of the German population. Surgical revisions registered in the EPRD are followed up based on insurance billing data, even if performed in a hospital not participating in the arthroplasty registry. This system guarantees nearly perfect tracking of patients covered by these companies' insurance, with the exception of treatments performed outside of Germany [11].

The German versions of the International Classification of Procedures in Medicine, the 'Operation and Procedure Code' (OPS) 301 system and the 10th International Classification of Diseases (ICD-10) were used to categorise and identify diagnoses and procedures.

Patients

The current analysis of the EPRD includes all patients between November 2012 and September 2022 with aseptic revisions after TKA or UKA due to primary gonarthritis as primary diagnosis (ICD-10: M17.0-, M17.1). Subpopulations of patients with constrained and unconstrained TKA and UKA were identified to analyse incidences and reasons for aseptic revisions according to the type of prothesis. Patient characteristics such as age, sex, body mass index (BMI), Elixhauser-Comorbidity Score, American Society of Anesthesiologists risk score, as well as hospital-related factors, for example, TKA and UKA volume, were reported in the registry. The Elixhauser score is an index that pools a variety of comorbidities of different organ systems and entities [25]. Coded comorbidities in the initial hospital stay during primary implantation of the arthroplasty were the basis for the calculation of the Elixhauser score. The use of unconstrained or constrained TKA was determined by evaluation of the applied implant during surgery using the classification information of the common product library of EPRD and The National Joint Registry. Revision rate was determined through search of the ICD-10 code for aseptic revision (T84.5) in the registry and registration of revision causes by the surgeons. The OPS-Codes analysis provided a detailed registry of the method and side of interest. Data provided by the registration of the surgeons were cross-validated by analysis of insurance data. Patients who were not treated for primary osteoarthritis as main diagnosis, with a follow-up under 12 months or implantation of a special implant (e.g., tumour prosthesis), as well as no clear information on used material were excluded from the analysis.

Statistical analysis

The data were analysed to determine rates and reasons for aseptic revisions in constrained and unconstrained TKA, as well as UKA in Germany. The statistical analysis was done using the statistical package R (R Foundation for Statistical Computing, version 4.2). Descriptive Statistics were calculated for the unconstrained and constrained TKA as well as UKA. Continuous variables are presented in mean and standard deviation, categorical variables in number of observations and frequency. Categorical variables were presented in terms of frequency and percentage. Cumulative incidences for the aseptic revision endpoint according to the type of prothesis were computed using Kaplan–Meier estimates. The corrected multiple Log-rank test with Holm's technique was used to compare the three groups with regard to ligament instability. Analysis of ligament instability in both genders was performed by using Pearsons's χ^2 test and multiple testing adjusted by Holm's technique. The significance level was defined at 5% (Figure 1).

RESULTS

In the EPRD, 396,284 primary arthroplasty knee procedures were identified. After exclusion of patients not matching the inclusion criteria, 300,998 patients were included into the final analysis. 254,144 (84.4%) patients received an unconstrained TKA, while 9993 (3.3%) were eligible for a constrained TKA. 36,861 (12.3%) received a UKA for treatment of primary gonarthritis. A comparable BMI was observed across all types of procedures and preobese was most commonly represented. In unconstrained TKA 23.1%, in constrained TKA 22.8% and in UKA 25.3% were preobese. While 52.1% of patients receiving constrained TKA were 75 years or older, 52.4% of those receiving UKA were younger than 64 years. Patient characteristics of the included TKA and UKA cases are summarised in Table 1.

Medical centres with a TKA volume of >250 per year performed 40.8% of the unconstrained TKA and 32% of the constrained TKA. With 38.8% the majority of

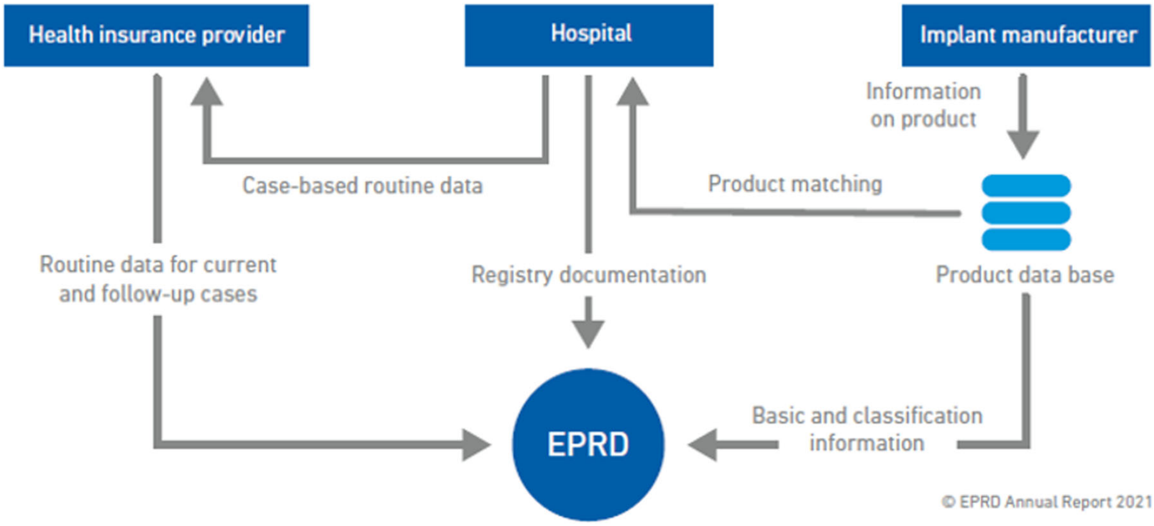

FIGURE 1 The flow of data from hospitals, health insurance, and implant manufacturers to the Endoprothesenregister Deutschland (German Arthroplasty Registry) (EPRD). The EPRD obtains its data from three different sources: health insurance provider, hospital and implant manufacturer. Healthy insurance provider obtain data from current and follow-up cases, hospitals regularly complete the register documentation and implant manufacturers transfer product information to the EPRD.

the constrained TKA occurred by medical centres with a TKA volume of 101–250. Medical centres with a UKA volume of >50 per year performed 52% of the UKA, whereas medical centres with a UKA volume of 0–10 per year carried out 5.7% of the UKA (Table 2).

Rate of aseptic revisions

In constrained TKA, an aseptic rate of 2.0% was reported after 1 year, 2.9% after 3 years and 3.3% after 7 years. In unconstrained TKA, 1.1%, 2.1% and 2.8% were identified during the same period. In case of UKA, 2.7% needed a revision for an aseptic reason after 1 year. After 3 years, 5.3% and after 7 years 7.8% needed revision for an aseptic reason. UKA demonstrated thereby a significant increased aseptic rate of revision compared to unconstrained and constrained TKA ($p < 0.0001$) (Table 3, Figure 2).

Resaons for aseptic revisions

In unconstrained TKA, ligament instability was the leading cause of aseptic revision accounting for 13.7%. Aseptic revision with unconstrained TKA was caused by tibial loosening in 7.9% and restricted mobility in 4.7%. In contrast, constrained TKA resulted in 2.8% to a revision due to ligament instability. In 21.3% of the cases, other factors such as failure of a component and condition after removal were reported as the primary cause for aseptic revision. Periprosthetic fractures were reason for revision surgery in 5.9% and prosthetic malalignment in 3.6%. In case of UKA, loosening of the tibia resulted in a revision in 14.6%, while osteoarthritis progression accounted for 7.9% of revisions (Table 4).

In addition, an analysis of ligament instability for aseptic revisions in unconstrained and constrained TKA and UKA patients for both genders were performed. Among female patients, ligament instability was detected in 15.9% of cases with unconstrained TKA, 4.9% with constrained TKA, and 4,6% with UKA. In male patients, ligament instability was demonstrated in 14.1% with unconstrained TKA, in 1.6% with constrained TKA and in 4.6% with UKA (Table 5).

DISCUSSION

For UKA, a significant increased rate of aseptic revisions was reported compared to unconstrained and constrained TKA. Ligament instability was the leading cause of aseptic revision accounting in unconstrained TKA. In the UKA, the most frequent cause of revisions was tibial loosening, while progression of osteoarthritis was the second most frequent reason for revisions. Comparable levels of ligament instability were observed in both sexes.

Rate of aseptic revisions

TKA is an effective treatment for knee osteoarthritis. However, revisions for aseptic reasons in primary knee arthroplasty are a major cause [12, 17]. The rate of aseptic revision differs between various studies and procedures [3, 4, 17, 18]. Namba et al. reported an cumulative incidence of aseptic revision of 1.3% [17]. An analysis of the Danish

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TABLE 1 Anthropometric data on patient collective.

Characteristic	Primary osteoarthritis TKA unconstrained, *N* = 254,144	TKA constrained, *N* = 9993	UKA, *N* = 36,861	*p* Value
BMI (kg/m²)				<0.001
Underweight (<18.5)	297 (0.1%)	39 (0.3%)	41 (0.1%)	
Normal (18.5–24.9)	22,946 (9%)	1394 (14%)	3471 (9.4%)	
Preobese (25–29.9)	58,694 (23.1%)	2275 (22.8%)	9336 (25.3%)	
Obese 1 (30–34.9)	49,958 (19.7%)	1665 (16.6%)	7285 (19.7%)	
Obese 2 (35–39.9)	25,188 (9.9%)	865 (8.7%)	3231 (8.8%)	
Obese 3 (>40)	14,205 (5.6%)	625 (6.3%)	1309 (3.6%)	
Unknown	82,856 (32.6%)	3130 (31.3%)	12,188 (33.1%)	
Age				<0.001
<64	78,197 (30.8%)	1926 (19.3%)	19,316 (52.4%)	
65–74	86,654 (34.1%)	2859 (28.6%)	10,645 (28.9%)	
75+	89,293 (35.1%)	5208 (52.1%)	6900 (18.7%)	
Sex				<0.001
Female	168,851 (66%)	7796 (78%)	20,796 (56%)	
Male	85,293 (34%)	2197 (22%)	16,065 (44%)	
ASA				<0.001
1	6038 (2.4%)	212 (2.1%)	1235 (3.4%)	
2	30,288 (11.9%)	1004 (10%)	5184 (14.1%)	
3+	17,569 (6.9%)	896 (9.1%)	1830 (5%)	
Unknown	200,249 (78.8%)	7881 (78.8%)	28,612 (77.5%)	
Elixhauser score weighted in numeric	0.9 (4.2)	2.3 (5.3)	0.2 (3.4)	<0.001
Elixhauser score				<0.001
<0	59,003 (23%)	1844 (18%)	8460 (23%)	
0	118,592 (47%)	3882 (39%)	20,607 (56%)	
1–4	27,432 (11%)	1150 (12%)	3308 (9.0%)	
5+	49,117 (19%)	3117 (31%)	4486 (12%)	

Abbreviations: BMI, body mass index; TKA, total knee arthroplasty; UKA, unicondylar knee arthroplasty.

knee arthroplasty register from 1997 to 2017 reported higher revision risk and lower mortality risk for UKA versus TKA at all time points [14]. A reduction in UKA patients' revision risk compared with TKA patients was reported over the last 20 years from a 3-year hazards ratio (HR) of over 5 to an HR of 1.5 for the most current patients [14]. In our analysis of the EPRD, UKA demonstrated a significant increased aseptic rate of revision compared to unconstrained and constrained TKA. After 1 year, 2.7% of the affected patients needed a revision surgery due to aseptic reasons, 5.3% after 3 years and 7.8% after 7 years. Studies directly comparing revisions rates after constrained and unconstrained TKA and UKA are lacking. Mikkelsen et al. reported higher rates of revision for aseptic reasons after 3 years with 7.6% and a revision rate of 10.0% after 10 years for UKA [14]. Whereas Burger et al. reported a 10-year revision rate of 8% for uncemented and 11% for the cemented UKA [4].

Mikkelsen et al. only analysed TKA in total and did not have a separated analysis for constrained and unconstrained TKA. For all TKA, a revision rate of 3.8% after 3 years and 6.2% after 10 years were reported [14]. In comparison, our analysis with division in constrained and unconstrained TKA demonstrated a similar revision

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TABLE 2 Hospital characteristics of hospitals performing TKA and UKA implantations of the included patient collective.

Characteristic	TKA unconstrained, *N* = 254,144	TKA constrained, *N* = 9993	UKA, *N* = 36,861
UKA implantation volume annually			
0–10			2090 (5.7%)
11–50			13,210 (35.8%)
>50			19,191 (52%)
Unknown			2370 (6.4%)
TKA implantation volume annually			
0–100	54,541 (21.5%)	2620 (26.2%)	
101–250	89,092 (35.1%)	3876 (38.8%)	
>250	103,567 (40.8%)	3202 (32%)	
Unknown	6944 (2.6%)	295 (3%)	

Note: Mean (SD); *n* (%).

Abbreviations: TKA, total knee arthroplasty; UKA, unicondylar knee arthroplasty.

TABLE 3 Cumulative rate of aseptic revisions for constrained and unconstrained TKA and UKA with corresponding 95% confidence Interval.

	1 Month	3 Months	6 Months	1 Year	3 Years	5 Years	7 Years
Unconstrained TKA in % (95% confidence Interval)	0.4 (0.4, 0.4)	0.5 (0.5, 0.6)	0.7 (0.7, 0.8)	1.1 (1.1, 1.2)	2.1 (2.1, 2.2)	2.5 (2.4, 2.6)	2.8 (2.7, 2.9)
Constrained TKA in % (95% confidence Interval)	1.1 (0.9, 1.3)	1.4 (1.2, 1.7)	1.6 (1.4, 1.9)	2 (1.8, 2.3)	2.9 (2.6, 3.2)	3.1 (2.8, 3.5)	3.3 (2.9, 3.7)
UKA in % (95% confidence Interval)	0.4 (0.3, 0.5)	0.8 (0.8, 0.9)	1.5 (1.4, 1.6)	2.7 (2.5, 2.9)	5.3 (5.1, 5.5)	6.6 (6.3, 6.9)	7.8 (7.4, 8.2)

Abbreviations: TKA, total knee arthroplasty; UKA, unicondylar knee arthroplasty.

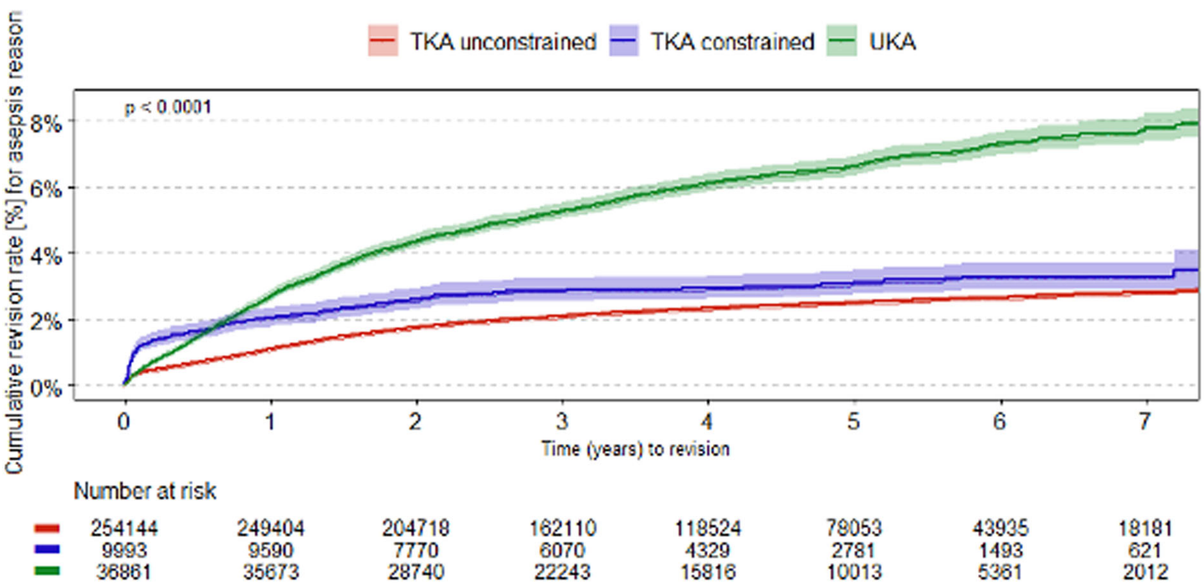

FIGURE 2 Cumulative aseptic revision rate for unconstrained and constrained total knee arthroplasty (TKA) and unicondylar knee arthroplasty (UKA). UKA demonstrated an increased rate of aseptic revisions compared to unconstrained and constrained TKA.

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TABLE 4 Reasons for aseptic revisions in unconstrained and constrained TKA and UKA patients.

Characteristic	TKA unconstrained, *N* = 6510[a]	TKA constrained, *N* = 389[a]	UKA, *N* = 2214[a]
Ligament instability	890 (13.7%)	11 (2.8%)	81 (3.7%)
Loosening (femur)	122 (1.9%)	10 (2.6%)	49 (2.2%)
Loosening (patella)	19 (0.3%)	1 (0.3%)	3 (0.1%)
Loosening (several)	275 (4.3%)	11 (2.8%)	171 (7.8%)
Loosening (tibia)	517 (7.9%)	12 (3.1%)	324 (14.6%)
Osteolysis	19 (0.4%)	0 (0%)	9 (0.4%)
Periprosthetic fracture	179 (2.7%)	23 (5.9%)	90 (4.1%)
Progression of osteoarthritis	79 (1.2%)	5 (1.3%)	175 (7.9%)
Prosthetic malalignment/ malrotation	174 (2.8%)	14 (3.6%)	47 (2.1%)
Restricted mobility	299 (4.7%)	8 (2.1%)	85 (3.8%)
Wear	131 (2.0%)	3 (0.8%)	36 (1.6%)
Other reasons	1171 (17.9%)	83 (21.3%)	453 (20.5%)
Unknown	2631 (40.3%)	208 (53.5%)	691 (31.2%)

Abbreviations: TKA, total knee arthroplasty; UKA, unicondylar knee arthroplasty.
[a]*n* (%).

TABLE 5 Ligament instability for aseptic revisions in female and male in unconstrained and constrained TKA and UKA patients.

Female Characteristic	TKA unconstrained, *N* = 3879[a]	TKA constrained, *N* = 226[a]	UKA, *N* = 1340[a]	*p* Value[b]
Ligament instability				<0.001
Ligament instability	615 (15.9%)	11 (4.9%)	62 (4.6%)	
Other reasons	1856 (47.8%)	105 (46.5%)	889 (66.3%)	
Unknown	1408	110	389	
Male Characteristic	**TKA unconstrained, *N* = 1800[a]**	**TKA constrained, *N* = 64[a]**	**UKA, *N* = 787[a]**	***p* Value[b]**
Ligament instability				<0.001
Ligament instability	253 (14.1%)	1 (1.6%)	36 (4.6%)	
Other reasons	846 (47%)	35 (54.7%)	524 (66.6%)	
Unknown	701	28	227	

Abbreviations: TKA, total knee arthroplasty; UKA, unicondylar knee arthroplasty.
[a]*n* (%)
[b]Pearson's χ^2 test.

rate. In constrained TKA, after 1 year an aseptic rate of 2.0%, after 3 years of 2.9% and after 7 years of 3.3% was reported and in the same period in unconstrained TKA 1.1%, 2.1% and 2.8% were identified. An analysis of the epidemiologic data in China for revision of TKA showed a revision burden of 2.4% for all arthroplasty procedures between 2013 and 2018 with an increasing trend from 2013 to 2018 from 2.3% to 2.5% [13]. Revision TKA procedures were more frequently performed in women, with a proportion of 67.5% [13].

Reasons for aseptic revisions

There are several reasons for aseptic revisions in constrained and unconstrained TKA and UKA. They

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varied in different kind of arthroplasties [13, 21, 22]. Long et al. mentioned mechanical failure (19.5%) and pain (18.8%) as the most common reason for aseptic revision [13]. Lewis et al. conducted a multi-registry study with analysation of variations and trends in reasons for knee arthroplasty revision. Swedish Knee Arthroplasty Register, the Australian Orthopaedic Association National Joint Replacement Registry and the American Kaiser Permanente Joint Replacement Registry were analysed for the period between 2003 and 2017. Among all three registers, infection, loosening, instability and progressing of osteoarthritis were among the five most common causes for revision in all types of arthroplasty with an increase in proportions of revisions for infection and a decrease in revisions for wear over time [21]. There have been inconsistent proportions and trends for the other reasons of revision [21]. As reasons for aseptic revisions in TKA, Quispel et al. reported instability with 37.2% as the most common reason for revision surgery, loosening of the tibial implant component with 36.6% and patella pain with 22.5% [22]. Division in constrained and unconstrained TKA for analysis of the various rates of aseptic revision could not be found in literature. The present analysis demonstrated that ligament instability led to 13.7% in unconstrained TKA and restricted mobility in 4.7% to a revision. Whereas constrained TKA only led in 3.1% to a revision due to ligament instability. Periprosthetic fractures were in 5.9% and prosthetic malalignment in 2.8% a reason for revision in constrained TKA. Furthermore, loosening of the tibial implant component occurred with 7.9% in unconstrained TKA less often as in comparison to 36.6% reported by Quispel et al.

In case of UKA, loosening of the tibia resulted in a revision in 14.6%, while osteoarthritis progression accounted for 7.9% of revisions. An analysis of the Total Joint Replacement Registry from 2001 to 2010 showed as well instability (32.2%) and aseptic loosening (22.9%) as the main reasons for aseptic revision [17]. Burger et al. analysed the Dutch Arthroplasty register from 2007 to 2018 in regard to risk of revision in UKA to fixation type. In cementless UKA, instability, defined as instability of the knee implant, resulting in inadequate flexion, malposition or malalignment of the implant, was in 23.6% the most common reason for revision and progression of the osteoarthritis (18.6%) and loosing of the tibial component (12.3%) were other frequent reason for revision. In case of cemented UKA, progressing of the osteoarthritis was with 22.3% the most common reason and loosening of the tibial component with 20.3% as well as malalignment with 15.3% common causes for aseptic revision [4]. The present analyses reported loosening of the tibial component in 14.6% and progression of osteoarthritis in 7.9% as the most common reason for revisions of UKA. However, it demonstrated lower percentages for loosening of the tibial component and progression of osteoarthritis compared to Burger et al. [4]. Ligament instability was in 3.7%, as well as prosthetic malalignment in 2.1% less common.

In addition, a subgroup analysis of the data of EPRD for ligament instability was performed to identify the reason for aseptic revisions in unconstrained and constrained TKA and UKA patients for both genders. It demonstrated ligament instability in male patients in 14.1% of unconstrained TKA, in 1.6% of constrained TKA, and in 4.6% of UKA. Among female patients, ligament instability was detected in 15.9% of unconstrained TKA, 4,9% of constrained TKA and 4.6% of UKA. Comparable levels of ligament instability were observed in both sexes. Ligament instability was observed in 14.1% of males compared to 15.9% of females in unconstrained TKA and in 4.6% in both genders in UKA. Despite the use of constrained TKA, ligament instability was detected in 1.6% of men and 4.6% of women. According to the literature, women are more likely than men to have higher knee laxity and a higher risk of ligament rupture because of differences in anatomy, physiology and hormones [6, 9, 20]. Women suffer ligament ruptures two to eight times more frequently than men [19]. Women's genu valgum, greater femoral anteversion and weaker musculature are thought to contribute to their increased risk of ligament ruptures [20]. In addition, several studies have been conducted regarding the influence of the female cycle on knee laxity and risk of ligament rupture [6, 9, 20]. An association between hormone status and knee laxity or risk of ligament rupture is assumed [9]. However, the analyses of EPRD demonstrated comparable levels of ligament instability in both sexes for all type of knee arthroplasty. Perhaps, this can be the result of improved muscle development. Thus, our research revealed for the first time no gender difference in ligament instability after knee arthroplasty. However, the reason for comparable levels of ligament instability and the persistent of ligament instability after the implementation of a constrained prosthesis, as found in our analysis, remains unclear.

LIMITATIONS

Despite multiple advantages of the EPRD, several limitations of the present study are worth to be mentioned. The quality of data in this registry is dependent on registration by surgeons and correct coding of procedures. The included patient data were cross-validated using insurance data in order to reduce this impact and constraint. Due to different indications of the investigated implants, different quantities were reported. Kaplan–Meier estimates and corrected multiple log-rank test were used to reduce this limitation. The Elixhauser comorbidity score was calculated by

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using the comorbidities reported in the initial hospital stay during primary implantation and inaccurate or insufficient coding is a further possible cofounder. Nevertheless, not all comorbidities are queried with the Elixhauser comorbidity Index. Another restriction is the duration of the registry's existence, which currently prohibits the investigation of follow-ups lasting longer than 7 years. Another limitation is the fact that the degree of coupling cannot be detailed for constraint prostheses. In addition, the stem lengths for shaft-anchored prostheses based on registry data cannot be comprehended, which reduces the informative value of the present analysis.

CONCLUSION

In patients with UKA, aseptic revision rates are significantly higher compared to unconstrained and constrained TKA. Ligament instability was the leading cause of aseptic revision in unconstrained TKA. In UKA, the most frequent cause of revisions was tibial loosening, while progression of osteoarthritis was the second most frequent cause of revisions. Comparable levels of ligament instability were observed in both sexes. Further patient information is warranted prior to arthroplasty index surgery. Future investigations may help to identify potential patient-specific risk factors.

AUTHOR CONTRIBUTIONS

The manuscript was created by Josina Straub, Dominik Szymski, Nike Walter and Markus Rupp. Josina Straub, Dominik Szymski, Yinan Wu, Nike Walter and Markus Rupp performed the statistical analysis and designed the study. Arnd Steinbrueck, Oliver Melsheimer, Alexander Grimberg and Markus Rupp conceived of the study, helped to draft the manuscript and participated in its design. Volker Alt, Arnd Steinbrueck and Markus Rupp supervised the study. Yinan Wu and Oliver Melsheimer are responsible for data assessment and databank management. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data available on request.

ETHICS STATEMENT

The study was approved by the Ethics Committee of the University of Kiel (ID D473/11).

ORCID

Markus Rupp http://orcid.org/0000-0001-7221-3783

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