Mortality after total hip replacement

0–10-year follow-up of 39,543 patients in the Norwegian Arthroplasty Register

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ABSTRACT – We have studied the mortality after total hip replacement (THR) of 39,543 patients, having a mean age of 69 years, who were reported to the Norwegian Arthroplasty Register. The median follow-up time was 5.2 (0–10.4) years. 323 of 6201 deaths occurred during the first 60 postoperative days. The patient mortality was compared with the mortality in the Norwegian population, using standardized mortality ratios (SMR). The SMRs were compared and adjusted for age, gender, and other possible confounders in a Cox regression model incorporating the population mortality.

We observed a lower mortality in patients with THR than in the Norwegian population (8-year patient mortality was 25%, versus 30% in the corresponding Norwegian population. SMR = 0.81). There was an increased standardized mortality ratio in patients less than 50 years (SMR = 2.50), patients 50–59 years (SMR = 1.16), patients with THR due to rheumatoid arthritis (SMR = 1.48), and patients with femoral neck fracture (SMR = 1.11). The SMR decreased with increasing age at the time of THR surgery. After revision surgery, the SMR was similar to that after the first primary operation, whereas a second primary operation in the opposite hip was associated with a further reduction in the SMR (SMR = 0.65). During the first 60 postoperative days, all patient categories had a higher mortality than the general population (0.8% mortality, SMR = 1.39).

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Total hip replacement (THR) is known to be a highly cost-effective operation increasing the quality of life (Rowland et al. 1996). We know less about the effect of this operation on life expectancy (Murray 1998). Some studies (Lindberg et al. 1984, Visuri et al. 1994) have indicated a reduced mortality in patients with a THR and similar results have been found in patients with total knee replacements (Schrøder et al. 1998). A few studies have also shown an increased mortality postoperatively (Seagroatt et al. 1991, Murray et al. 1996, Fender et al. 1997, Dearborn and Harris 1998), mainly explained by thromboembolic disease.

During its first 10 years, the Norwegian Arthroplasty Register provided important information on the epidemiology of total hip replacements (Havelin et al. 1994, 1995a, b, c, Espehaug et al. 1995, 1997a, b).

We have now studied the mortality, during the entire follow-up period and the first 60 postoperative days, in THR patients in relation to gender, age, primary diagnosis, prosthesis fixation technique, year of operation and multiple operations, using data from the national register.

Patients and methods

This article is based on data concerning total hip replacement (THR) operations reported to the Norwegian Arthroplasty Register from September 1987 to February 1998. Information was collected using a questionnaire filled in by the surgeon immediately after surgery (Havelin et al. 1993). In

68 of the 69 hospitals where hip prosthesis surgery is performed in Norway, 57,830 THR operations have been recorded in 46,035 patients. We have included 39,543 patients with the first primary prosthesis operation during the time of this study. Later operations, revisions or primary operations on the opposite side were linked to the first primary operation, using the unique personal identification number that is assigned to each inhabitant of Norway. The patients were followed until their death or until February 1, 1998. The date of death was obtained from the National Population Register of Norway. We assessed the following variables: gender, age, primary diagnosis, prosthesis fixation technique, year of operation and multiple operations. The patients were divided into age groups ≤ 49 years, 50–59 years, 60–69 years, 70–79 years, 80–89 years and ≥ 90 years. In the Cox regression analysis, the two oldest and two youngest age groups were combined in the groups ≤ 59 years and ≥ 80 years, because only a few deaths occurred in patients less than 49 years and in those more than 90 years. The primary diagnoses in the three groups, primary osteoarthrosis, rheumatoid arthritis, and femoral neck fracture, were defined on the questionnaire. The group pediatric hip diseases includes patients having dysplastic hips with or without dislocation, Perthes' disease and patients having slipped capital femoral epiphysis. The group "other causes" consists of patients with the remaining primary diagnoses (64 different causes, 23% avascular necrosis, and 30% various types of fractures). Patients with the same fixation techniques for the implant in the acetabulum and femur were divided into four groups: high viscosity cement, low viscosity cement, Boneloc cement, and uncemented. Patients in the group mixed fixation are patients operated on with various fixation methods in the acetabulum and femur. The patients were categorized according to the year of the first primary operation (1987–1990, 1991–1994 and 1995–1998). Patients with multiple operations were those who had had a second primary operation in the opposite hip or revision surgery in the first primary hip.

Statistical methods

The Kaplan-Meier method was used to calculate the observed survival curves. The observed curves are presented with log-log transformed 95% pointwise confidence intervals (Andersen et al. 1993). Lower confidence intervals were adjusted for the number of patients at risk, as described by Dorey and Korn (1987).

The observed survival curves were compared with expected survival curves calculated from mortality rates obtained from Statistics Norway (Lie et al. 1998). The expected curves are the survival curves for the Norwegian population corresponding to the patients, in age, gender, and year of birth. A log-rank test (Lie et al. 1998) was used to test differences between the observed and expected survival curves. Median follow-up time was calculated by the reverse Kaplan-Meier method (Schemper and Smith 1996).

To compare the observed mortality with expected mortality a standardized mortality ratio was used (SMR) (Andersen and Væth 1989). The SMR is the ratio of the observed patient mortality and the mortality in the Norwegian population with corresponding age, gender, and year of birth as the patients.

To compare the SMRs for different covariates (such as age, gender etc.), a Cox model for time-dependent covariates was fitted (Andersen et al. 1985). This model permits incusion of population mortality rates and adjustment for potential confounders (age, gender, primary diagnosis, fixation technique, year of operation and multiple operations). The quantities estimated in this model are referred to as relative mortality ratios (RMR). In an unadjusted model, the RMR will be almost the same as the SMR for one category of the covariate divided by the SMR for the reference category (e.g., for gender $RMR_{male} \cong SMR_{male}/SMR_{female}$). An indicator for multiple operations was included in the model as a time-dependent variable with the value 0 until a second operation occurs and 1 afterwards.

The analyses were done with custom-made Fortran programs and the Fortran program used by Andersen et al. (1985) for the Cox proportional hazard model with time-dependent covariates. Some of the findings were checked using the statistical package S-Plus.

This method of performing the analyses has three purposes. First, to present (graphically) the survival for prosthesis patients together with com-

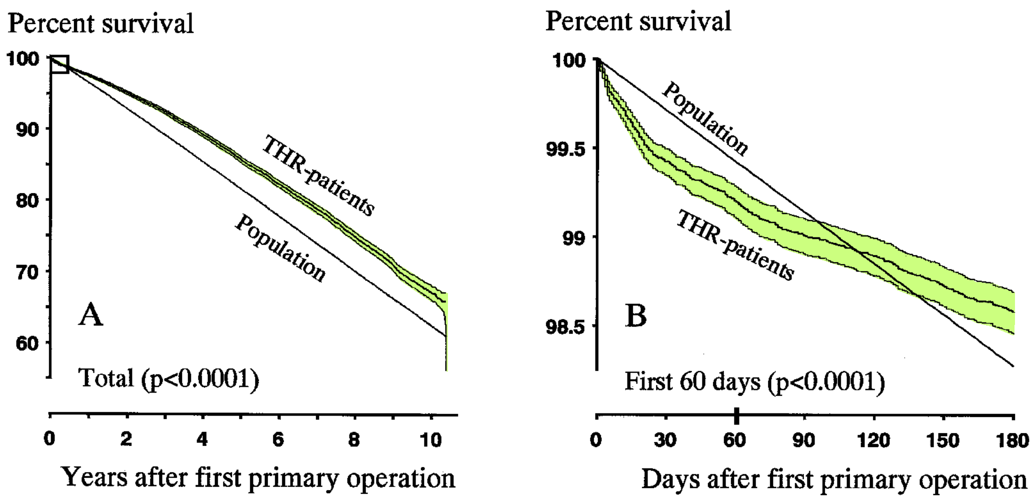

Figure 1. A. Total observed patient survival for entire follow-up period. B. Observed patient survival for the first 180 days. Both curves are shown with 95% confidence intervals and survival curves of the corresponding Norwegian population. Figure B is a magnification of the first 180 days in Figure A.

parable curves for the Norwegian population. Second, to compare the mortality of patients with that of the Norwegian population (SMR). And finally, to use a regression technique to compare the standardized mortality ratios (SMR) of various patient categories (RMR).

Results

Of the 39,543 total hip replacement (THR) patients, 70% were women. The mean age of the patients, on the day of the operation, was 69 years and higher among women than men (71 versus 67 years). Patients who were given uncemented prostheses were younger (mean age 53 years) and comprised relatively fewer women (59%). Two primary operations were recorded in 6,505 patients (both hips), and 2,113 patients had both a primary operation and a revision (in the same hip) during the observation period. The median follow-up time was 5.2 (min–max: 0–10.4) years (186,487 person years), and 6,201 patients died.

Overall, the 8-year survival was higher in patients (75%) with total hip prostheses than in the corresponding Norwegian population (70%) with the same composition of age, gender, and year of birth (Figure 1; $p < 0.0001$). The observed patient survival curve compared with the survival curve of the corresponding population were similar for females and males ($p < 0.0001$ for both). The standardized mortality ratio (SMR) was 0.81 (Table 1). Compared to females (SMR = 0.80), male patients (SMR = 0.83) had an increase in the standardized mortality ratio (RMR = 1.11; Table 1).

Patients less than 49 years (SMR = 2.50; Table 1) had a lower survival than the Norwegian population of corresponding age, gender, and year of birth ($p < 0.001$, Figure 2). The patient survival of the age group 50–59 years (SMR = 1.16; Table 1) was slightly lower than the survival of the corresponding population ($p = 0.03$; Figure 2). In all age groups of patients older than 60 years the mortality was lower than that of the corresponding population (Table 1, Figures 2 and 3). The adjusted analysis showed a very significant difference in the standardized mortality ratio (SMR) of the age groups, increasing for decreasing age (Table 1), with a statistically significant trend ($p < 0.001$).

Concerning diagnosis, patients given a prosthesis because of primary osteoarthrosis had a lower mortality than those in the corresponding population (SMR = 0.68; Table 1, Figure 4). The highest SMR was observed in the group of patients with a prosthesis due to rheumatoid arthritis (SMR = 1.48; Table 1, Figure 4). Patients with a prosthesis due to rheumatoid arthritis (RMR = 2.57), femoral neck fracture (RMR = 1.93), and the group "other causes" (RMR = 2.01) showed significant in-

Table 1. The standardized mortality ratio (SMR) is the observed mortality divided by the mortality in the general population with the same composition of age, gender, and year of birth. The relative mortality ratios (RMR) compare the SMRs for different levels of the variables and are adjusted for the other variables

	Number of patients	Observed deaths	8-year mortality, %	SMR	95% CI	RMR	P-value
Gender							
Female	27,496	3,907	23	0.80	0.77–0.82	1	–
Male	12,047	2,294	30	0.83	0.79–0.86	1.11	<0.001
Age							
≤ 49	2,329	74	4.6	2.50	1.99–3.14		
50–59	4,071	212	8.1	1.16	1.01–1.32	2.38	<0.001
60–69	11,811	1,148	15	0.86	0.81–0.91	1.46	<0.001
70–79	16,263	3,079	31	0.79	0.76–0.82	1.26	<0.001
80–89	4,899	1,597	57	0.76	0.72–0.79	1	–
≥ 90	170	91	78	0.87	0.71–1.07		
Primary diagnosis							
Primary osteoarthritis	26,433	3,618	22	0.68	0.66–0.70	1	–
Rheumatoid arthritis	1,484	280	30	1.48	1.32–1.67	2.57	<0.001
Femoral neck fracture	6,038	1,729	44	1.11	1.06–1.17	1.93	<0.001
Pediatric hip diseases	3,924	272	11	0.75	0.66–0.84	0.99	0.9
Other causes	1,664	302	29	1.30	1.16–1.46	2.01	<0.001
Fixation technique							
High viscosity	28,706	4,918	28	0.80	0.78–0.82	1	–
Low viscosity	874	212	29	0.81	0.71–0.93	1.05	0.5
Boneloc cement	978	172	15 [d]	0.75	0.65–0.88	1.08	0.4
Uncemented	5,074	248	7.9	0.92	0.81–1.04	0.84	0.03
Mixed fixation	3,911	651	23	0.84	0.78–0.91	1.02	0.7
Year of operation							
1995–1998	11,616	441	4.5 [e]	0.63	0.58–0.70	1	–
1991–1994	15,082	2,175	14 [d]	0.75	0.72–0.78	1.05	0.4
1987–1990	12,845	3,585	25	0.88	0.85–0.91	1.14	0.03
Multiple operations							
First primary	39,543	6,201	25	0.81 [a]	0.79–0.83	1	–
Second primary	6,505	565	18	0.65 [b]	0.60–0.71	0.75	<0.001
First revision	2,113	207	27	0.84 [c]	0.74–0.97	0.97	0.7

[a] overall results after first primary operation.
[b] overall results after second primary operation.
[c] overall results after and first revision.
[d] % mortality at 5 years.
[e] % mortality at 2 years.

Table 2. Number of deaths and mortality (%) during the first 60 postoperative days (with 95% confidence intervals) by primary diagnosis, age, and gender

	Female				Male			
Primary diagnosis	Number of patients	Observed deaths	60-day mortality, %	95% CI	Number of patients	Observed deaths	60-day mortality,%	95% CI
Primary osteoarthritis								
≤ 59	1,543	1	0.06	0.01–0.46	1,008	2	0.20	0.05–0.79
60–69	5,747	8	0.14	0.07–0.28	2,899	9	0.31	0.16–0.60
70–79	8,436	51	0.60	0.46–0.79	3,747	35	0.91	0.65–1.27
≥ 80	2,247	37	1.6	1.16–2.22	806	13	1.6	0.94–2.76
All other diagnoses								
≤ 59	2,361	5	0.17	0.06–0.45	1,488	5	0.34	0.14–0.81
60–69	2,275	11	0.48	0.27–0.87	890	10	1.1	0.61–2.08
70–79	3,205	45	1.4	1.02–1.84	875	20	2.1	1.30–3.25
≥ 80	1,682	55	3.2	2.42–4.11	334	16	4.8	2.97–7.71

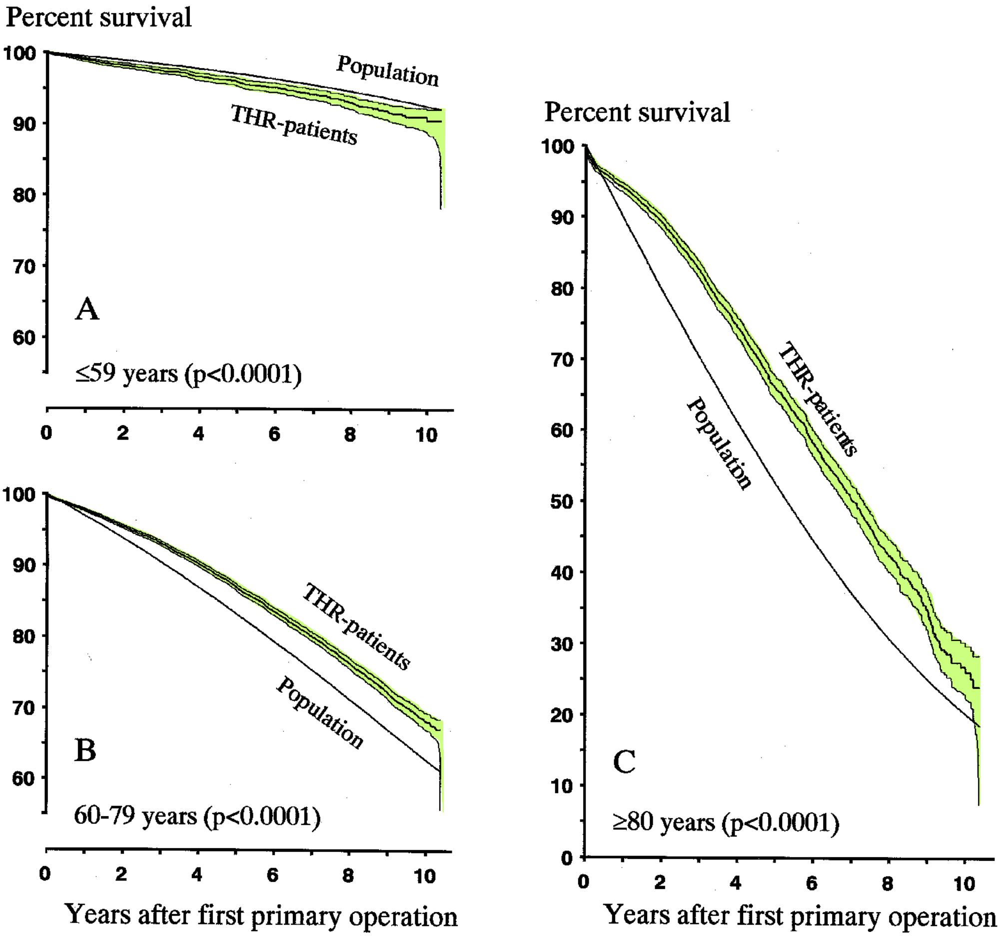

Figure 2. A-C. Observed patient survival of different age groups. All curves are shown with 95% confidence intervals and survival curves of the corresponding Norwegian population.

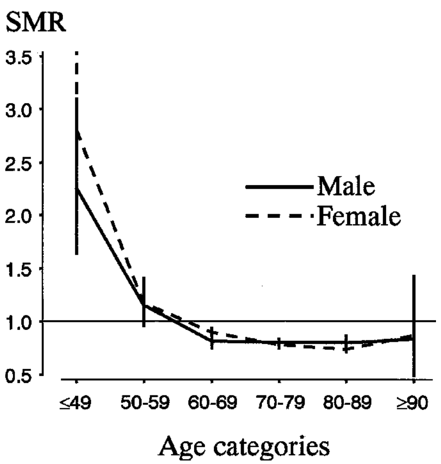

Figure 3. Standardized mortality ratios (SMRs) of prosthesis patients by age and gender, with 95% confidence intervals.

creases in the SMR, compared to patients with a prosthesis due to primary osteoarthritis (Table 1).

No tendency to differences in SMR was observed between the groups with different fixation techniques (Table 1). In the adjusted regression analysis, patients with uncemented prostheses had a lower SMR than patients with high viscosity cemented prostheses (RMR = 0.84; Table 1). The SMR decreased in patients operated on in the three periods (1987–1990, 1991–1994 and 1995–1998) (Table 1). This was confirmed in the adjusted analysis (Table 1), with a statistically significant difference in the SMR between the periods 1987–1990 and 1995–1998 (RMR = 1.14; Table 1), but a test for trend was not statistically significant ($p = 0.4$).

We found that patients with a second primary

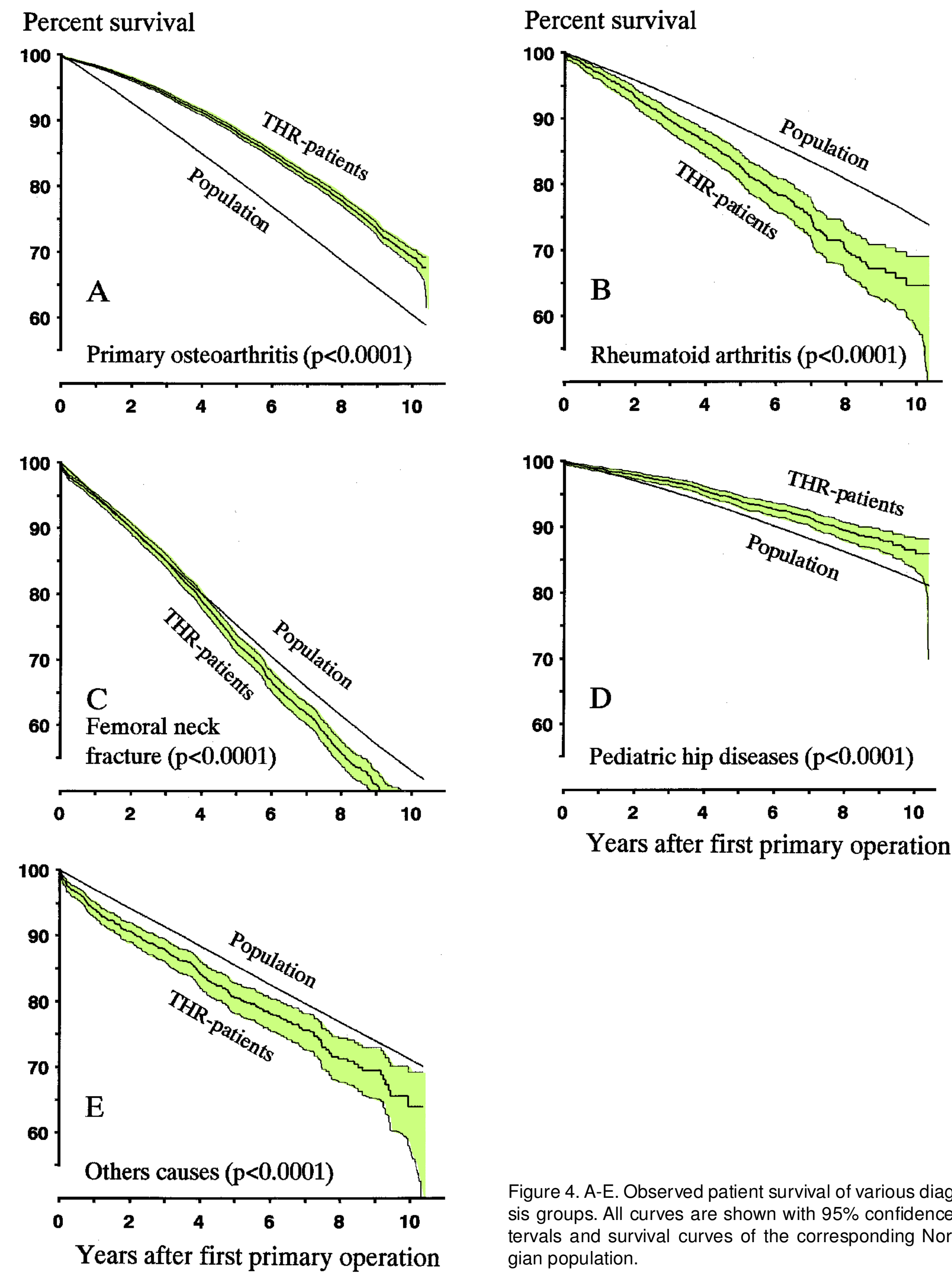

Figure 4. A-E. Observed patient survival of various diagnosis groups. All curves are shown with 95% confidence intervals and survival curves of the corresponding Norwegian population.

operation (i.e., opposite hip) had a very low standardized mortality ratio (SMR = 0.65; Table 1). In the adjusted analysis the SMR was lower after a second primary operation than after only one primary operation (RMR = 0.75; Table 1).

During the first 60 postoperative days, 0.80% of the patients died, while 0.57% was expected in the general population (Figure 1; $p < 0.0001$). The mortality during the first 60 postoperative days increased with age, was lower in females than in males, and was lower for patients with a THR due to primary osteoarthrosis than in the other primary diagnosis group (Table 2). The standardized mortality ratio (SMR) for the first 60 postoperative days was 1.39 (95% CI = 1.25–1.56) in all patients, compared to the corresponding population. This increase in the SMR was higher than the SMR during the entire follow-up (RMR = 1.83, p < 0.0001). We found no statistically significant difference in the standardized mortality ratio (SMR) during the first 60 postoperative days related to gender, age, fixation technique, year of operation, or multiple operations. In the case of various diagnoses, we found that patients with a prosthesis due to pediatric hip diseases (RMR = 1.79, p-value = 0.03) and patients in the category "other causes" (RMR = 2.05, p-value = 0.001) had a higher SMR during the first 60 postoperative days than those with THR due to primary osteoarthrosis.

Discussion

The mortality rate of patients with total hip replacements was lowere than that in the corresponding Norwegian population with the same composition of age, gender, and year of birth. This is in accordance with the results reported by Surin and Sundholm (1983), Lindberg et al. (1984), Seagroatt et al. (1991), Whittle et al. (1993), Visuri et al. (1994) and Visuri et al. (1997). One recent article shows the same tendency in patients with total knee replacements (Schrøder et al. 1998). The most likely explanation of the reduced mortality in prosthesis patients is the preoperative selection of healthier people, than the average population, for hip replacements, as sugested by Seagroatt et al. (1991). The reduced mortality in THR patients was not seen in all subgroups. Patients who were young (i.e., less than 60 years), with rheumatoid arthritis, femoral neck fracture, and those in the group "other causes" had a higher mortality than the corresponding population. Differences in the standardized mortality ratio (SMR) were seen for gender, where male patients had an increased SMR, compared to female patients. This accords with the findings of Whittle et al. (1993) who reported an increased mortality in male patients, compared to females. The standardized mortality ratio (SMR) decreased with increasing age. When interpreting the increased SMR among young patients, it must be remembered that the population mortality in the young age groups is very low. This fact and the fact that having a prosthesis operation at a young age may indicate an underlying disease that affects the mortality of these patients explains the high SMR of younger patients. There seems to be a selection of healthy people who have a THR in the older age groups, whereas young patients often undergo a prosthesis operation due to chronic diseases (Whittle et al. 1993).

As regards the various primary diagnoses, we found an increased standardized mortality ratio (SMR) in patients with rheumatoid arthritis, femoral neck fracture, and "other causes". In these diagnostic groups, the THR is part of the treatment for the diseases. Patients with rheumatoid arthritis (Koota et al. 1977) or with a femoral neck fracture, but no prosthesis (Kenzora et al. 1984, Schrøder and Erlandsen 1993) have a higher mortality than those in the population. The increased mortality of these prosthesis patient categories is probably due to the disease rather than the prosthesis.

After adjusting for age and other risk factors, there was a slightly lower SMR in patients who had an uncemented prosthesis than in those prostheses fixed with high viscosity cement. Some authors have reported debris and high levels of metal ions from uncemented prostheses (Engh Jr. et al. 1997, Jacobs et al. 1998a, b). This could theoretically cause an increase in the long-term mortality of patients with uncemented prostheses due to toxicity, but our results did not confirm this. A reduced SMR in patients with an uncemented prosthesis is probably due to a tradition of selecting healthier patients for this procedure.

We observed a difference in the SMRs during the observation period with an increased SMR in patients operated on in the earliest period (1987–1990), compared to the latest period (1995–1998). This would suggest some improvements in pre-, per-, and postoperative care.

Patients with a second succeeding primary operation in the opposite hip had a reduced SMR. The most likely explanation seems, again, to be that these patients are selected twice for two primary operations. Patients who underwent a revision showed no change in the SMR.

During the first 60 postoperative days, we found an increased SMR in all patient categories. This corresponds with the findings of Seagroatt et al. (1991) and Fender et al. (1997). The mortality obviously varies with gender, age, and primary diagnosis, but there was no difference in the SMR during the first 60 postoperative days for the variables of gender, age, fixation technique, year of operation, or multiple operations. We know that there has been a change in the use of thrombosis prophylaxis during recent years, but this has not caused a change in the SMR during the first 60 postoperative days. We found a further increase in the SMR during the first 60 postoperative days in patients with various primary diagnoses, in those with pediatric hip diseases and in "other causes". We cannot explain why pediatric hip diseases have a high mortality during the first 60 postoperative days, but an increased tendency to thrombosis in patients with Perthes' disease has been discussed (Liesner 1999).

Overall, patients with total hip replacements had a reduced mortality compared to the corresponding population. However, total hip replacement patients with femoral neck fracture, rheumatoid arthritis, or less than 60 years of age had an increased mortality compared to the population. All patient categories had an increased mortality during the first 60 postoperative days.

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