Patient-related risk factors for early revision of total hip replacements

A population register-based case-control study of 674 revised hips

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In this population register-based, matched case-control study, we assessed patient-related factors and early risk of revision after total hip replacement (THR). Information was obtained via a mail survey among patients reported to the Norwegian Arthroplasty Register during the period 1987–1993. The study included 674 revised hips, as cases, and 1,343 hips with a primary operation only, as controls. Completed questionnaires were received from 81% of the 2,017 individual cases and controls.

We identified a set of patient-related factors associated with poor THR prognosis. Increasing weight was a risk factor among male patients older than 67 years who were more than 1.77 m tall (p = 0.01). Smoking had no overall effect, but former heavy smokers had an increased risk of 2.6 compared to never-smokers. Alcohol intake was associated with an increased risk of dislocation. Revision due to infection was commoner among patients taking antidiabetic drugs (OR = 14) than among patients taking no medication. An increased overall revision risk was found among patients using systemic steroids (OR = 2.8) or local pulmonary steroids (OR = 6.0). The risk also increased in male patients performing regular exercise before the primary operation (OR = 2.6), and in female patients of working-age doing heavy work (OR = 1.9).

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Several factors associated with total hip replacement (THR), like type of prosthesis, cement and antibiotic prophylaxis, influence the survival of implants (Havelin et al. 1994, 1995a,b,c, Espehaug et al. 1995, Murray et al. 1995, Espehaug et al. (in press)). The effect of gender and age on risk of revision has been studied by several authors (Ahnfelt et al. 1990, Malchau et al. 1993, Havelin et al. 1994). Less is known, however, about the prognostic value of other patient characteristics (NIH Consensus Development Panel on Total Hip Replacement 1995).

An association has been reported between the development of primary coxarthrosis and load on the hip because of overweight (Rissanen et al. 1990, Vingård 1991, Heliövaara et al. 1993), and physical demands in relation to occupation (Vingård et al. 1991a,b, Axmacher and Lindberg 1993, Roach et al. 1994) and recreation (Lindberg et al. 1993, Vingård et al. 1993). That similar loading mechanisms also increase the risk of THR revision has been demonstrated (Dorr et al. 1983, Surin and Sundholm 1983, White 1988, Schurman et al. 1989, Hozack et al. 1990, Kilgus et al. 1991, Karachalios et al. 1993). Smoking, alcohol abuse and steroid medication are associated with an increased risk of osteonecrosis of the femoral head (Chang et al. 1993, Hirota et al. 1993). Impairment of the circulatory system caused by these factors may also have an impact on THR survival. There are other kinds of medication or diseases that can be considered risk factors for revision. In particular, some reports indicate that non-steroidal anti-inflammatory drugs (NSAIDs) inhibit bone-repair (Keller et al. 1987, Ahrengart et al. 1988, McLaren 1990, Høgevold et al. 1992), and that patients with diabetes run an increased risk of THR revision due to infection (Vannini et al. 1984, Wymenga et al. 1992).

We investigated various patient-related factors, like weight, height, type of occupation, smoking, alcohol consumption, types of medication, and preoperative and postoperative exposure to physical demands, as risk factors for THR revision in a large population register-based, matched case-control study.

Patients and methods

Study population

The Norwegian Arthroplasty Register has since September 1987 collected information on practically all THRs performed in Norway at 68 hospitals. Detailed information concerning the operations is obtained from a standard form filled in by the surgeon. An English translation of this form has been made (Havelin et al. 1993). Data on revisions are linked to the primary operation, using the unique personal number assigned to each inhabitant of Norway. A revision is defined as an exchange or removal of a part or the whole of the prosthesis.

Definition of cases and controls

Cases were hips registered as having undergone a primary operation and a reoperation, and controls were hips registered with a primary operation only. Patients operated on in 1987–1993 were included, with 683 hips eligible as cases and 26,486 as possible controls. Following a density sampling procedure (Wacholder et al. 1992), two controls, matched for gender, age at the primary operation (± 5 years), the date of the primary operation (± 30 days) and bilaterality, were selected randomly among patients at risk for revision. Only 1 control was found for 5 of the cases and none for 9 cases. This left 2,017 hips, of which 674 were cases and 1,343 controls. The number of patients, however, was 1,896. Among these patients, 1,353 were operated on unilaterally, 437 bilaterally and 106 patients were operated on bilaterally but with the first operation performed before the registration started in September 1987.

Among the 437 patients operated on bilaterally, 9 patients were included with both hips as cases, 7 patients with both hips as controls and 6 patients with 1 hip as case and the other as control. All other patients were included with 1 hip only. The discrepancy between the number of observation units and the number of patients was also due to the density sampling procedure used when selecting controls. Following this procedure, controls were selected from all unrevised hips at the time of the case revision. This means that a control hip may appear as a case at a later time. Here, 38 patients were selected as both case and control. 2 patients were selected as case and twice as control (accounting for 4 additional observation units), 53 patients were selected twice as control and 2 patients were selected three times as control (4 additional observations).

Questionnaire

Information on patient-related factors was obtained through a mail survey among the patients selected for the study. The form contained, inter alia, questions regarding type of occupation, weight and height, medication use, lifestyle, and function with respect to occupational status, recreation, need of help, pain and walking ability. Information on function was retrieved for the period just before the primary operation and when the form was filled in. Patients with revised implants (the cases) received additional questions regarding their function prior to the second operation.

We assessed the potential effect of the following factors on revision risk: weight and height categorized in quintiles; history of smoking reported as "never", "former" or "smoking at follow-up" as well as amount of smoking (cutpoint at median value, ≤ 8 and > 8 cigarettes per day) and years of smoking (cutpoint at median value < 30, ≥ 30); alcohol consumption reported in units per week (cutpoints at 0, < 1, 1–4, > 4), where 1 unit was 1 drink, 1 small bottle of beer or 1 glass of wine; medication when answering the questionnaire and information on any month-long treatment for infection after the primary operation (yes, no); function just before the primary operation reported as need of help (yes, no), severe pain (yes, no) and poor walking ability (yes, no); physical activity in relation to occupation, reported as "doing heavy physical work" (yes, no), being salaried or not (yes, no) just before and also after the primary operation, as well as type of occupation; and physical activity in relation to sports and recreation, reported as previous participation in competitive sports (yes, no) and weekly exercise (yes, no) before the first symptoms from the hip and after the operation. The dichotomized factors in relation to pain and walking ability were based on the Merle D'Aubigné and Postel scale (1954), as modified by Charnley (1972). Severe pain was defined as severe and spontaneous pain at rest and at night, and poor walking ability was defined as ability to walk only a few meters on crutches or being bedridden.

Statistics

Relative risks (incidence density ratios) were estimated by odds ratios obtained from conditional logistic regression analyses. Although matching was performed according to gender, age, bilaterality and time of the operation, the patient-related revision risk estimates may be further confounded by other acknowledged risk factors, such as use of a cemented or uncemented prosthesis (Havelin et al. 1994), type of cement (Havelin et al. 1995a), brand of prosthesis (Espehaug et al. 1995, Havelin et al. 1995b,c) and regimen for antibiotic prophylaxis (Espehaug et al.

(in press)). Thus all statistical analyses were performed with adjustment for use of systemic antibiotic prophylaxis (yes, no) and for a factor reflecting use of cement type among cemented prostheses (high-viscosity cement with added antibiotics, plain high-viscosity cement, plain low viscosity cement and Boneloc cement), prosthesis brand among uncemented prostheses ('good' and 'inferior' prosthesis brands), and whether a hybrid or unknown cementation had been used. As in previous studies (Havelin et al. 1995b,c), the uncemented prosthesis brands Ti-fit (acetabulum)/Bio-fit (femur) (Richards, Memphis, Tennessee, USA) and Coxa (acetabulum)/Femora (femur) (Thackray, Leeds, UK), were grouped as uncemented prostheses with inferior prognoses.

Subgroup analyses were performed within gender and age groups, where age was dichotomized according to whether the patient was of working age when the primary operation was performed. In Norway, the general age of retirement is 67 years.

The statistical analyses were performed using the program package SPSS (1993). The SPSS does not include a conditional logistic regression procedure for analyses of matched case-control data as such, but the Cox proportional hazards regression module of SPSS, gives conditional logistic regression results when performed with risk-sets restricted by the matching factors and the time set at a constant value. The partial likelihood of the Cox module is thus equivalent to the conditional logistic regression likelihood (Walker 1982, Le and Lindgren 1988).

Table 1. Distribution among cases and controls of different risk predictors for reoperation after total hip replacement, Norway 1987–1993

Risk predictors	Percent of cases (n 536)	Percent of controls (n 1,092)
Smoke and alcohol		
Current smokers	20	22
Former smokers	32	30
Alcohol abstainers	36	33
Medication		
Antibiotics after prim. op.	17	7.5
Medication excl. analgesics	43	45
Medication incl. analgesics	16	11
Analgesics only	9.0	4.7
Function when operated		
Needs help	65	68
Severe pain	88	87
Poor walking ability	58	53
Recreation		
Previous competitive sports	16	16
Previous regular exercise	57	48
Regul. exercise after prim. op.	53	55
Occupation		
Heavy work [a]	47	46
Salaried at prim. op.	28	26
Salaried after prim. op	21	25
Primary diagnosis		
Coxarthrosis	67	67
Rheumatoid arthritis	3.8	3.6
Femoral neck fracture	9.3	8.9
Sequelae after dysplasia	11	12
Cement and prosthesis		
Cemented	63	74
High-viscosity cement	45	65
Low-viscosity cement	3.3	2.2
Boneloc cement	6.5	1.1
Uncemented	28	21
Antibiotic prophylaxis		
Systemic	90	93
In cement	15	27
Systemic and in cement	12	25

[a] Previous exposure or, when relevant, exposure at follow-up

Results

We received complete questionnaires from 81% of the 2,017 individual cases and controls selected for the study. Thus, the study included 536 patients with primary and revision surgery and 1,092 patients who underwent primary surgery alone. Only small variations in response percentages were found between age and gender groups. Male patients constituted 43% of the material and the median age at the primary operation was 67 (16–88) years. Table 1 gives the distribution of various predictors of revision risk among revised hips and controls.

Diagnosis, type of cement, type of prosthesis and antibiotic prophylaxis regimen

The commonest primary diagnoses were coxarthrosis (67%) and sequelae after congenital dysplasia (arthrosis secondary to congenital dysplasia without dislocation) (12%). No differences in revision risk were observed among the different diagnoses ($p = 0.5$). Cemented prostheses were used in 71% of the operations, and 31% of these had had antibiotics added to the cement. The lowest revision risk was found among THRs cemented with antibiotic-containing high-viscosity cement, whereas the highest revision risk was found among prostheses cemented with the Boneloc cement (OR =11, 95% CI: 4.7–27) and among some of the uncemented prosthesis brands (Ti-fit (acetabulum)/Biofit (femur) and Coxa (acetabulum)/Femora (femur)) (OR = 6, CI: 3.4–11). Furthermore, THRs performed without systemic antibiotic prophylaxis had a 1.5 (CI: 1.0–2.3) times higher revision risk than THRs using systemic antibiotics.

Patient weight and height

Median height and median weight in male patients were 1.78 m and 81 kg in patients with a revised hip and 1.76 m and 80 kg in the controls. Among female

Table 2. Smoking and alcohol intake as risk predictors for reoperation after total hip replacement, Norway 1987–1993. Relative risks estimated as odds ratios (OR) in conditional logistic regression analyses

Risk predictors	n	OR [a]	95% CI
Smoking [b]			
Never	774	1.0	
Former			
Light	118	1.0	(0.6–1.5)
Medium	187	0.9	(0.6–1.3)
Heavy	88	2.6	(1.5–4.4)
Current			
Light	34	0.9	(0.4–2.0)
Medium	178	0.8	(0.5–1.2)
Heavy	105	0.8	(0.5–1.3)
Test for homogeneity			p = 0.01
Alcohol intake per week [c]			
Teetotaller	543	1.0	
< 1 unit	533	0.8	(0.6–1.1)
1–4 units	155	0.9	(0.6–1.4)
> 4 units	125	1.4	(0.8–2.2)
Test for homogeneity			p = 0.2
Test for departure from linear trend			p = 0.1

[a] Adjusted for gender, age, date of operation and bilaterality (matching factors) via the study design.
[b] Smokers divided into heavy (>8 cig. per day (median value) in ≥30 years (median value)), medium (≤8 cig in ≥30 years or >8 cig. in <30 years) and light (≤8 cig in < 30 years) smokers.
[c] 1 unit = 1 drink = 1 glass of wine = 1 small bottle of beer.

patients, the median height and weight were 1.65 m and 68 kg in revision patients and 1.64 m and 66 kg in the controls. There was no overall effect on the revision risk of an increasing body mass index (kg/m^2), neither among men or women. However, we found a linear increase in revision risk through the weight (p = 0.03) and height quintiles (p = 0.003). Subgroup analyses showed that the weight trend was confined to men above median male height (1.77 m) and over 67 years at the primary operation (OR = 1.7, CI: 1.2–2.6). In this group (n 143), patients weighing more than 89 kg had a 7 times higher revision risk than patients weighing 71 kg or less. Similarly, increasing height as a predictor of revision risk was found only in men above median weight and older than 67 years (n 132).

Smoking and alcohol intake

Overall, neither former nor current smokers ran an increased risk of revision compared to never-smokers. However, we found that the risk was 3 times higher in former heavy smokers, compared to never-smokers (Table 2). This finding was consistent among subgroups defined by gender, age and use of cemented or uncemented prostheses. Further adjustment for alcohol intake, occupation (physically heavy/not heavy), weight and height did not alter these results.

The association of alcohol intake with revision risk was J-shaped (Table 2), where the lowest risk was found among patients with a moderate alcohol intake and the highest risk among patients having a consumption of more than 4 units per week (OR = 1.6, CI: 1.0–2.7). Similar results were obtained with smoking and occupation included in the model. Although not statistically significant, we observed that, compared to non-drinkers, the revision risk due to dislocation was 2.7 (CI: 0.9–9) times higher among patients drinking less than 1 unit per week, 2.7 (CI: 0.6–12) for 1–4 units and 4.1 (CI: 0.6–26) for a consumption of more than 4 units per week.

Medication at follow-up

63% of the patients were using some kind of medication when completing the form. Patients using analgesics, either alone or in combination with other medication, had twice as high revision risk as patients not using medication. No overall association between use of medication and THR outcome was observed among patients not using analgesics (Table 3). However, there was an association between a poor prognosis and use of specific types of medication. Patients using anti-diabetic drugs, taking female sex hormones (estrogen, progestogen), systemic steroids, local pulmonary steroids or non-steroidal anti-inflammatory drugs (NSAIDs) had higher risks for reoperation than patients not on medication (Table 3). The poorer results among patients using systemic steroids or local pulmonary steroids were primarily restricted to patients operated on because of primary coxarthrosis. The increased risk associated with NSAID use was observed both among patients with primary coxarthrosis and those with rheumatoid arthritis. In considering patients treated with anti-diabetic drugs, there was no difference in revision risk among patients on insulin (n 16) and those on oral medication (n 23). A more pronounced association between revision risk and anti-diabetic medication was found with infection as the cause of revision (n 65) (OR = 14, 95% CI: 1.4–137). When the patient group receiving female sex hormones was restricted to medication preferably given to patients with osteoporosis or at high risk for osteoporosis (n 30), the revision risk estimate increased to 2.3 (95% CI: 1.0–5.6).

Patients who had been treated with antibiotics for at least one month (not necessarily due to signs of infection in the hip) (n 165), had a 3 times higher risk for reoperation than other patients had (Table 3). With infection as the cause of revision, we found a relative risk of 23 (95% CI: 7–74).

Table 3. Type of medication (or disease treated with medicine) as a risk predictor for reoperation after total hip replacement, Norway 1987–1993. Relative risks estimated as odds ratios (OR) in conditional logistic regression analyses

Risk predictor	No medicine (n 580)	Not combined with analgesics			Combined with analgesics		
		n	OR [a]	95% CI	n	OR [a]	95% CI
Medication at follow-up [b]							
All types of medication	1.0	697	1.2	(0.9–1.5)	202	1.7	(1.2–2.4)
Drugs for diabetes	1.0	42	1.9	(1.0 –3.9)	6	1.0	(0.2–5.8)
Drugs for cardiovascular disease	1.0	367	1.0	(0.7–1.3)	118	1.3	(0.8–2.0)
Female sex hormones	1.0	49	1.8	(0.9–3.5)	15	1.8	(0.6 –5.4)
Thyroxins	1.0	51	0.9	(0.4–1.8)	8	2.5	(0.5–11)
Systemic steroids	1.0	45	2.8	(1.4–5.4)	19	1.3	(0.4–3.7)
Local pulmonary steroids	1.0	22	6.0	(2.1–17)	5	2.9	(0.5–17)
NSAIDs	1.0	143	1.5	(1.0–2.3)	64	2.5	(1.4–4.5)
Analgesics	1.0	–	–	–	298	1.8	(1.3–2.5)
Psycholeptics, psychoanalept.	1.0	99	0.9	(0.5–1.4)	70	2.8	(1.6–4.9)
	No antibiotic (n 1,381)	Antibiotic treatment					
Antibiotics after primary operation [c]	1.0	165	2.7	(1.9–3.9)			

[a] Adjusted for gender, age, date of operation and bilaterality (matching factors) via the study design.
[b] Medication when completing the questionnaire.
[c] Treatment lasting for at least 1 month.

Function at the primary operation

Just before the primary operation, 87% of the patients reported severe pain, 55% poor walking ability and 67% said they could not take care of themselves and needed help. Need for assistance and the level of pain prior to the operation did not affect the outcome of surgery. An association between very limited walking ability immediately before the primary operation and an increased revision risk almost reached statistical significance (p = 0.06) (Table 4).

Competitive sports and regular exercise

Overall, previous participation in competitive sports (n 243) did not affect the outcome of the hip surgery, a result that was independent of years of activity. Male patients of working age who exercised regularly before the first symptoms from the hip, had 3 times as high a risk as male patients who did not. This finding was consistent through age groups among male patients, but was not observed among female patients. In patients younger than 67 years at the primary operation, regular exercise after the primary operation was associated with a good prognosis (Table 5).

Table 4. Function of patient immediately before the primary operation as a risk predictor for reoperation after total hip replacement, Norway 1987–1993. Relative risks estimated as odds ratios (OR) in conditional logistic regression analyses

Risk predictor		n	OR [a]	95% CI
Needs help	No	522	1.0	
	Yes	1065	0.9	(0.7–1.1)
Severe pain	No	205	1.0	
	Yes	1386	1.1	(0.8–1.6)
Poor walking ability	No	714	1.0	
	Yes	862	1.2	(1.0–1.5)

[a] Adjusted for gender, age, date of operation and bilaterality (matching factors) via the study design.

Occupation

Patients of working age who were salaried or not salaried just before the primary operation had the same estimated risk for a later reoperation. Patients of working age who were salaried after the primary operation had 0.5 times the revision risk of those who were not (Table 5). This finding did not depend on employment status when operated on.

30% of all male patients were or had been working in agriculture, in forestry or on ships at sea, and 41% of these in combination with work in industry, construction or engineering. An additional 30% were otherwise employed in industry, construction or engineering. Although 77% of these patients regarded their occupation as physically heavy, compared to 28% among male patients in other professions, we found no differences in revision risk among the various professions (p = 0.8). This result was upheld among patients younger than 67 years at the primary operation and among patients who were salaried or not salaried after the primary operation.

Table 5. Physical activity in relation to occupation and recreation as risk predictors for reoperation after total hip replacement among patients of working age (≤ 67 years) at the primary operation, Norway 1987–1993. Relative risks estimated as odds ratios (OR) in conditional logistic regression analyses

Risk predictors	n	OR [a]	Men OR [b]	Women OR [b]
Recreation				
Active in competitive sports before primary operation				
No	665	1.0	1.0	1.0
Yes	142	1.3 (0.9–2.1)	1.1 (0.6–1.9)	1.8 (0.9–3.5)
Regular exercise before primary operation				
No	380	1.0	1.0	1.0
Yes	404	1.6 (1.1–2.2)	2.6 (1.4–4.7)	1.2 (0.8–1.8)
Regular exercise after primary operation				
No	366	1.0	1.0	1.0
Yes	436	0.8 (0.5–1.0)	0.7 (0.4–1.2)	0.8 (0.5–1.2)
Occupation				
Heavy work [c]				
No	476	1.0	1.0	1.0
Yes	331	1.5 (1.1–2.2)	1.1 (0.7–2.0)	1.9 (1.2–3.2)
Salaried at primary operation				
No	511	1.0	1.0	1.0
Yes	321	1.1 (0.8–1.5)	1.4 (0.8–2.3)	0.9 (0.6–1.4)
Salaried after primary operation				
No	491	1.0	1.0	1.0
Yes	304	0.5 (0.4–0.8)	0.6 (0.3–1.0)	0.5 (0.3–0.9)

[a] Adjusted for gender, date of operation and bilaterality (matching factors) via the study design.
[b] Adjusted for date of operation and bilaterality (matching factors) via the study design.
[c] Previous exposure or, when relevant, exposure at follow-up

Among female patients, we found that 72% performed or had performed domestic work in their own homes, and that 49% of these also had another occupation. The lowest revision risk was found among women reporting domestic work as their only occupation (n 219). On the other hand, we found a doubled revision risk among women with health-related work, or health-related work in addition to domestic work. In almost all types of occupations, a higher revision risk was observed in female patients who performed additional domestic work (Table 6). In total, the risk of revision was statistically significant higher among females of working age performing self-reported heavy work, compared to easier work (Table 5). Similar results were observed among female patients salaried and not salaried after the operation.

To avoid potential confounding, additional analyses were performed using factors representing the type of cement, type of prosthesis and use of antibiotic prophylaxis included in the statistical models. However, only negligible differences were observed in revision risk estimates for the various patient-related factors. Results were also similar when unilaterally operated patients alone were included in the analyses.

Table 6. Type of occupation as a risk predictor for reoperation after total hip replacement among female patients, Norway 1987–1993. Relative risks estimated as odds ratios (OR) in conditional logistic regression analyses

Risk predictors	n	% heavy work [a]	OR [b]	95% CI
Occupation [c]				
Domestic work	219	24	1.0	
Industry/engineering/ construction	23	35	1.3	0.5–3.3
and domestic work	22	41	2.0	0.7–5.7
Office/trade/hotel/service	101	16	1.4	0.8–2.4
and domestic work	126	23	1.4	0.8–2.2
Health-service work	35	31	2.1	1.0–4.8
and domestic work	49	53	2.5	1.2–5.1
Others/combinations	97	32	1.2	0.6–2.2
and domestic work	191	53	1.5	0.9–2.3
Agriculture/forestry/at sea and domestic work	64	85	1.7	0.9–3.3
Test for homogeneity				p = 0.3

[a] Percent with self-reported physically heavy work.
[b] Adjusted for age, date of operation and bilaterality (matching factors) via the study design.
[c] Previous exposure or, when relevant, exposure at follow-up

Discussion

Few large-scale studies have focused on patient-related factors as predictors for reoperation after total hip replacement. In this population register-based case-control study, we have identified several patient-related factors as revision risk factors, while controlling for other relevant factors.

Risk factors

Our study indicated that increased weight was an important risk factor among older male patients above median male height. Several other studies have also reported a positive correlation between overweight and revision risk after THR (Surin and Sundholm 1983, Schurman et al. 1989, Hozack et al. 1990, Karachalios et al. 1993). The age dependency observed in our study was in accordance with a report by Schurman et al. (1989), where the highest risk of revision was found among patients older than 75 years and weighing more than 75 kg. We found that the effect of patient weight depended not only on age, but also on the patient's height. This might explain why risk estimates among female patients were not affect-

ed by increased weight. Previous studies have shown that overweight is greatly overrepresented among patients requiring common orthopedic surgical procedures (Böstman 1994), and further that overweight also predisposes to coxarthrosis (Rissanen et al. 1990, Vingård 1991, Heliövaara et al. 1993).

Alcohol abuse, smoking and steroid use among other factors have been associated with an increased risk of osteonecrosis of the femoral head (Chang et al. 1993, Hirota et al. 1993). In our study, these factors also affected the prognosis of the hip implant. Few patients had a high consumption of alcohol. An increased revision risk, however, was observed among patients drinking more than 4 units of alcohol per week. A higher risk of revision associated with alcohol abuse has been reported among patients less than 45 years old (Dorr et al. 1983). Irrespective of the amount of alcohol, our findings indicated an increased risk for revision due to dislocation among patients drinking alcohol. A similar relationship between alcohol and dislocation has been suggested by Hedlundh and Fredin (1995). We observed no overall association between smoking and revision risk, but former heavy smokers ran a significantly higher revision risk than did the never-smokers. The increased risk was present also after adjustment for a number of potential confounders. It is plausible that this finding indicates an increased risk of revision for patients who have stopped smoking for medical reasons—for example, circulatory problems. Furthermore, we found that patients taking systemic steroids as well as those treated locally with pulmonary steroids, ran a higher risk of reoperation than those without such medication. The increased risk was primarily found among patients operated on because of primary coxarthrosis. The effects of various risk factors, and medication in particular, may differ among the various primary diagnoses. Investigation of such effects, however, was difficult as 67% of the patients were operated on because of primary coxarthrosis and other diagnoses were reported in small numbers only.

In general, type of medication could not be established as a risk factor, since the treated disease itself might just as well represent the increased revision risk. However, in addition to steroid use, we observed an increased revision risk among patients using various kinds of medication. In accord with other studies (Vannini et al. 1984, Wymenga et al. 1992), we found that patients taking anti-diabetic drugs ran a considerably higher risk of being reoperated because of an infection than those not using medication. There was no difference, however, in the risk of revision between patients treated with insulin and those treated with oral medication. We also found inferior results among patients taking female sex hormones (estrogen, progestogen) and even worse results among those treated with female sex hormones given to patients with osteoporosis or at high risk of osteoporosis. This finding indicated a substantial osteoporosis-related revision risk. Non-steroidal anti-inflammatory drugs (NSAIDs) have been said to inhibit bone-repair (Keller et al. 1987, Ahrengart et al. 1988, McLaren 1990, Høgevold et al. 1992). We found an increased revision risk associated with use of NSAID among patients operated on because of primary coxarthrosis and rheumatoid arthritis. However, these patients might have received NSAID as an analgesic. In that case, NSAID medication could not be regarded as a risk factor, but rather as an indication of a poorly functioning implant. Patients using analgesics were otherwise treated separately in analyses investigating medication and revision risk.

Many recent studies have reported an association between occupation and coxarthrosis (Vingård et al. 1991a,b, Axmacher and Lindberg 1993, Roach et al. 1994) and between sports and coxarthrosis (Lindberg et al. 1993, Vingård et al. 1993). A higher revision risk has also been reported in patients returning to hard manual work or athletic activities after hip arthroplasty (White 1988, Kilgus et al. 1991), whereas other studies have shown no consistent difference in revision rates among patients who were or were not active (Ritter and Meding 1987). The present recommendation concerning sports encourages participation in low-impact sports only (McGrory et al. 1995). In accordance with a report by Dubs et al. (1983), we found a lower revision risk among patients of working age returning to work after the operation and among working age patients who exercised regularly after the operation. However, this result may be a consequence of the short follow-up after the primary operation. The effect of a longer exposure to physically demanding activities after the operation could not be evaluated in this material.

In our study, it was only among female patients that we found a difference in revision risk depending on occupation. Women of working age with self-reported physically hard work had, on average, a higher revision risk than women with self-reported sedentary work. As this finding did not occur among men, one might speculate that women in professions with a heavy work-load undergo too much physical strain, especially with additional domestic work. The highest risk for reoperation was observed among women in health-related professions.

Preoperative levels of pain and ability to look after one self did not relate to THR outcome, as also reported by Schurman et al. (1989).

Potential limitations commonly associated with case-control studies are selection bias and recall bias. Since both revised hips and controls came from the same well-defined population, selection bias was not an important issue in our study. Only very serious under-reporting to the register for specific patient groups, might introduce excessive selection bias. This, however, is not likely for patient-related risk factors. Furthermore, the Norwegian Arthroplasty Register comprises nearly all THRs performed in Norway (Havelin et al. 1993). Nevertheless, there is a risk that outcome knowledge will influence exposure classification. Although we were unable to rule out this possibility of recall bias, its probable trend was difficult to ascertain. Either an inflation or a deflation of any true association between patient-related factors and revision risk is possible.

We were concerned that some patients might have found it impossible to give retrospective information regarding specific questions. In order to facilitate completion of the form, we asked for current and not retrospective information on patient weight, medication and alcohol and tobacco consumption. All analyses involving these factors were thus based on an assumption of stability in exposure status. A study by Woolf et al. (1994) found no trend towards weight loss after total hip replacement. However, one cannot assume that the same medication was used after the primary operation. Regarding alterations in alcohol and tobacco consumption, we believe that only a few patients would dramatically alter their smoking and drinking habits during this rather brief period, particularly since the study population mainly consisted of older patients.

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