Comparison of the Norwegian Knee Arthroplasty Register and a United States Arthroplasty Registry

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Abstract: Several national total joint arthroplasty registries exist outside of the United States (U.S.) and have been used to compare rates and outcomes of total knee arthroplasty. Within the U.S., regional arthroplasty registries provide an opportunity to compare U.S. practices and outcomes with those of other countries. The purpose of this study was to compare the demographics, choice of implants, techniques, and outcomes of total knee arthroplasties in Norway to those from a large, U.S. integrated health-care system and to determine the feasibility of using aggregate-level data for international registry comparisons. The study sample consisted of 25,004 primary total knee arthroplasties performed in Norway and 56,208 from the Kaiser Permanente health-care system. Summary-level data were used to compare the two cohorts. At the time of the seven-year follow-up, the cumulative survival of the total knee prosthesis was 94.8% for the arthroplasties performed in Norway and 96.3% for those performed at Kaiser Permanente. The primary reasons for revision arthroplasty included infection, instability, pain, and aseptic loosening. Patient characteristics, selection of implants, surgical techniques, and outcomes differed between the cohorts. Harmonization of data elements and definitions is necessary for future international research.

Several national total joint arthroplasty registries have been influential in reducing the revision rates associated with total joint arthroplasty by identifying implant failures and providing feedback on clinical practices[1-7]. Comparisons between these national registries have provided important information on variation in incidence rates, surgical techniques, implant selection, and outcomes of total joint arthroplasty procedures[8,9].

Within the U.S., claims and administrative databases have been used to compare arthroplasty rates, demographics, and revision rates with those of other countries[10]. While these studies provide important information on total joint arthroplasty revision rates through the use of large, representative samples, they are limited by the lack of laterality and specific clinical and implant details that are necessary for assessment of implant survival after total joint arthroplasty.

Total joint arthroplasty registries provide an alternative to the use of claims data for the assessment of total joint arthroplasty outcomes in the U.S. Several regional and institutional registries exist within the U.S.[11-13] and collect the data (e.g., patient demographics, surgical technique, type of implant, and reasons for revision) necessary to assess total joint outcomes. Although these registries have been used to assess total joint replacement outcomes within specific institutions and/or regions, direct comparisons with international total joint arthroplasty registries have not been published, to our knowledge.

These regional and institutional total joint arthroplasty registries provide a unique opportunity to compare U.S. total joint arthroplasty demographics, practices, and revision arthroplasty rates with those of other countries. Therefore, the purpose of this study was to compare patient characteristics, implant characteristics, surgical techniques, revision rates, and reasons for revision arthroplasty in a cohort of patients with primary total knee arthroplasty from the Norwegian Arthroplasty Register and the Kaiser Permanente Total Joint Replacement Registry to assess the feasibility of aggregating international registry data while identifying the strengths and limitations of such an approach.

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TABLE I Diagnosis and Patient Characteristics*

	Norwegian Arthroplasty Register (N = 25,004)		Kaiser Permanente Total Joint Replacement Registry (N = 56,208)	
	No.	%	No.	%
Procedure				
Primary only	24,154	96.6	55,060	98.0
Revision	850	3.4	1148	2.0
Total†	25,004	100	56,208	100
Sex				
Male	8164	32.7	20,787	37.0
Female	16,840	67.3	35,412	63.0
Unknown	NA	NA	9	0.0
Age *(yr)*				
Mean and standard deviation	69.6 ± 10.0	NA	67.4 ± 9.6	NA
Category				
<45	408	1.6	544	1.0
45-59	3750	15.0	11,135	19.8
60-69	7644	30.6	20,235	36.0
70-79	9610	38.4	18,486	32.9
≥80	3592	14.4	5808	10.3
Diagnosis‡				
Osteoarthritis	21,733	86.9	54,399	96.8
Rheumatoid arthritis	1317	5.2	1019	1.8
Inflammatory arthritis§	255	1.0	228	0.4
Posttraumatic arthritis	2878	11.5	689	1.2
Osteonecrosis	43	0.2	238	0.4
Other	580	2.3	511	0.9
Missing	81	0.3	2	0.0
ASA Score#				
1	4039	22	1147	2.0
2	10,397	56.6	32,307	57.5
3	3366	18.3	21,116	37.6
4	28	0.2	436	0.8
5	2	<0.1	2	0.0
Unknown	529	2.9	1200	2.1

*NA = not applicable. †The total comprises the limbs that underwent a primary procedure only and the limbs that underwent a primary as well as a revision procedure. ‡Patients can have more than one diagnosis at the time of surgery. §Includes psoriatic arthritis. #The American Society of Anesthesiologists (ASA) scores from the Norwegian Arthroplasty Register are from the years 2005 through 2009 (N = 18,361 cases).

Materials and Methods

Institutional review board approval was obtained for this study, allowing for the sharing of summary data while protecting individual patient health information at both institutions.

Data Sources

The Norwegian Arthroplasty Register, a national registry that was started in 1987 as a hip registry, contains data regarding more than 114,400 hip replacements. The Norwegian knee registry was established in 1994 and, by 2009, had registered data on 40,000 knee arthroplasties. The registry tracks total knee arthroplasty procedures in a population of approximately 4.6 million[2,14], with high completeness of reporting[15]. The Kaiser Permanente Total Joint Replacement Registry was developed in 2001 and registered over 63,000 knee arthroplasty cases by the end of 2009. Kaiser Permanente provides health-care coverage for 8.6 million members who are part of a large, integrated health-care system in seven geographical areas of the U.S.[16], and it has reported good participation and completion rates with regard to the registry[13]. The Norwegian Arthroplasty Register and the Kaiser Permanente Total Joint Replacement Registry were used to identify primary total knee arthroplasty cases that were performed between January 1, 2001, and December 31, 2009. Patient demographics, surgical techniques, type of implants, cumulative survival rates, and reasons for revision arthroplasty were summarized from each registry by means of tables with summary level statistics (percent, means, medians, and standard deviation) and survival function by strata. Revision for all reasons, aseptic revision only (excluding revision due to infection), and revision due to infection were reported.

TABLE II Type of Fixation, Implant Type, and Implant Characteristics*

	Norwegian Arthroplasty Register (N = 25,004)		Kaiser Permanente Total Joint Replacement Registry (N = 56,208)	
	No.	%	No.	%
Fixation				
Cemented	20,964	83.8	47,810	85.1
Uncemented	852	3.4	5338	9.5
Hybrid	2991	12.0	3060	5.4
Unknown	197	0.8	0.0	0.0
Femoral components†				
Profix	9252	37.0	218	0.4
LCS	3193	12.8	1072	1.9
LCS Complete	5153	20.6	2	0.0
AGC	2892	11.6	0.0	0.0
Genesis I†	413	1.7	0.0	0.0
Duracon†	1305	5.2	39	<0.1
PFC	0.0	0.0	26,977	48.0
NexGen	1223	4.9	21,925	39.0
Genesis II†	0.0	0.0	2678	4.8
E-motion†	457	1.8	0.0	0.0
Natural Knee II†	0.0	0.0	942	1.7
Other	1113	4.5	1605	2.9
Missing	3	0.0	750	1.3
Design				
Fixed (total)	16,113	64.4	48,683	86.6
Unknown	0.0	0.0	316	0.6
CR	15,234	60.9	16,649	29.6
PS	879	3.5	31,718	56.4
Rotating platform (total)†	8803	35.2	5413	9.6
LCS and LCS Complete	8255	33.0	1074	1.9
CR	1	0.0	730	1.3
PS	90	0.4	3609	6.4
Other	457	1.8	0.0	0.0
Unknown	57	0.2	669	1.2
Other (hinged)	31	0.1	1443	2.6
Total knee arthroplasty resurfacing	23,677	94.7	961	1.7

*CR = cruciate retaining, PS = posterior stabilized, LCS = low contact stress. †Tibial components not shown as they are almost identical to femoral components. ‡Manufacturer's information: Genesis I (Smith & Nephew, London, United Kingdom), Duracon (Stryker Howmedica Osteonics, Kalamazoo, Michigan), Genesis II (Smith & Nephew, Memphis Tennessee), E-motion (B. Braun-Aesculap, Tuttlingen, Germany), and Natural Knee II (Zimmer, Warsaw, Indiana).

Data Collection

All data are reported to the Norwegian Arthroplasty Register by the orthopaedic surgeon, who completes the same standard paper form for each primary or revision arthroplasty (but with separate forms used for hip replacements and for replacements of joints other than the hips)[15]. Similarly, operative data are documented by the surgeon at the point of care in the Kaiser Permanente Total Joint Replacement Registry. In addition to operative forms, preoperative and postoperative ambulatory encounters are also captured with use of electronic forms in the Kaiser Permanente Total Joint Replacement Registry. These forms are then supplemented with additional data elements from the electronic medical record of the patients[13]. The Norwegian Arthroplasty Register and the Kaiser Permanente Total Joint Replacement Registry collect similar data elements, including patient demographics, implant names and attributes, surgical techniques, revisions, and reasons for revisions. Some differences in documentation exist. For example, American Society of Anesthesiologists (ASA) classification in the Norwegian Arthroplasty Register is assigned by surgeons, whereas in the Kaiser Permanente Total Joint Replacement Registry this classification is determined by anesthesiologists.

Statistical Analyses

Descriptive statistics such as means, standard deviations, and proportions were used to describe the study sample. Chi square, Fisher exact test, and independent t tests were applied to compare demographics, surgical techniques,

TABLE III Reasons for Revision*

	Norwegian Arthroplasty Register (N = 25,004)		Kaiser Permanente Total Joint Replacement Registry (N = 56,208)	
	No.	%	No.	%
Total number of revised cases	850	3.4	1148	2.0
Reason for revision				
Infection	193	22.7	464	40.4
Instability	138	16.2	233	20.3
Pain	342	40.2	212	18.5
Aseptic loosening	269	31.6	143	12.5
Arthrofibrosis	33	3.9	124	10.8
Fracture (tibial and/or femoral)	38	4.5	33	2.9
Wound drainage	0	0.0	21	1.8
Extensor mechanical failure	0	0.0	17	1.5
Osteolysis	2	0.2	18	1.6
Wound dehiscence	0	0.0	15	1.3
Hematoma	0	0.0	15	1.3
Polyliner wear (defect, damaged, or fractured)	23	2.7	17	1.5
Patellofemoral joint malfunction	0	0.0	13	1.1
Ingrowth failure	0	0.0	11	1.0
Component fracture	0	0.0	6	0.5
Malalignment	63	7.4	0	0.0
Dislocation (patellar or nonpatellar)	44	5.2	0	0.0
Other	25	2.9	62	5.4

*Each revision can be associated with more than one reason for revision.

types of implants, revision rates, and reasons for revision arthroplasty. Kaplan-Meier survival curves with revision as the end point were used to compare implant survival from the different registries. Revisions in the Norwegian Arthroplasty Register were defined as reoperations in which implant parts were added, exchanged, or removed, and the date of the first revision (when the procedure involves a two-stage revision) was considered to be the revision date. In the Kaiser Permanente Total Joint Replacement Registry, revisions were defined as a reoperation in which any implant was exchanged and/or added. If a two-stage revision was performed (i.e., the prosthesis was removed during the first operation and a new prosthesis was implanted during the second), the date of the second procedure was considered to be the revision date. If no second operation was performed (for instance, if the patient died after the first procedure or if the second procedure could not be performed for any other reason), then the date of the first-stage revision procedure was considered to be the revision date.

Patients who died, emigrated, left the hospital health plan, or reached the end of the study period without a reported outcome were censored in the survival analyses. SAS software (version 9.1.3 for Windows; SAS Institute, Cary, North Carolina) and SPSS software (SPSS for Windows, release 18.0; SPSS, Chicago, Illinois) were used to analyze the data, with $p < 0.05$ used as the statistical threshold.

Results

The study consisted of 25,004 primary total knee arthroplasties performed in Norway and 56,208 primary total knee arthroplasties performed at Kaiser Permanente. During the study period, 9.1% of the patients died and 0.2% of the patients were lost to follow-up in the Norwegian cohort. Within the Kaiser Permanente Total Joint Replacement Registry cohort, 3.4% of the patients died and 7.5% of the patients left the Kaiser Permanente health plan during the study period.

Patient Characteristics and Diagnosis

Comparisons of patient demographics indicated that the Norwegian total knee arthroplasty patients were older ($p < 0.001$), had a lower proportion of osteoarthritis as a diagnosis ($p < 0.001$), and had lower ASA scores ($p < 0.001$) as compared with the Kaiser Permanente patients (Table I). Kaiser Permanente also had a significantly higher proportion of male patients who received total knee arthroplasty than Norway ($p < 0.001$).

Fixation and Implant Type

Implant fixation differed between Norway and Kaiser Permanente, with a significantly higher rate of uncemented total knee arthroplasty fixation in the Kaiser Permanente Total Joint Replacement Registry ($p < 0.001$) (Table II). The types of femoral components also differed between Norway and Kaiser Permanente. In Norway, Profix (Smith & Nephew, London, United Kingdom) (37%), Low Contact Stress (LCS, DePuy Orthopaedics, Warsaw, Indiana) (12.8%), LCS Complete (DePuy Orthopaedics) (20.6%), and AGC (Biomet, Bridgend, South Wales,

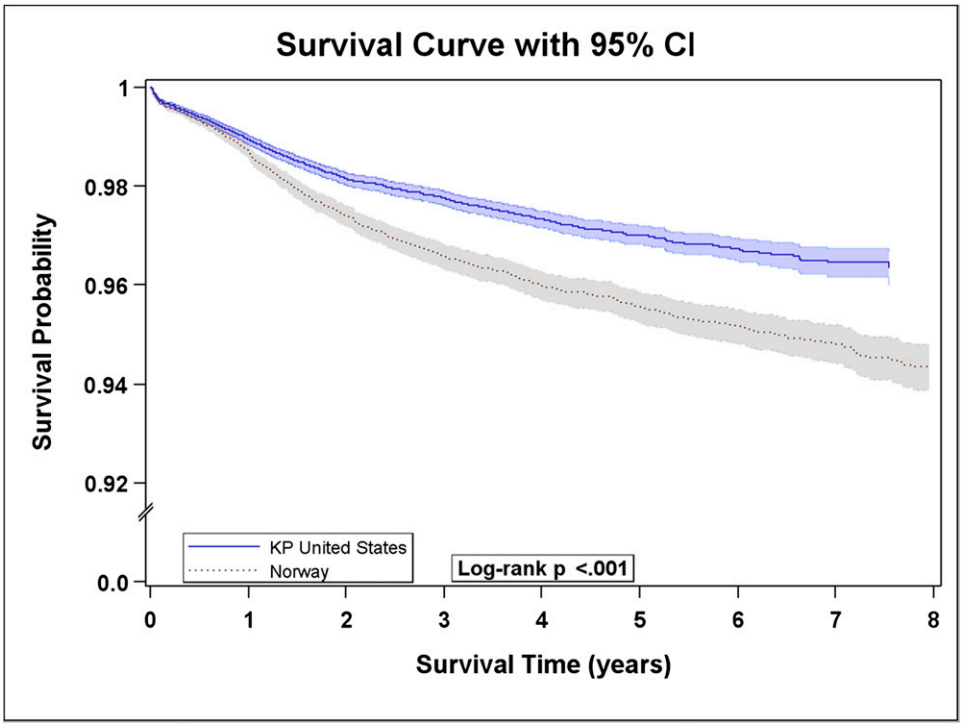

Fig. 1
Overall prosthesis survival and 95% confidence intervals after total knee arthroplasty, with revision for any reason as the end point. KP = Kaiser Permanente.

United Kingdom) (11.6%) accounted for the majority of total knee arthroplasty implants, while Press-Fit Condylar (PFC, DePuy Orthopaedics) (48.0%) and NexGen (Zimmer, Warsaw, Indiana) (39.0%) were the primary implants used at Kaiser Permanente.

The use of mobile-bearing total knee prostheses also differed between Norway and Kaiser Permanente. A low-contact-stress design was used in 33% of the total knee arthroplasties in Norway, and mobile-bearing knees were used in 35% of the knees. In the Kaiser Permanente Total Joint

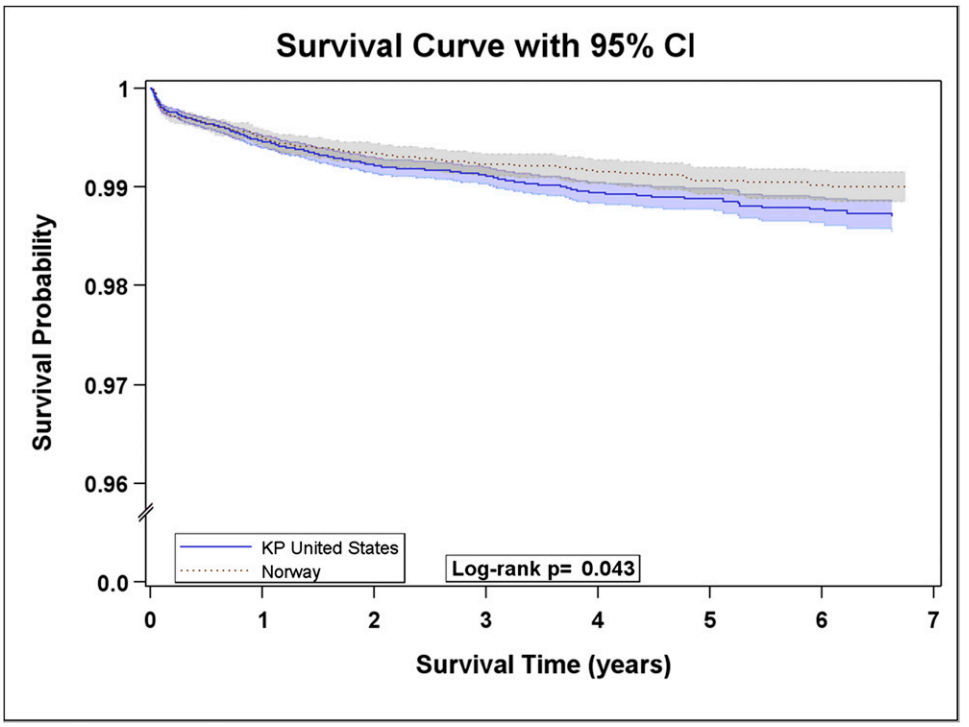

Fig. 2
Overall prosthesis survival and 95% confidence intervals after total knee arthroplasty, with revision for infection as the end point. KP = Kaiser Permanente.

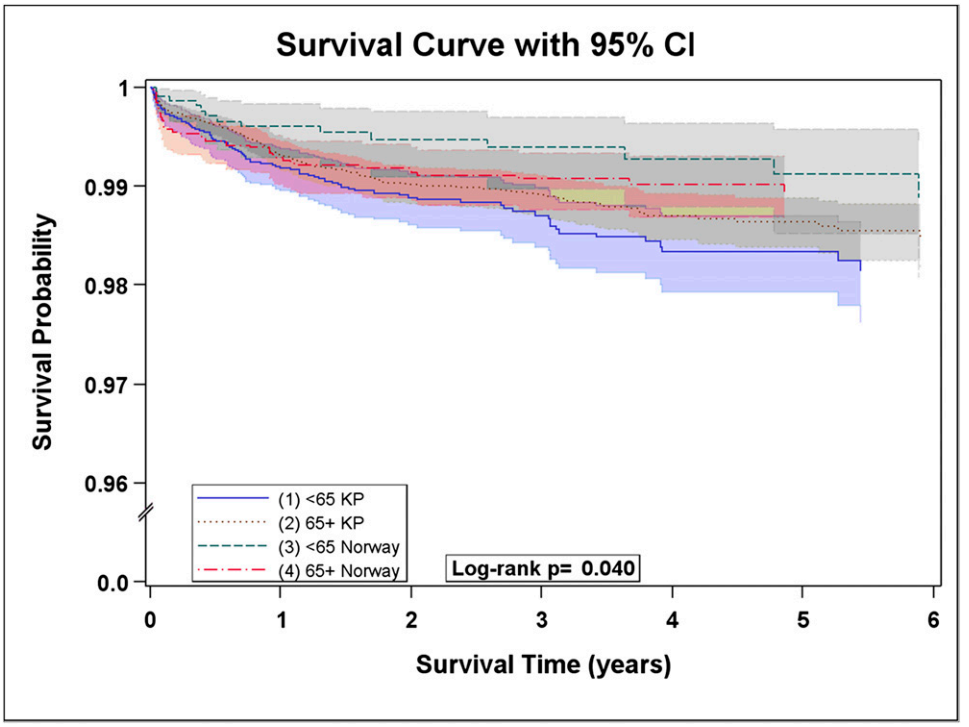

Fig. 3

Prosthesis survival and 95% confidence intervals after total knee arthroplasty, with revision for infection as the end point, by age group in men whose primary diagnosis was osteoarthritis. KP = Kaiser Permanente.

Replacement Registry, mobile-bearing knees represented 9.6% of total knee arthroplasty implant usage, with the majority of implants being the PFC-Rotating Platform implant.

The use of cruciate-retaining or substituting fixed-bearing total knee arthroplasty knee implants differed between Norway and Kaiser Permanente. The majority of fixed-bearing total knee arthroplasty implants used in Norway were cruciate-retaining implants (60.9% versus 3.5%), whereas a posterior-stabilized design was used in the majority of Kaiser Permanente patients (56.4% versus 29.6%), $p < 0.001$.

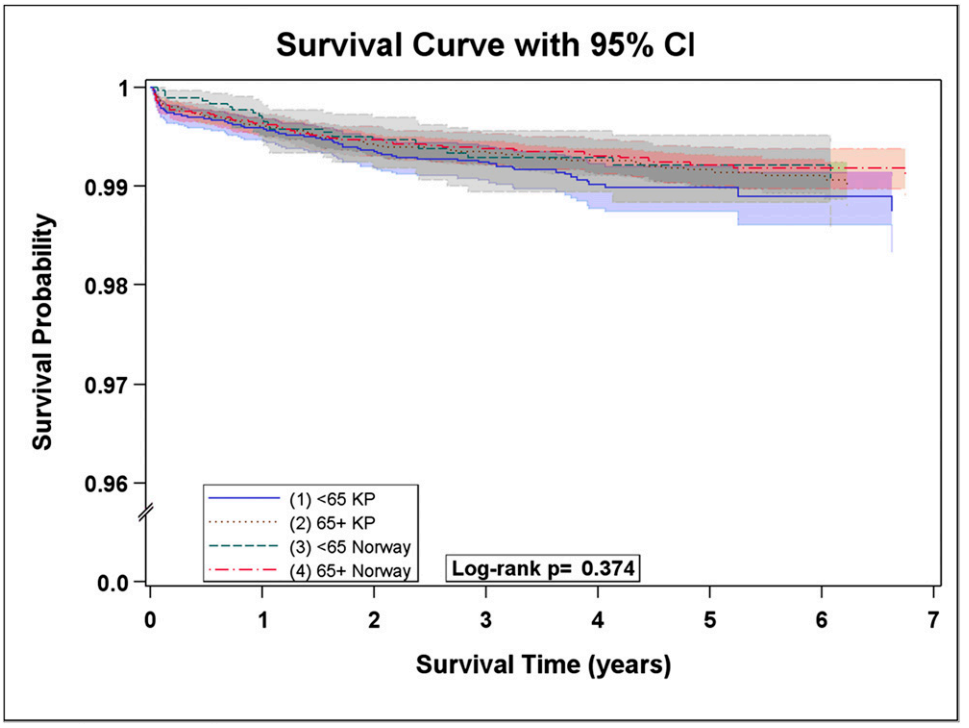

Fig. 4

Prosthesis survival and 95% confidence intervals after total knee arthroplasty, with revision for infection as the end point, by age group in women whose primary diagnosis was osteoarthritis. KP = Kaiser Permanente.

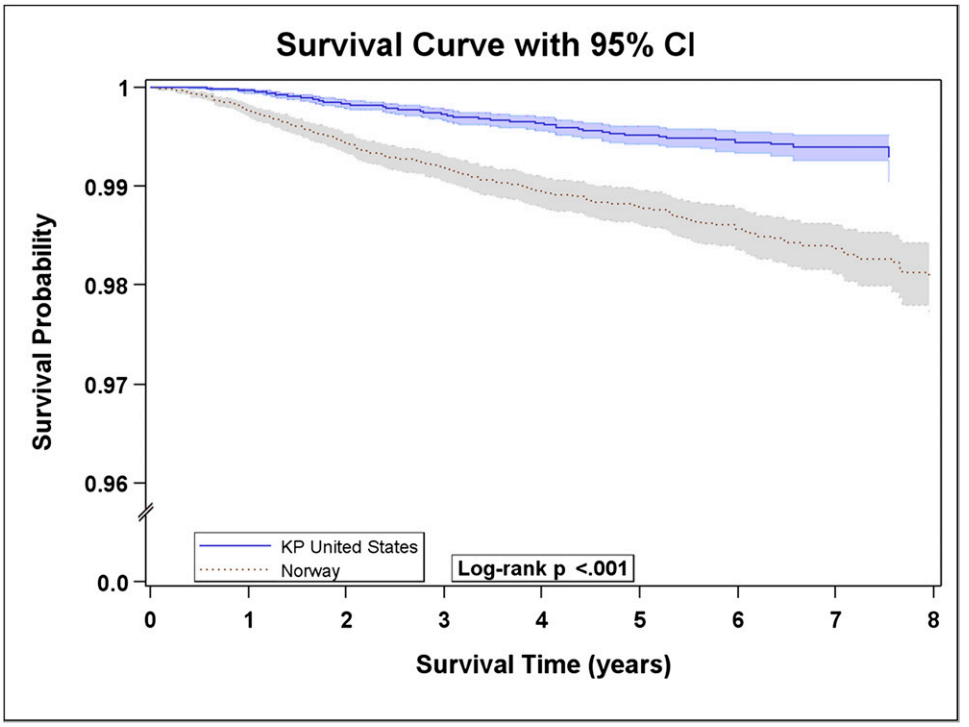

Fig. 5
Overall prosthesis survival and 95% confidence intervals after total knee arthroplasty, with revision for aseptic loosening as the end point. KP = Kaiser Permanente.

In comparing patellar resurfacing, there was also a significant difference in practice between Norway and Kaiser Permanente. While 94.7% of total knee arthroplasties were performed without resurfacing of the patella in Norway, 98.3% of total knee arthroplasties were performed with patellar resurfacing at Kaiser Permanente.

Operative Time

Mean operative time and standard deviation (from the time of the first incision to the time of completion of skin closure) for total knee arthroplasties was slightly higher for the Kaiser Permanente patients compared with the Norwegian patients (96.4 min ± 33.3 versus 95.5 min ± 31.8, $p < 0.001$).

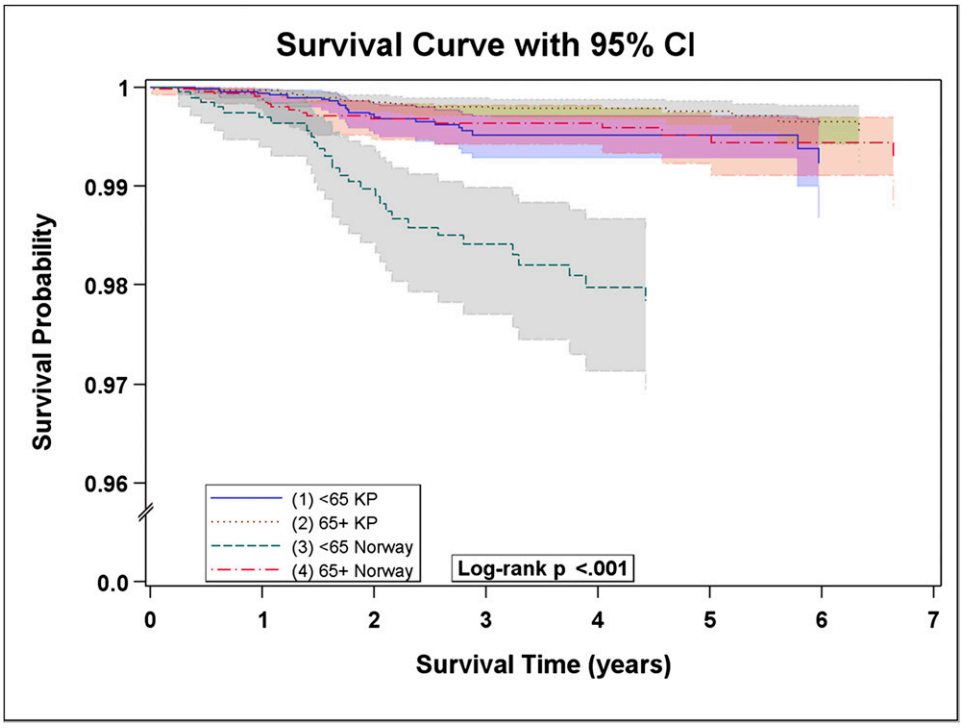

Fig. 6
Prosthesis survival and 95% confidence intervals after total knee arthroplasty, with revision for aseptic loosening as the end point, by age group in men whose primary diagnosis was osteoarthritis. KP = Kaiser Permanente.

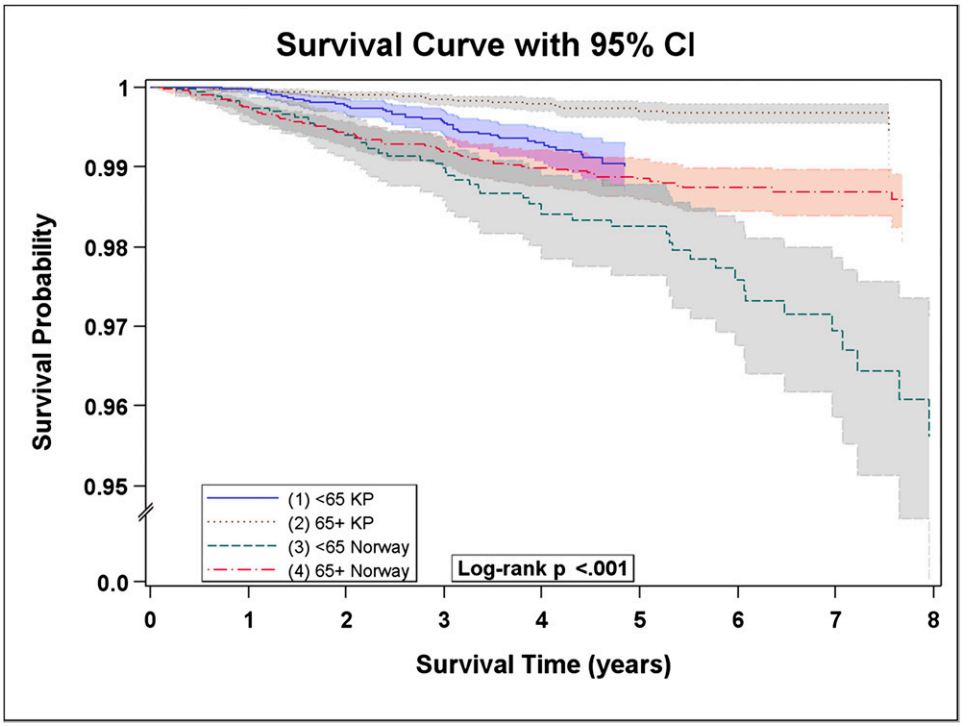

Fig. 7
Prosthesis survival and 95% confidence intervals after total knee arthroplasty, with revision for aseptic loosening as the end point, by age group in women whose primary diagnosis was osteoarthritis. KP = Kaiser Permanente.

While this difference is significant, clinical significance is questionable.

Revision Rates and Reasons for Revision

The overall cumulative survival of total knee implants at seven years was 94.8% (95% confidence interval [CI], 94.4% to 95.2%) for Norway and 96.3% (95% CI, 96.0% to 96.6%) for Kaiser Permanente. For aseptic loosening, cumulative survival was lower for Norway than for Kaiser Permanente. While cumulative total knee implant survival was higher for Kaiser Permanente when aseptic loosening was used as the end point, Norway had a higher cumulative survival when infection was

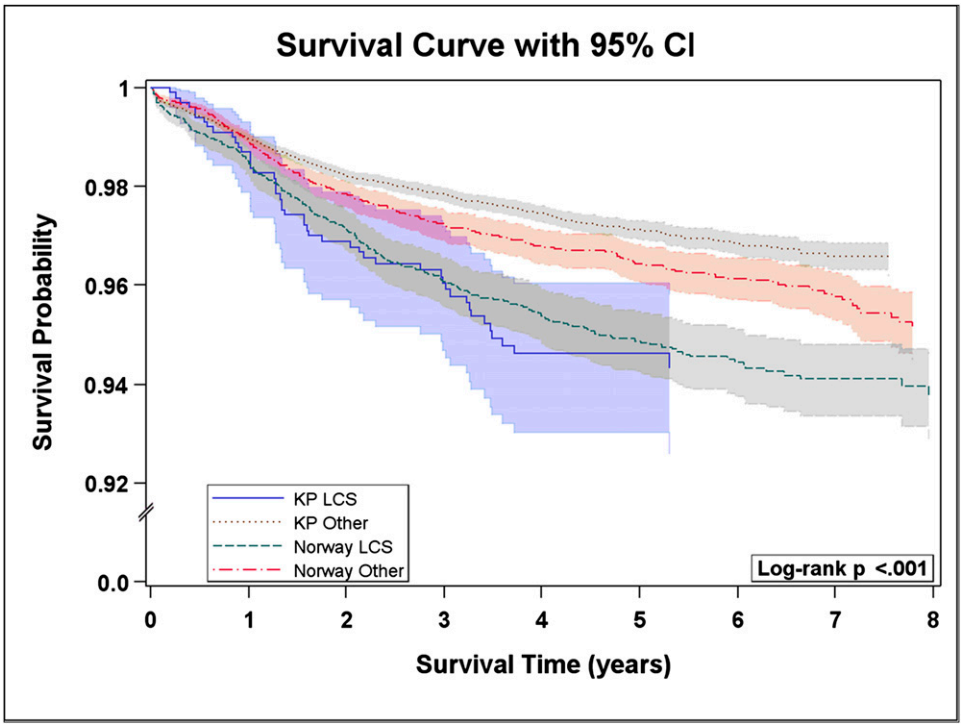

Fig. 8
Overall survival of the prosthesis (by implant type—LCS or other) and 95% confidence intervals after total knee arthroplasty, with revision for any reason as the end point, in patients whose primary diagnosis was osteoarthritis. KP = Kaiser Permanente.

used as the end point. Comparisons of specific implants indicated that the LCS was associated with a higher revision rate for both Kaiser Permanente and Norway (Figs. 1 through 8).

Reasons for revision during the study differed between Kaiser Permanente and Norway (Table III). While total knee arthroplasty revisions due to infection were more common in the Kaiser Permanente patients than in the Norwegian patients ($p < 0.001$), pain was the most common reason for total knee arthroplasty revision in Norway ($p < 0.001$). Aseptic loosening as a reason for revision arthroplasty was more common in the Norwegian patients than it was in the Kaiser Permanente patients ($p < 0.001$). Arthrofibrosis as a reason for revision was higher in the Kaiser Permanente patients than it was in the Norwegian patients (10.8% versus 3.9%).

Discussion

Comparisons between the Norwegian Arthroplasty Register and the Kaiser Permanente Total Joint Replacement Registry suggest that these primary total knee arthroplasty cohorts differ with regard to patient demographics, implants, surgical techniques, and survival of the total knee arthroplasty implant. While mean age was similar, distributions were slightly different between Kaiser Permanente and Norway, with patients in the Norwegian Arthroplasty Register being older. Both the Norwegian Arthroplasty Register and the Kaiser Permanente Total Joint Replacement Registry had a predominance of female patients, with the Kaiser Permanente Total Joint Replacement Registry having a slightly higher percentage of male patients compared with that in the Norwegian Arthroplasty Register.

The apparent mild disparity between patients in the Norwegian Arthroplasty Register and patients in the Kaiser Permanente Total Joint Replacement Registry with regard to the prevalence of osteoarthritis as the underlying diagnosis may represent a lag in the demand for total knee arthroplasty for this condition in Norway. Due to earlier adoption of total knee arthroplasty for the treatment of knee osteoarthritis in the U.S., the Kaiser Permanente Total Joint Replacement Registry probably represents a more mature state in which the demand for total knee arthroplasty for the treatment of end-stage arthritis has been met. Such an artifact could skew the findings toward a greater proportion of total knee arthroplasty performed for rheumatoid arthritis and inflammatory arthritis in the Norwegian register[8].

Differences in ASA scores between the Norwegian Arthroplasty Register and the Kaiser Permanente Total Joint Replacement Registry may suggest higher comorbidities in the Kaiser Permanente Total Joint Replacement Registry cohort. With an older patient population, ASA scores would be expected to be elevated in Norway; however, obesity and other comorbidities may be higher in the Kaiser Permanente cohort and may explain the higher ASA scores. The difference in ASA scores could also be accounted for by interreliability issues. In Norway, the surgeon assigns the ASA designation. In the United States, patients are typically classified by anesthesiologists, who may overestimate ASA scores. Studies that have assessed both intrarater and interrater reliability of ASA scores indicate low reliability. Other comorbidity indices, such as the Charlson score[17], may provide more reliable measures of patient comorbidities for future studies.

Several differences in surgical techniques were also observed between the two cohorts. Comparisons of the Norwegian Arthroplasty Register and Kaiser Permanente Total Joint Replacement Registry indicated differences in patellar resurfacing and fixation methods. More than 94% of total knee arthroplasties were performed without resurfacing of the patella in the Norwegian cohort, whereas more than 98% of total knee arthroplasties were performed with patellar resurfacing in the Kaiser Permanente cohort. Many of the revision procedures in the Norwegian cohort were performed for anterior knee pain in patients who had undergone total knee arthroplasty without initial patellar resurfacing. Although these procedures were technically reoperations, the femoral and tibial implants were not revised in those limbs. While Norway and Sweden have similar practices with regard to nonpatellar resurfacing, Denmark, similar to the U.S., has a practice for patellar resurfacing[8]. In Norway, the functional status and revision rate associated with patellar resurfacing and nonpatellar resurfacing total knee arthroplasty was investigated and no difference was encountered, which may serve as an explanation for the low use of patellar resurfacing in that country[18,19]. A slightly higher revision rate in nonresurfaced knees might be explained by the option of adding a patellar component in nonresurfaced knees[19].

In addition to differences in surgical techniques, we also observed differences in implant selection between the two cohorts. There was significant variation in the types of implant used in each country, with few implants overlapping between the cohorts. Implant designs also differed, with mobile-bearing total knee prostheses implanted at a higher frequency in the Norway cohort than in the Kaiser Permanente cohort. An LCS design was used in more than 33.4% of total knee arthroplasty procedures in the Norwegian cohort. In the Kaiser Permanente cohort, mobile-bearing knees were used in almost 10% of the total knee arthroplasty procedures, with the majority of the prostheses being the PFC posterior-stabilized (PS) implant. Initial results suggest that the LCS was associated with a higher revision rate in both registries. A more in-depth assessment of these mobile-bearing implants is planned as part of the International Consortium of Orthopaedic Registries (ICOR) initiative.

The use of cruciate-retaining or cruciate-substituting fixed-bearing total knee arthroplasty knee designs also differed between the Norwegian Arthroplasty Register and the Kaiser Permanente Total Joint Replacement Registry. The majority of fixed-bearing total knee arthroplasty procedures in Norway involved cruciate-retaining implants, whereas, in the Kaiser Permanente system, a posterior-stabilized design was used in the majority of cases. There has long been a debate on the merits of each design, and this debate cannot be addressed within this observational study due to the low number of cases in which a posterior-stabilized design was used in Norway.

TABLE IV Thromboembolism Prophylaxis by Registry*

	Norwegian Arthroplasty Register (N = 16,066)†		Kaiser Permanente Total Joint Replacement Registry (N = 56,208)	
	No.	%	No.	%
Prophylaxis given†				
Yes, medication started preoperatively	7855	48.9	NA	NA
Yes, medication started postoperatively	5647	35.1	NA	NA
Yes, missing when medication started	2278	14.2	NA	NA
No prophylaxis	43	0.3	NA	NA
Unknown	243	1.5	NA	NA
Type of prophylactic medication‡				
Fragmin (dalteparin)	8562	53.3	NA	NA
Klexane (enoxaparin)	6882	42.8	NA	NA
Other	292	1.8	903	1.6
Coumadin	NA	NA	19,094	34.0
Aspirin (acetylsalicylic acid)	NA	NA	8116	14.4
Anti-inflammatory medication	NA	NA	1357	2.4
Low-molecular-weight heparin	NA	NA	21,092	37.5
Arixtra (fondaparinux)§			1568	2.8

*NA = not applicable. †Data are with regard to primary total knee arthroplasty only. Started data collection in 2005. ‡Started data collection in 2005. §Note: In the Kaiser Permanente Total Joint Replacement Registry, data regarding use of Arixtra started being collected in a separate data field in 2010.

Cumulative Survival of Total Knee Implants and Reasons for Revision

Differences in patient characteristics were controlled for by stratification on key variables to assess the survival of total knee implants. Similar to the findings of Kurtz et al.[10], the overall cumulative survival of total knee implants was higher in the Kaiser Permanente cohort than it was in the Norwegian cohort. However, in assessing infection as the end point, a higher cumulative survival rate was observed for the Norwegian total knee implants. Identification of knee infections after total knee arthroplasty may be underreported in the Norwegian registry, however, since only the reoperations in which an implant is removed or exchanged are identified. The AGC implant was used in approximately 10% of total knee arthroplasty procedures in Norway. Knee infections after AGC total knee implantation might not be captured in the data as deep infection, even though an operative irrigation and debridement is performed. The reason for this is that AGC monoblock tibial components do not have an exchangeable tibial liner, and thus this surgical procedure would not be categorized as a revision procedure. Within the Kaiser Permanente organization, a comprehensive infection surveillance protocol with chart review captures occurrence of deep infection whether a revision was performed or not. Another potential explanation is the difference in the use of antibiotic-loaded bone cement. While antibiotic-loaded bone cement has not been shown to reduce infection rates in U.S. patients after primary total knee arthroplasty[20,21], the use of antibiotic-loaded bone cement was substantially different between the two cohorts in our study. Antibiotic-loaded bone cement was used in 100% of the Norwegian primary total knee arthroplasties, but only in 12% of primary total knee arthroplasties in the Kaiser Permanente cohort. The main reason for the high use of antibiotic-loaded bone cement in Norway is because a lower rate of revisions due to infections was found after total hip replacement in a Norwegian cohort when antibiotic-loaded bone cement was used[22]. The infection rate was also shown to be lower after total knee arthroplasty in a Finnish cohort of patients in whom antibiotic-loaded cement was used[23,24]. In both registries (Kaiser Permanente and Norway), intravenous prophylactic antibiotics are routinely administered to all patients undergoing total knee arthroplasty (Table IV). Additional analyses are necessary to identify the underlying source of these differences in infection.

Revision arthroplasty surgery is considered to be an important outcome in the surveillance of primary total knee arthroplasty procedures by both registries. Interpretation of revision rates, however, must be interpreted with care because of differences in "community standards" in Norway and the United States. These important differences include the proportion of total knee arthroplasty procedures that are performed without resurfacing the patella and the use of unicompartmental knee replacements. Differences in data collection methods and definitions are also critical to the interpretation of study findings.

Strengths and Limitations of the Study

This study has several strengths and limitations. The strengths of the study include the large sample sizes from established

registries with prospectively collected data and contemporary implants. The limitations include the observational research design, the short to intermediate period of follow-up, and the lack of patient-reported outcomes. Other limitations include the lack of standardization of reporting the diagnosis, the different choices of diagnosis, and the cause of revision on the patient forms. The different number of patients lost to follow-up in the two cohorts might also influence the reported revision rate.

Conclusions

Total joint arthroplasty registries provide an important role in post-market surveillance of total knee arthroplasty implants. The comparisons made between the Norwegian knee arthroplasty register and the Kaiser Permanente registry highlight important similarities and differences between the outcomes of total knee arthroplasty, and the surgical practices, in each country. This study also emphasizes the need to address regional and national differences in demographics, surgical techniques, implants, and definitions in order to compare results across existing registries.

Understanding the differences in surgical practices was recognized as an important factor in the interpretation of the data. We have identified areas of interest for focused analyses and hope to expand this collaboration. Development of collaborations via a global network of international registries such as ICOR will require development of structured common data elements, convergence of definitions for outcomes, recognition of differences in patient populations and surgical practices, and facilitation of the removal of regulatory and legal obstacles to enhance future orthopaedic research efforts. ■

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