The Swedish Knee Arthroplasty Register 1975–1997

An update with special emphasis on 41,223 knees operated on in 1988–1997

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ABSTRACT – From 1975, when the Swedish Knee Arthroplasty Register (SKAR) started, until the end of 1997, 57,533 primary arthroplasties and revisions have been registered. Recently, the register underwent a comprehensive validation and update regarding revisions.

We now report on general demographic and epidemiological data for the whole period and on the survivorship of arthroplasties performed in Sweden during 1988–1997. During this 10-year period, 41,223 primary knee arthroplasties were performed on 34,877 patients. We found, as in our earlier reports, that survivorship was affected by patient-, time-, implant- and method-related factors but, apart from an overall higher cumulative revision rate, general conclusions reported from the register in recent years appeared to be unaffected.

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The Swedish Knee Arthroplasty Register (SKAR) was started in 1975 (Bauer et al. 1980, Robertsson et al. 2000). The register is used for a prospective on-going study of prosthetic revision rates, and has been extensively documented since the start with reports made at national and international meetings and in scientific journals. The latest major survey was published in 1994 regarding results of the period 1976–1992, (Knutson et al. 1994). In 1997, the register was validated and updated by questionnaires, cross-checking with other registers and study of relevant medical charts, which improved the routines regarding follow-up of revisions by use of the official Patient Administrative System (PAS) (Robertsson et al. 1999). At that update, one fifth of the revisions had not been reported, which he led to an underestimate of the overall revision-rate. However, after the update, we concluded that 94% of the revisions performed had been accounted for. Since then we have used the PAS to find further missing revisions performed during 1996–1997.

In this report, we present an update of the register regarding demographic data and survivorship, with special reference to previously reported results.

Patients and methods

Over the years, and especially during the first years of the Register, patient selection, operative technique, material and implant design changed. As a result, the cumulative risk for patients undergoing revision gradually declined (Lewold et al. 1993). Therefore, for cumulative revision rates (CRR) and risk-ratios (RR) of presently used methods, the survivorship analyses were generally limited to operations done during the 10-year period 1988–1997. For the demographic and epidemiological analyses, the whole period 1975–1997 was included.

41,223 primary arthroplasties, performed during the years 1988–1997, were reported to the SKAR by participating units. Of these, 1,902 had been revised by the end of 1997 and they formed the basis for survival statistics. As osteoarthrosis (OA) accounted for 85% of all primary knee arthroplasties performed and rheumatoid arthritis (RA) for 11% (Table 1), the revision analyses were confined to patients having these diseases with a true revision defined as a reoperation during which one or more components were added, exchanged or removed (including amputation and arthrodesis).

Table 1. Distribution of 41,223 primary knee arthroplasties in 1988–1997 according to mean age, gender and diagnosis

	OA			RA			Posttraum. OA			Other			Total		
	n	%	Age	n	%	Age	n	%	Age	n	%	Age	n	%	Age
Women	23,210	66	72	3,411	76	66	466	58	68	525	69	70	27,612	67	71
Men	11,953	34	71	1,084	24	66	343	42	64	231	31	64	13,611	33	71
Total	35,163		72	4,495		66	809		66	756		68	41,223		71

When describing indications for and type of revision surgery during 1988–1997, all 3,198 revisions done during this period were included, even if the primary operation had been performed earlier.

Statistics

The end-points used for survival statistics after primary arthroplasty were as follows: 1) when analyzing overall revision rates, the end-point was the first true revision done for any reason, 2) when analyzing the revision rate for loosening, it was also the first true revision, but only if loosening was the reason stated as the indication for the revision, and 3) when analyzing infection, the end-point was defined as revision for infection, whether or not this was the first or a later revision. Unrevised patients alive by the end of 1997 were classified as successful cases while deceased unrevised persons were classified as withdrawals at the time of death.

When analyzing the secondary revision rate after a primary revision, the end-point was the first re-revision for any reason.

CRR-curves were produced using the life table method at monthly intervals. The confidence intervals were calculated, using the Wilson quadratic equation with Greenwood and Peto effective sample-size estimates (Dorey et al. 1993). Curves were cut-off when 40 knees remained at risk.

For significance level calculations, Cox regression was used, allowing for adjustment for differences in age, gender, and time of operation. When comparing categories (e.g., diagnosis), a reference category (e.g., OA) was defined as having a relative risk of 1. The risk for other categories (e.g., RA) was measured relative to the reference category and expressed as risk ratio (RR). For continuous variables, the relative risk relates to the change in risk if the variable increased by 1 unit (e.g., increase of 1 year in mean age or 1 calendar year). CI are 95% confidence intervals.

The covariates used in the regression were year of operation, age at operation, gender and the factor of interest (if it was not one of the previous covariates). A p-value of < 0.05 was considered significant.

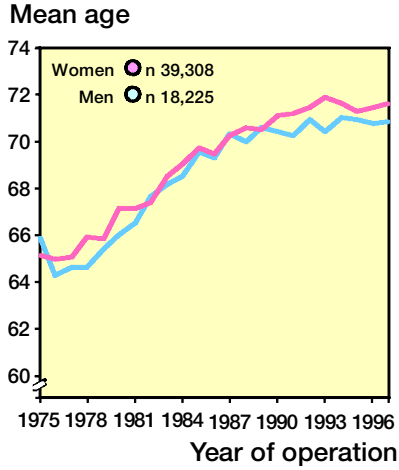

Figure 1. Mean age at operation for primary knee arthroplasties in 1975–1997. The increase in mean age was mainly caused by an increased incidence in the elderly.

Results

Age and gender

Since 1975, the mean age at primary operation has increased in both sexes (Figure 1). This was mainly caused by an increased incidence in the elderly (Figure 2) and only partly by changes in the age profile of the population. Women accounted for 68% of the operations with an almost constant sex ratio over the years. The difference in age specific incidence between the sexes decreased with age. In patients younger than 45 years, the incidence in men was 39% of that of women, increasing

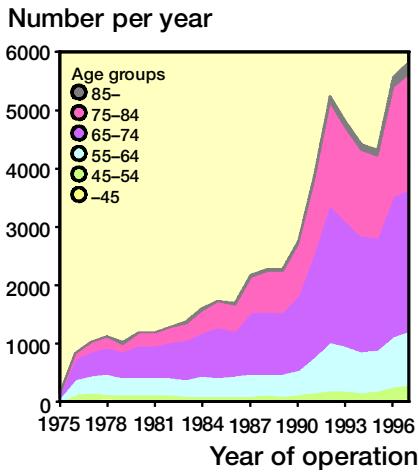

Figure 2. Annual number of knee arthroplasties divided into 10-year age groups. The increase in the elderly is only partly caused by changes in the age profile of the population.

to an equal incidence in patients over 85 years. This was mainly caused by the number of operations for RA with a female/male ratio of 3:1, which decreased with age from 68% of operations in patients younger than 45 years to 4.5% in patients over 85 years.

We found that the higher the age of the patients at the primary operation, the lower the overall revision rate (Figure 3). The same was found if the revision was for loosening (Figure 4), but not for infection.

The overall CRRs after TKA (total knee arthroplasty) and UKA (unicompartmental knee arthroplasty) were similar in both sexes for OA while in RA, men had a higher CRR (Figure 5). A similar trend (but not significant) was found if the end-point was revision for loosening, while the CRR with infection as an end-point was generally higher in men than in women (Figure 6).

Primary disease

Since 1975, the annual number of primary knee arthroplasties for OA increased greatly while the number of arthroplasties for other conditions such as RA and posttraumatic conditions remained unchanged (Figure 7). In patients younger than 55 years, RA was the commonest indication while OA was commonest in patients 55 years or older. Posttraumatic conditions were commoner in the younger age groups. The overall CRRs after TKA for OA and RA in 1988–1997 were similar (Figure 5). However, the mean age of patients with RA was 7 years lower than in those with OA (Table 1). When age was taken into account in the Cox regression together with gender and year of operation, we found that OA patients ran 1.3 times (CI 1.1–1.6, p = 0.003) the risk of RA of revision for any reason whatever (1.7 for loosening; CI 1.2–2.5 p = 0.005). However, the risk of revision for infection was higher for RA than OA (RR 1.4; CI 1.1–1.9, p = 0.03).

The use of UKA in RA has declined with only 114 operations registered during 1988–1997. They had 3.1 times (CI 2.2–4.3, p < 0.001) the risk of UKA patients with OA of being revised, mainly

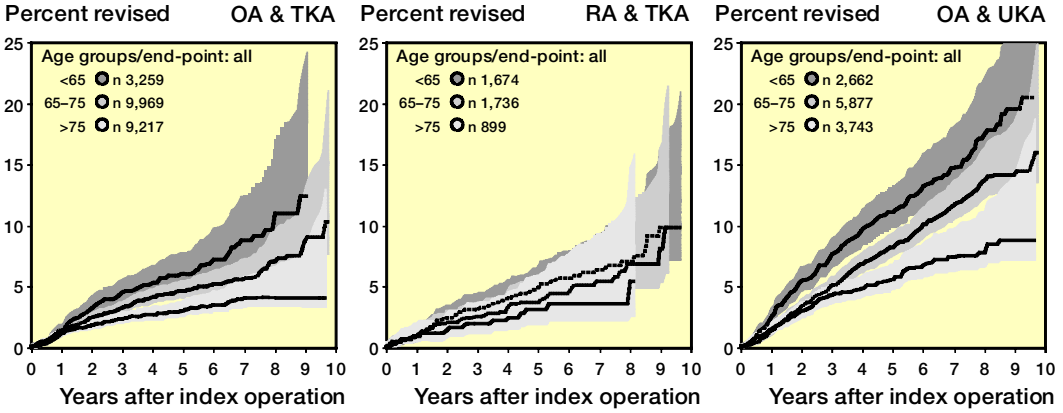

Figure 3. Cumulative revision rate (CRR) for primary arthroplasties performed in 1988–1997, with first revision for any reason as end-point. Patients less than age 65 (dark grey), 65–75 (grey) and older than 75 (light grey) were compared. The reduction in CRR with age was not significant in TKA for RA.

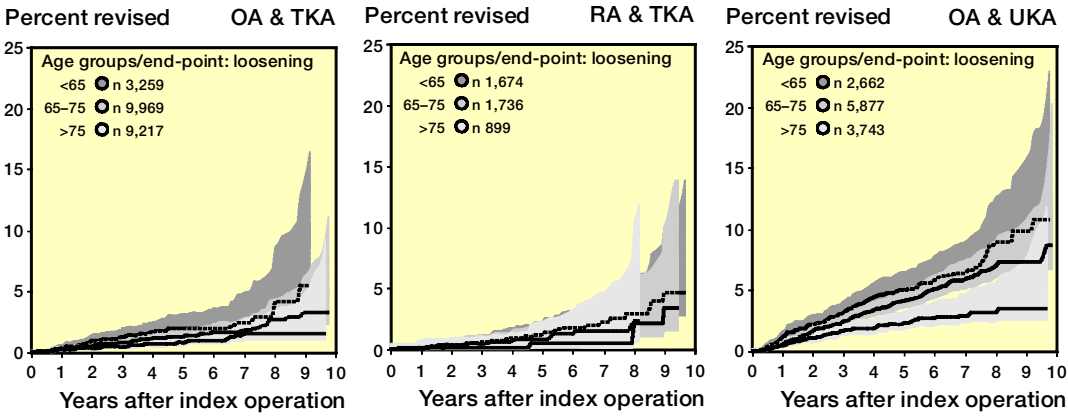

Figure 4. CRR for primary arthroplasties performed in 1988–1997, with a first revision for loosening as end-point. The reduction in CRR with age was not significant for TKA in RA.

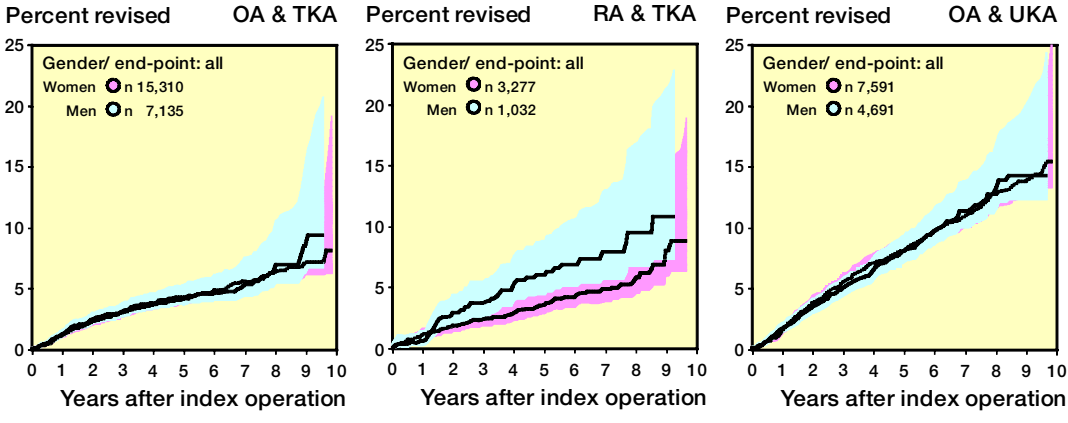

Figure 5. CRR for primary arthroplasties performed in 1988–1997, with a first revision for any reason as end-point. Women (red) and men (blue) were compared. A higher CRR in men was significant for RA alone (RR 1.5; p = 0.01).

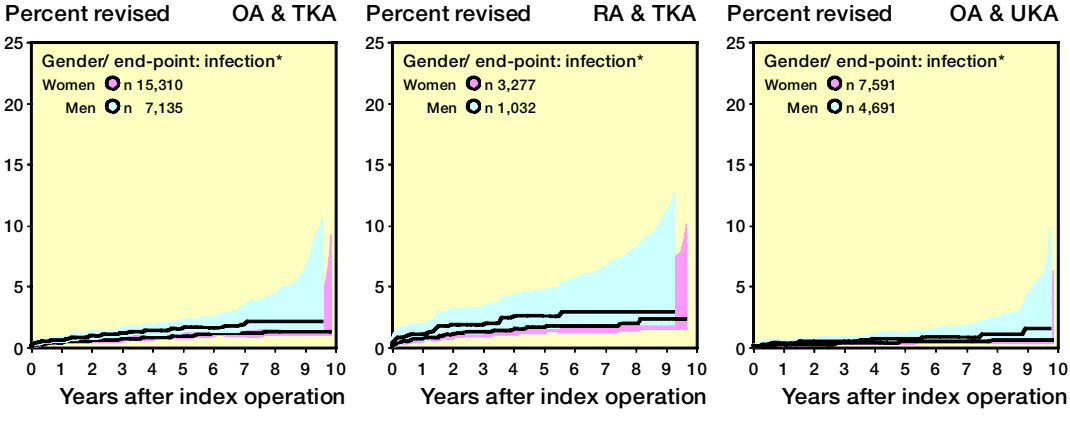

Figure 6. CRR for primary arthroplasties performed in 1988–1997 with revision for infection as end-point. Women (red) and men (blue) were compared. Men had a higher CRR.

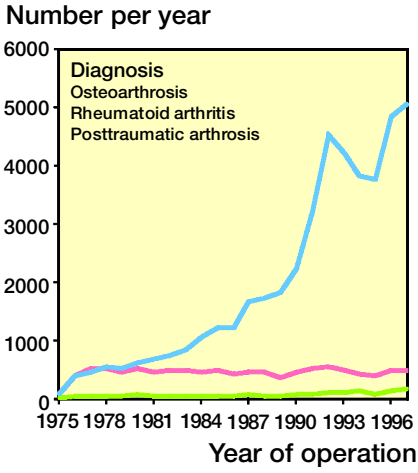

Figure 7. Annual number of arthroplasties.

because of progress of the disease affecting the remaining compartments.

Effect of year of operation on surgical results

From the start of the Register, the overall CRR after TKA has fallen significantly over the years (Figure 8). Cox regression with the year of operation as a continuous variable (not periods), taking into account the age and gender of patients, showed that in TKA for both OA and RA, the mean yearly reduction in risk of revision during 1976–1997 was 7% (CI 6–8%; $p < 0.001$), the reduction being greatest during the first years. The main reasons were reductions in the risk of revision for loosening (11%, CI 8–14%; $p < 0.001$) and for infection (7%, CI 4–9%, $p < 0.001$) (Figure 9).

Reduction in overall CRR with the time of surgery was not seen after UKA ($p = 0.7$), in which revision for loosening increased for a period in the late 1980s (Figure 10), and in which revision for infection was low from the start and did not change.

Implant type

In recent years, TKA has become the main arthroplasty type for RA, while UKA still account for one fifth of the OA implants (Figure 11). Bilateral UKA (unicompartmental prostheses in both femoro-tibial compartments of the same knee) are not performed any more. Hinged and linked prostheses, rarely used in primary arthroplasties, are still used in revision surgery.

For the period 1988–1997, in primary arthroplasty for OA, UKA had a higher CRR than TKA (RR 1.7; CI 1.5–1.9; $p < 0.0001$). However, the risk of becoming revised for infection was 2.3 times higher (CI 1.7–3.1; $p < 0.0001$) for TKA than for UKA, making the TKA more prone to arthrodesis and amputation.

Fixation

In the mid-1980s, there was a period when fixation of components without the use of PMMA-cement was popular, but since then, the use of PMMA has steadily increased. During the period 1988–1997, in 4 of 5 TKAs and in almost all UKAs, all the components implanted were cemented. In TKA,

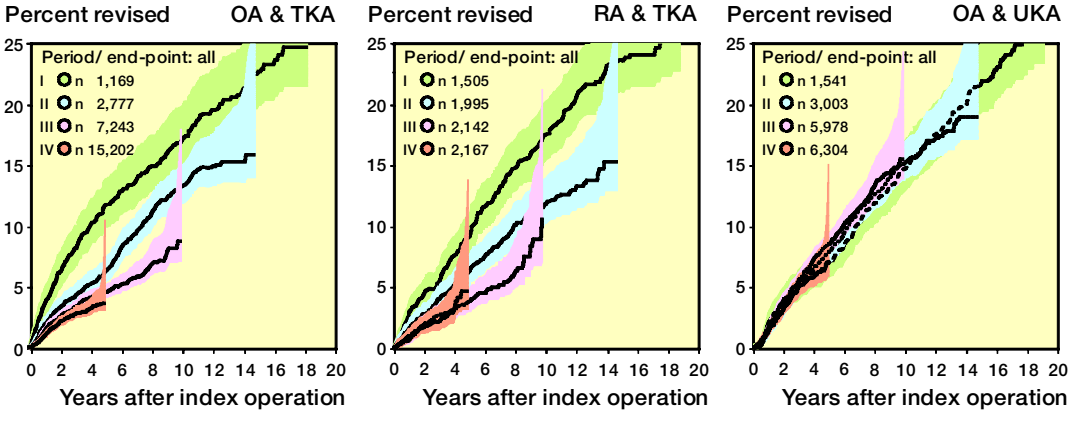

Figure 8. CRR for primary arthroplasties performed in 1978–1997 with first revision for any reason as end-point. We compared arthroplasties performed in 1978–1982 (green), 1983–1987 (blue), 1988–1992 (violet) and 1993–1997 (red). Improvement was seen in TKA alone.

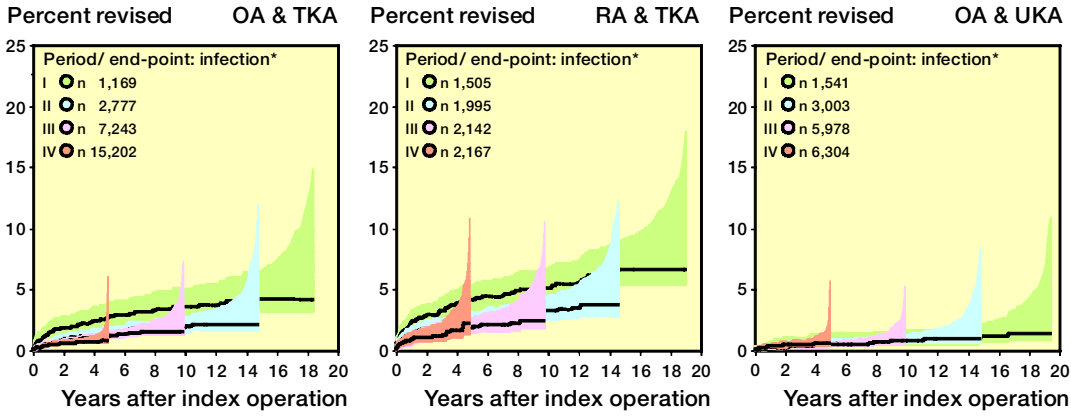

Figure 9. CRR for infection in 1993–1997 was lower in TKA for OA, but only when compared to the earliest period in TKA for RA. For color codes, see Figure 8.

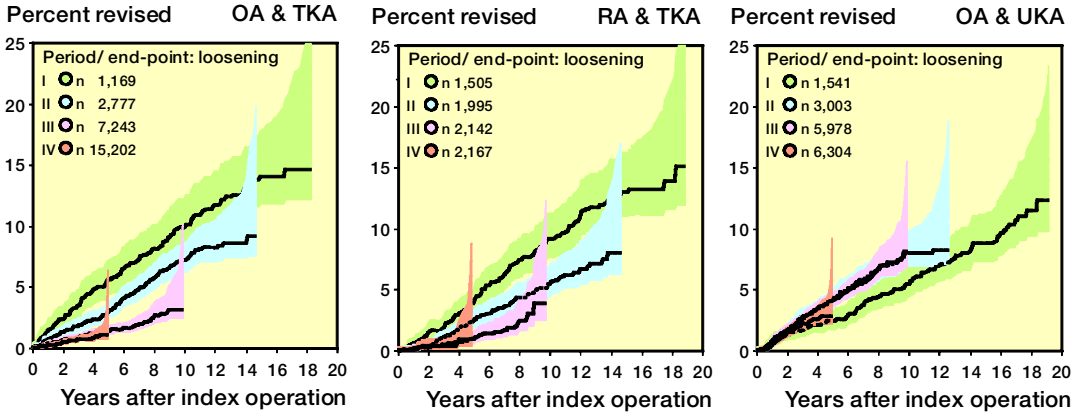

Figure 10. CRR for loosening increased in the 1980s in UKA for OA. For color codes, see Figure 8.

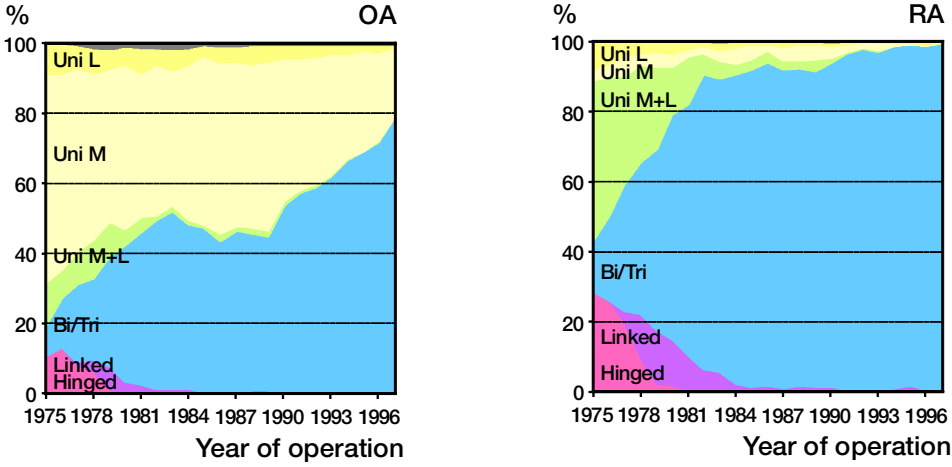

Figure 11. Distribution of arthroplasty types, in relative percentages per year, in OA and RA.

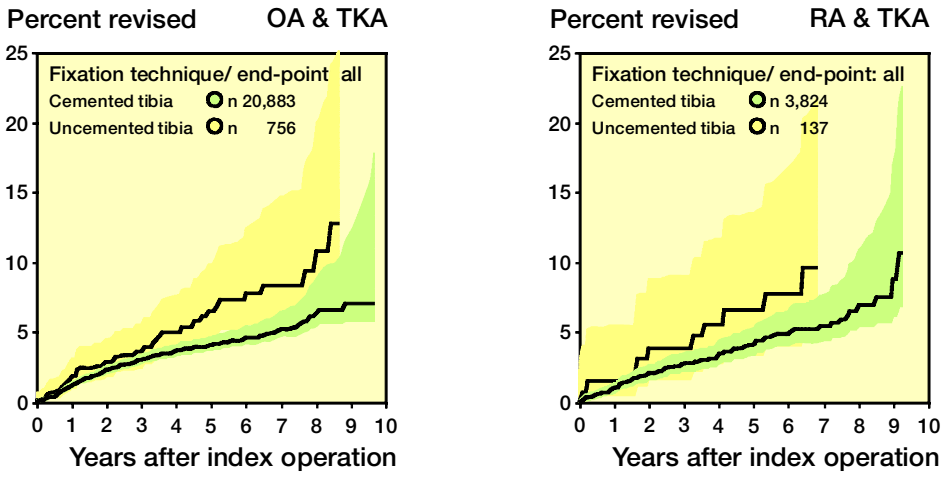

Figure 12. CRR for the uncemented tibial component was significantly higher in TKA for OA (p = 0.04), but not for TKA in RA (p = 0.07).

the patellar and femoral were the commonest components inserted without cement. We found no significant difference in risk of revision, with regard to the cementing of the femoral or patellar components. TKAs with a cement-free tibial component (3.5% of all TKAs) had 1.4 times higher risk of revision than TKAs with a cemented tibial component (CI 1.1–1.9, p = 0.01). When analyzed separately, the difference was significant only in OA (p = 0.04), but not in RA (p = 0.07) (Figure 12).

Patellar replacement in TKA

During the mid-1980s, there was a period when patellar resurfacing was popular in TKA. Patellar replacement was used in more than half of the TKA during 1983–1987, but has since fallen to 1/3 of TKA during 1988–1997.

The overall risk of revision was not significantly affected by patellar replacement (p = 0.2). However, the risk of revision for loosening was 1.9 times higher in the patella resurfaced knees (CI 1.4–2.4, p < 0.001) and thus it seems that the need for secondary patellar replacement in unreplaced knees is balanced by the need for revision of failed patellar components in patellar replaced knees. The risk of revision for infection was not significantly affected by patellar replacement (p = 0.4).

Prosthetic design

Models are classified on the basis of their brand names, and it must be kept in mind that almost all brands have had some minor modifications during the study period. The most commonly registered models for primary arthroplasties during 1988–1997 are listed in Tables 2–4, which also show that in TKA for OA (Table 2), TKA for RA (Table 3) and UKA for OA (Table 4), the most commonly used models were also among those which had the lowest risk of revision. Most evident

Table 2. Commonly used TKA models for primary arthroplasty in OA 1988–1997. Risk ratio with 95% confidence limits as compared to the commonest model (AGC). Cox regression taking gender, year of operation and age of patient into account

	n	Risk ratio for revision Exp(B)	Conf. limits Lower	Upper
AGC	8,339	1.00		
AMK	226	1.78	0.56	5.60
Duracon	1,554	1.05	0.72	1.52
F/S Mk III	2,501	0.94	0.69	1.28
F/S unspec.[a]	781	1.41	1.01	1.97
Kinemax	1,841	0.89	0.63	1.27
LCS	255	1.05	0.49	2.22
Miller-Galante II [a]	754	1.76	1.13	2.72
Miller-Galante unspec.[a]	342	3.10	2.19	4.40
PCA unspec.[a]	556	2.28	1.66	3.12
PCA Modular	619	1.32	0.90	1.92
PFC	1,826	1.16	0.82	1.64
Scan	1,667	1.24	0.91	1.69
Synatomic [a]	253	2.31	1.50	3.55
Other models [a]	930	1.44	1.01	2.06

[a] Implants showing a significant difference in risk ratio

Table 3. Commonly used TKA models for primary arthroplasty in RA 1988–1997. Risk ratio with 95% confidence limits as compared to the commonest model (AGC). Cox regression taking gender, year of operation and age of patient into account

	n	Risk ratio for revision Exp(B)	Conf. limits Lower	Upper
AGC	1,211	1.00		
AMK	24	0.00		
Duracon	183	1.12	0.39	3.22
F/S Mk III	474	1.56	0.85	2.87
F/S unspec	325	1.04	0.55	1.97
Kinemax	290	1.02	0.45	2.32
LCS	27	1.49	0.20	10.9
Miller-Galante II	111	1.55	0.46	5.20
Miller-Galante unspec.[a]	68	2.75	1.15	6.59
PCA Modular	137	1.57	0.72	3.41
PCA unspec	187	1.41	0.71	2.81
PFC	311	1.19	0.52	2.74
Scan	630	0.82	0.44	1.50
Synatomic	59	2.46	0.96	6.31
Other models [a]	269	2.47	1.44	4.24

[a] Implants showing a significant difference in risk ratio

Table 4. Commonly used UKA models for primary arthroplasty in OA 1988–1997. Risk ratio with 95% confidence limits as compared to the commonest model (Link). Cox regression taking gender, year of operation and age of patient into account

	n	Risk ratio for revision Exp(B)	Conf. limits Lower	Upper
Link Uni	4,301	1.00		
Alligretto[a]	228	2.03	1.18	3.50
Brigham	997	1.04	0.75	1.46
Duracon Uni	539	1.41	0.93	2.14
Oxford[a]	906	1.86	1.46	2.35
Marmor/Richards	2,641	1.57	1.30	1.90
Miller-Galante Uni	375	1.66	0.92	3.00
PCA Uni[a]	748	2.97	2.36	3.73
PFC Uni[a]	374	2.50	1.56	4.00
Repicci (AARS)[a]	203	2.25	1.22	4.16
St. Georg	846	1.04	0.77	1.41
Other models[a]	124	2.84	1.40	5.76

[a] Implants showing a significant difference in risk ratio

in OA, TKA models where a major design change was registered, the succeeding implants steadily improved their early CRR. The difference in ranking of implants with respect to RR was similar if only implants in which the tibial component had been cemented were analyzed. We can not say how much of the improvement was due to changes in design as opposed to improvements in surgical technique or changes in patient selection.

Table 5. Indications for primary revisions performed in 1988–1997 showing knees revised before and after 45 months (median) after index arthroplasty

	Early n	Late n	All n	%
Infection	231	86	317	9.9
Loosening	557	854	1411	44.1
Other mech.	158	237	395	12.4
Fracture	15	15	30	0.9
Patella	180	31	211	6.6
Instability	113	70	183	5.7
Progress	253	225	478	14.9
Other	91	82	173	5.4
Total	1598	1600	3198	100.0

Indications for, and types of primary (first) revisions

3,198 primary revisions were performed during 1988–1997 (Table 5) (2,760 TKA for OA and RA and UKA for OA; Table 6) of which one third were revisions of primary arthroplasties performed during 1975–1987. Half of the revisions were done within 4 years of the primary operation. Loosening appeared to be the commonest reason for primary revision, being reported in 44% of all revisions. Primary revisions for infection and patellar problems were more frequent during the first 45 months than later (Table 5).

After a failed primary TKA, revision with a new TKA was commonest (33%). However, partial exchanges and patellar revisions (exchange/removal/addition) were frequent and extraction of the prosthesis or arthrodesis was the first TKA revision in 13% of OA cases and 19% of RA cases.

Failed primary UKA was usually revised to a TKA (75%) while revisions with a new UKA (including additional UKA in the contralateral compartment) were performed in 11% of the UKA. Extraction of the prosthesis or arthrodesis amounted to only 2% of primary revisions after UKA for OA (Table 6).

Re-revision

Only patients with OA, primarily revised because

Table 6. Type of and indications for primary revisions performed 1988-1997 in TKA for OA and RA and UKA for OA

	Index arthroplasty type and diagnosis					
	TKA/OA (n 996)		TKA/RA (n 396)		UKA/OA (n 1368)	
	n	%	n	%	n	%
Revisions						
Hinged	0	0	3	0.8	0	0
Linked	64	6.4	34	8.6	11	0.8
TKA	330	33.1	186	47	1,028	75.1
Partial exch.	219	22	42	10.6	127	9.3
Patella	242	24.3	44	11.1	–	–
New UKA	–			–	85	6.2
Addition	–			–	72	5.3
Extraction	102	10.2	61	15.4	32	2.3
Arthrodesis	25	2.5	14	3.5	2	0.1
Amputation	14	1.4	12	3	11	0.8
Indications						
Infection	147	14.8	85	21.5	49	3.6
Loosening	395	39.7	196	49.5	648	47.4
Other mechan.	115	11.5	33	8.3	206	15.1
Fracture	9	0.9	3	0.8	9	0.7
Patella	148	14.9	27	6.8	17	1.2
Instability	83	8.3	28	7.1	33	2.4
Progress	61	6.1	8	2	317	23.2
Other	38	3.8	16	4	89	6.5

of failures without infection were analyzed as regards the risk of an additional failure with re-revision. The risk of re-revision for a failed primary TKA revised to a new TKA was used to compare risk ratios. This was defined as having a re-revision risk of 1.0.

A failed TKA revised with a partial exchange of components had a RR of 2.8 (CI 1.6–4.8; p = 0.0003). A failed TKA with only a patellar revision had no significantly higher risk (CI 0.8–2.8; p = 0.22).

A failed UKA revised to a new UKA had a RR of 3.7 (CI 2.0–6.7; p < 0.0001). A failed UKA partially revised or with addition of UKA components in the other compartment had a RR of 3.2 (CI 1.9–5.6; p < 0.0001). A failed UKA revised to a TKA ran a similar risk of re-revision as a failed TKA revised to a new TKA (CI 0.6–1.6; p = 0.82). This risk of re-revision after UKA to TKA was higher than the corresponding risk of revision after a primary TKA (had the patients never undergone a UKA) (RR 1.9, CI 1.4–2.4; p < 0.0001). However, in view of the time elapsed and increase in age of the patients since the primary operation, the risk of re-revision was not significantly higher than that of revision, if the patients had been primarily operated on with a TKA at the time when they had their first UKA (RR 1.3, CI 0.9–1.8; p = 0.1).

Discussion

As described elsewhere (Robertsson et al. 1999), a major validation and update of the SKAR resulted in generally higher revision rates than have been reported from the register in recent years (Knutson et al. 1994, Robertsson et al. 1997). However, apart from this generally increased CRR, the outcome and trends reported were minimally affected.

The increase in the number of operations for osteoarthrosis was noted in 1994, and has increased still more since then. It was mainly due to an increase in surgical procedures in older age groups. As previously, younger age was associated with an increased risk of revision. The type of disease leading to arthroplasty affected both the age at which patients were operated on, and the results. In RA patients having generalized multi-joint disease, a

lower activity level and lower life expectancy may be reflected by the lower (age-matched) failure rate, while the increase in risk of having a revision for infection is probably due to the disease, which is systemic and often combined with use of immunosuppressive therapy. The fact that Swedish surgeons have operated on younger RA patients with the same overall results as in older OA patients, suggests that they select patients for arthroplasty on the basis of symptoms as well as chronological age.

Men ran a higher risk than women of undergoing revision for infection, and in RA, men had an overall higher risk of revision. However, in OA, gender did not affect the risk of revision, which differs from findings in hip arthroplasties in Sweden (Malchau et al. 1993).

Since age, gender, and the disease leading to surgery can affect the rate and type of failures, these factors should be taken into consideration when comparing joint implants.

The CRR for TKA has gradually declined during the years, which illustrates the difficulty in comparing published results of different periods. UKA has not improved down the years, which may be due partly to the higher failure rate of some recently introduced UKA implants.

In the early 1970s the types of implants used in Sweden were hinged or linked or unicompartmental prostheses (used in one or both femorotibial compartments) or bicompartmental prostheses (two unicompartmental implants united into a single femoral and tibial component). After the introduction of the total condylar prostheses (TKA), this type soon became more popular since the risk for complications was lower than with the relatively large, constrained hinged and linked prostheses. As it became clear that UKA was unsuitable in multi-compartmental diseases, such as RA (Jonsson 1981, Rand and Ilstrup 1991) or unstable knees (Engelbrecht et al. 1976, Bert 1991), its use declined further. Reports of a higher revision rate of UKA than TKA in Sweden (Knutson et al. 1986, Lewold et al. 1993, Knutson et al. 1994) also made TKA the primary implant-choice for primary arthroplasty in many units.

In comparing the CRR of different implant models, we have taken account of the type of disease, gender, age of patients and year of operation. The CRR varies greatly between different designs. However, the differences observed were not necessarily due to differences in durability. Other patient-related factors, surgical routine and technique may affect the results, as well as the willingness of surgeons to perform a revision (surgical risk, difficulty of revision, bone stock, gain in quality of life). We found that the commonest models in TKA and UKA were among those that ran the lowest risk of revision after accounting for differences in age of patients, gender and year of operation. This, of course, may be implant-related, but other factors, including the increased surgical skill gained by using the same implant routinely must be considered. It should also be remembered that during the years, most implants have undergone at least some minor changes in design. In some cases we could distinguish clearly between older and newer versions (PCA-Duracon), while in others it has been more difficult (Marmor/Richards). Fortunately for TKA, the changes usually seem to have improved the CRR.

In TKA, we found that tibial components inserted without cement fixation ran an increased risk of revision while the risk was not significantly affected by whether or not the patella had been resurfaced. This accords with our previous report (Robertsson et al. 1997). Unlike what has been found for metal-backed patellar components (Petrie et al. 1998), we found no evidence that patellar resurfacing affected the revision rate for infection.

The CRR for UKA was higher than for TKA. However, the failure pattern was different. As in previous studies (Bengtson and Knutson 1991, Knutson et al. 1994), the risk of UKA being revised for infection is substantially lower than with TKA, making it less likely that UKA will require an arthrodesis or amputation. As previously stated (Lewold et al. 1998), a failed UKA is best revised to a TKA. Moreover, if revised to a TKA, the risk of a re-revision was about the same as the risk of revision had they been operated with a TKA in the first place.

Our findings in this study, after an update of the Register, further strengthen the general conclusions previously reported from the SKAR.

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