Improved outcome after hip fracture surgery in Norway

10-year results from the Norwegian Hip Fracture Register

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Background and purpose — The operative treatment of hip fractures in Norway has changed considerably during the last decade. We used data in the Norwegian Hip Fracture Register to investigate possible effects of these changes on reoperations and 1-year mortality.

Patients and methods — 72,741 femoral neck (FFN) fractures and trochanteric fractures in patients 60 years or older were analyzed. The fractures were divided into 5 time periods (2005–2006, 2007–2008, 2009–2010, 2011–2012, 2013–2014). Cox regression models were used to calculate unadjusted and adjusted (age group, sex, and ASA class) relative risks (RRs) of reoperation and of 1-year mortality in the different time periods.

Results — For undisplaced FFNs treatment with hemiarthroplasty increased from 2.1% to 9.7% during the study period. For displaced FFNs treatment with arthroplasty increased from 56% to 93%. The use of intramedullary nails increased from 9.1% to 26% for stable 2-fragment (AO/OTA A1) trochanteric fractures, from 15% to 33% for multifragment (AO/OTA A2) trochanteric fractures, and from 27% to 61% for intertrochanteric fractures (AO/OTA A3)/subtrochanteric fractures. Compared with the first time period the adjusted 1-year RR for reoperation was 0.43 (95% CI: 0.37–0.49) for displaced FFNs in the last time period. The adjusted 1-year mortality in the last time period was lower for all fractures (RR: 0.87 (0.83–0.91)), displaced FFNs (RR: 0.86 (0.80–0.93)), AO/OTA A1 trochanteric fractures (RR: 0.79 (0.71–0.88)), and AO/OTA A2 trochanteric fractures (RR: 0.87 (0.77–0.98)) when compared with the first study period.

Interpretation — Hip fracture treatment in Norway has improved: The risk of reoperation and the 1-year mortality after displaced femoral neck fractures have decreased over a 10-year period. National registration is useful to monitor trends in treatment and outcomes after hip fractures.

Worldwide more than 1.3 million hip fractures occur each year (Johnell and Kanis 2004). Oslo, the capital of Norway, has the highest incidence of hip fractures ever reported (Falch et al. 1993). In Norway (with 5.2 million inhabitants) more than 9,000 patients sustain a hip fracture each year (Directorate for Health and Social Affairs 2005). Even if a decrease in hip fracture incidence has been found in some recent studies, the burden of these fractures will continue to rise due to the advancing age of the population with an increasing number of elderly people at risk of fragility fractures (Lofthus et al. 2001, Kannus et al. 2006, Brauer et al. 2009). Thus, the management of hip fractures will remain an important task for healthcare systems worldwide.

While some countries have national guidelines (National Institute for Health and Clinical Excellence 2011, American Academy of Orthopedic Surgeons 2014), such recommendations do not exist in Norway. The Norwegian Hip Fracture Register (NHFR) was established in 2005 to collect nationwide data as the basis for improved management of hip fracture patients (Gjertsen et al. 2008). During the last decade the treatment of hip fractures in Norway has gone through major changes, following recommendations from national and international publications. An increasing number of patients with femoral neck fractures are currently treated with arthroplasty. Further, at the expense of sliding hip screws, the use of intramedullary nails for unstable trochanteric and subtrochanteric fractures has increased in the last decade (Havelin et al. 2016). We used the data in the NHFR to assess possible effects of these changes on rate of reoperations and 1-year mortality after hip fractures.

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Patients and methods

The Norwegian Hip Fracture Register (NHFR) has earlier been described in detail (Gjertsen et al. 2008). The NHFR contains data from almost 80,000 operations for acute hip fractures performed in the 10-year period January 2005–December 2014. Information regarding the patient, the fracture, and the operation are reported to the NHFR on a 1-page questionnaire completed by the surgeon immediately after each operation. Both primary operations and reoperations are registered. In 2011–2012 the completeness of reporting to the NHFR compared with the Norwegian Patient Register was 89% for primary operations (Wiik et al. 2014). Total hip arthroplasties (THAs) after acute hip fractures as well as reoperations with a THA after hip fracture surgery were reported separately to the Norwegian Arthroplasty Register (NAR). These THAs were finally duplicated to the NHFR database before analyses were performed. Each reoperation was linked to the primary operation with use of the national identification number assigned to each inhabitant in Norway. A reoperation is in the NHFR defined as any surgical procedure for complications, including removal of hardware, closed reduction for dislocation of a prosthesis, and soft tissue debridement for infection. All reoperations in the NHFR were included in the analyses of this study.

In the NAR, a reoperation has until recently been defined as comprising only secondary procedures involving exchange or removal of a prosthesis component. Accordingly, closed reduction for dislocated THAs and soft tissue debridement for infected THAs were not registered during the inclusion period of this study. All patients were followed until time of reoperation, time of death, time of emigration, or until censoring on December 31, 2015. Information on time of death and emigration was obtained from Statistics Norway. Physical status was recorded according to the ASA classification. The surgeons classified intracapsular fractures of the femoral neck (FFNs) as undisplaced (Garden 1 or 2) or displaced (Garden 3 or 4). Extracapsular fractures were divided into basocervical FFNs, trochanteric fractures, and subtrochanteric fractures. The trochanteric fractures were further classified into 2-part trochanteric (AO/OTA Type A1), multi-fragment trochanteric (AO/OTA Type A2) or intertrochanteric (AO/OTA Type A3) fractures. The A3 fractures were first included as a separate fracture group in the NHFR in 2007. As basocervical fractures constituted only 3.8% of all fractures with considerable variation in the treatment methods they were excluded from the survival analyses.

As of June 15, 2016, there was information on 79,758 hip fractures in the NHFR treated in 2005–2014. Operations on patients with a hip fracture of unknown type (n = 37) and on patients with complex fractures involving more than 1 hip fracture type or hip fractures in combination with femoral shaft fractures (n = 687) were excluded. Further, 33 trochanteric fractures treated with total hip arthroplasty were excluded as this was a very uncommon treatment for these fractures. Further, pathological fractures (n = 952) and patients with unknown physical status (ASA classification) were excluded (n = 1,114). Finally, to get a more homogeneous group, patients less than 60 years of age were excluded (n = 4,194). After exclusion, 72,741 fractures were included in the analyses.

Statistics

The Cox regression model was used to calculate the unadjusted and adjusted (age group, physical status (ASA score), and sex) relative risk of reoperation of any cause for the different time periods. Similarly, the Cox model was used to calculate unadjusted and adjusted relative risk of deaths (1-year mortality) in the different time periods. Further, the Cox model was used to construct survival curves for the different fracture types with adjustments for age group, physical status (ASA score), and sex. There were very few patients with ASA class 5, and these patients were excluded in all adjusted Cox regression analyses to avoid very broad 95% confidence intervals (CIs). In all regression models the period 2005–2006 was used as the reference, to which the other time periods were compared. Relative risks are presented with CIs. The proportional hazards assumption was investigated visually by use of log-minus-log plots and was fulfilled for reoperation analyses on all fractures, undisplaced FFNs, and displaced FFNs and for the mortality analysis on all fractures. Adjustments for patients operated on both sides were not done, since an earlier study has shown that this will not alter the conclusion for the entered covariates (Lie et al. 2004). All tests were 2-sided, and the significance level was set to 0.05. Since death is a competing risk, and hence influences the accumulated probability for revision, regression analyses for competing risk were performed. The Fine and Gray (1999) regression model for the sub-hazard was applied. These results were compared with the results from the Cox proportional hazards regression model. The analyses were performed using IBM-SPSS, version 22.0 (IBM Corp., Armonk, NY, USA) and the cmprsk Library in the statistical package R (http://CRAN.R-project.org/Package=cmprsk<http://cran.r-project.org/Package=cmprsk>).

Ethics, funding and potential conflicts of interest

The NHFR has permission from the Norwegian Data Inspectorate to collect patient data based on written consent from the patients. (Permission issued January 3, 2005; reference number 2004/1658-2 SVE/-) Informed consent from patients was entered in the medical records at each hospital. The Norwegian Hip Fracture Register is financed by the Western Norway Regional Health Authority (Helse-Vest). No competing interests declared.

Table 1. Baseline characteristics of patients in the 5 time periods

	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014	p-value
Total number	12,182	14,818	15,116	15,539	15,086	
Mean age (SD)	82 (8.0)	82 (8.2)	82 (8.2)	82 (8.4)	82 (8.2)	0.003 [b]
Age groups, n (%)						< 0.001 [c]
< 70	1,033 (8.5)	1,382 (9.3)	1,420 (9.4)	1,549 (10)	1,686 (11)	
70–74	1,018 (8.4)	1,168 (7.9)	1,256 (8.3)	1,271 (8.2)	1,310 (8.7)	
75–79	1,928 (16)	2,238 (15)	2,133 (14)	2,051 (13)	1,950 (13)	
80–84	3,151 (26)	3,480 (23)	3,468 (23)	3,411 (22)	3,118 (21)	
85–89	3,017 (25)	3,928 (27)	4,068 (27)	4,058 (26)	3,770 (25)	
≥ 90	2,035 (17)	2,622 (18)	2,771 (18)	3,199 (21)	3,252 (22)	
Women, n (%)	8,981 (74)	10,732 (72)	10,802 (71)	10,962 (71)	10,666 (71)	
Mean ASA class (SD)	2.5 (0.74)	2.6 (0.71)	2.6 (0.67)	2.7 (0.65)	2.7 (0.65)	< 0.001 [b]
ASA-class, n (%)						< 0.001 [c]
ASA-1	1,072 (8.8)	982 (6.6)	647 (4.3)	452 (2.9)	367 (2.4)	
ASA-2	4,644 (38)	5,286 (36)	5,116 (34)	5,255 (34)	5,101 (34)	
ASA- 3	5,818 (48)	7,642 (52)	8,343 (55)	8,738 (56)	8,447 (56)	
ASA-4	623 (5.1)	895 (6.0)	984 (6.5)	1,082 (7.0)	1,142 (7.6)	
ASA-5	25 (0.2)	13 (0.1)	26 (0.2)	12 (0.1)	29 (0.2)	
Fracture type, n (%)						< 0.001 [c]
Undisplaced FFN	2,245 (18)	2,436 (16)	2,181 (14)	2,249 (14)	1,968 (13)	
Displaced FFN [a]	4,949 (41)	6,061 (41)	6,478 (43)	6,774 (44)	6,744 (45)	
Basocervical FFN	542 (4.4)	655 (4.4)	571 (3.8)	477 (3.1)	485 (3.2)	
Trochanteric A1	2,168 (18)	2,664 (18)	2,436 (16)	2,452 (16)	2,468 (16)	
Trochanteric A2	1,649 (14)	2,161 (15)	2,421 (16)	2,523 (16)	2,372 (16)	
Inter-/subtrochanteric	629 (5.2)	841 (5.7)	1,029 (6.8)	1,064 (6.8)	1,049 (7.0)	

ASA: American Society of Anaesthesiologists
FFN: fracture of the femoral neck
Trochanteric fractures classified according to the AAOS/OTA classification
[a] Including 1,825 undefined FFNs treated with total hip arthroplasty
[b] ANOVA
[c] Pearson chi-square

Results

Patients

The mean age was 82 years (females: 83 years, men: 81 years). 72% were women. The fractures were divided into 5 time periods (2005–2006, 2007–2008, 2009–2010, 2011–2012, 2013–2014). Baseline characteristics for patients treated in the different time periods are shown in Table 1. There were only small differences in age and sex between the 5 time periods, but due to a large number of patients the differences were statistically significant. According to the ASA classification, we found a statistically significant ($p < 0.001$) increase in the physical status, and in particular the proportion of patients in ASA class 3, during the 10-year study period. Further, an increasing proportion of intracapsular fractures were classified as displaced during the study period ($p < 0.001$).

Time trends

The surgical treatment changed for all fracture types. The proportion of undisplaced FFNs treated with hemiarthroplasty (HA) increased from 2.1% in the first period (2005–2006) to 9.7% in the last period (2013–2014) (Figure 1A). The proportion of displaced FFNs treated with HA increased markedly from 52% to 85%. When including also THAs, the number of arthroplasties for displaced FFNs increased from 56% to 93%. In the last period only 5.6% of the displaced FFNs were treated with internal fixation (Figure 1B). Most basocervical fractures were treated with a sliding hip screw (SHS), but a higher number of these fractures were treated with an intramedullary nail (IMN) or HA in the last period (14% and 13% respectively) (Figure 1C). AO/OTA A1 trochanteric fractures were most often treated with an SHS. However, the proportion of fractures treated with an IMN increased from 9.1% in 2005–2006 to 26% in 2013–2014 (Figure 1D). An SHS was also the most commonly used treatment for the AO/OTA A2 trochanteric fractures, but a trochanteric support plate was used in addition in 51% of the SHS operations. For these fractures, the proportion of IMNs increased from 15% to 33% during the study period (Figure 1E). For the AO/OTA A3 intertrochanteric fractures and subtrochanteric fractures, the proportion of IMNs increased markedly during the study period from 27% in 2005–2006 to 61% in 2013–2014 (Figure 1F).

Implants

Olmed screws (DePuy Synthes) and Richards CHP (Smith & Nephew) were the most commonly used implants for screw osteosynthesis (Table 2, see Supplementary data). All prostheses used were contemporary. The same brands of femoral

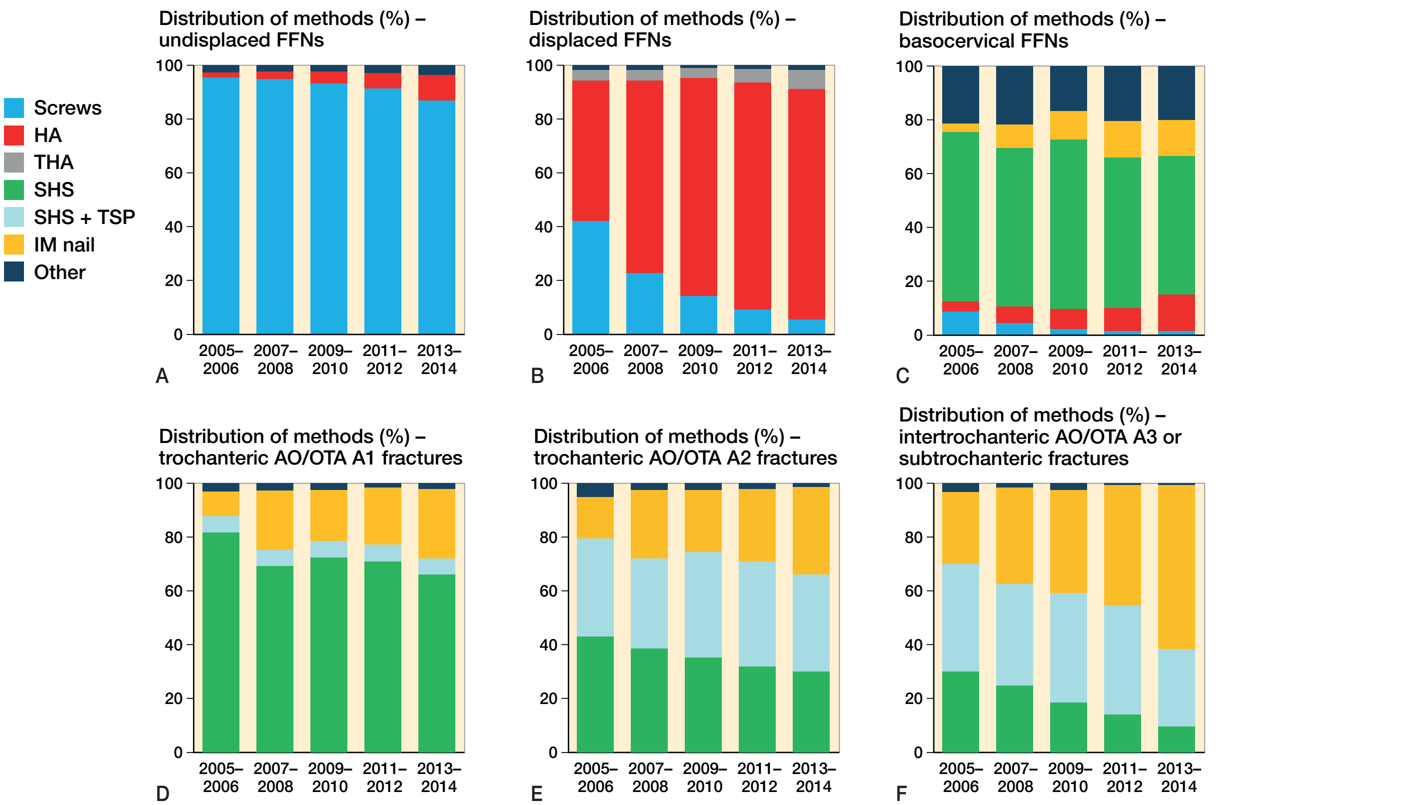

Figure 1. Operation methods for different fracture types. HA hemiarthroplasty, THA total hip arthroplasty, SHS sliding hip screw, TSP trochanteric supportplate, IM intramedullary.

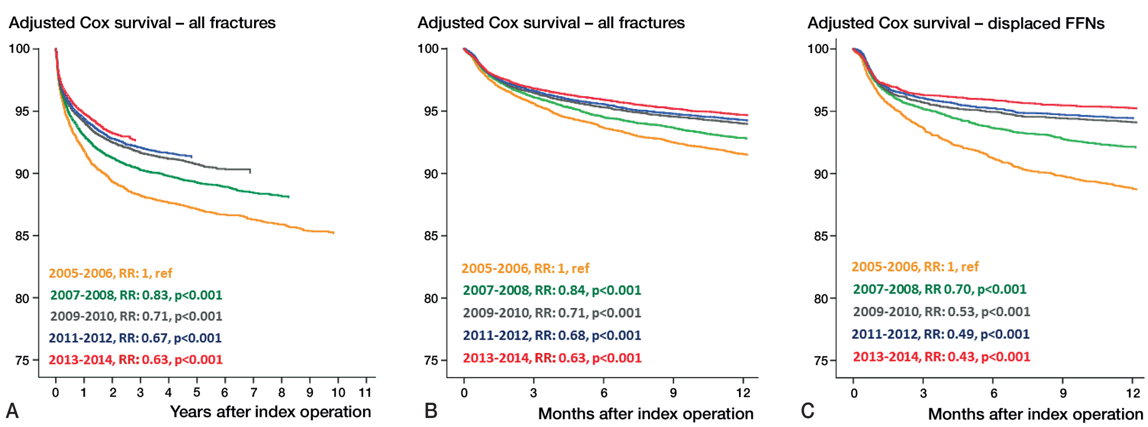

Figure 2. Reoperations. Cox survival curves adjusted for differences in age groups, sex, and ASA class.

stems were used for both HAs and THAs. The Exeter polished stem (Stryker) was the most frequently used cemented stem (34%) and the Corail HA-coated stem (DePuy Synthes) was the most frequently used uncemented stem (31%). Uncemented stems were more frequently used in THAs than in HAs (38% vs. 26% of the cases respectively).

Reoperations

The adjusted overall risk for reoperation for all fractures was reduced by 37% from the first study period (2005–2006) to the last study period (2013–2014) (RR 0.63 (95% CI: 0.57–0.68) (Table 3, see Supplementary data, Figure 2A). Also adjusted 1-year risk for reoperation was reduced for all fractures (RR 0.63 (0.57–0.69)) (Figure 2B) and for displaced FFNs (RR 0.43 (0.37–0.49)) (Figure 2C). For the other fracture types no statistically significant changes in risk for reoperation were found. The estimates from the competing risk analyses were virtually the same as those from the Cox proportional hazards analyses.

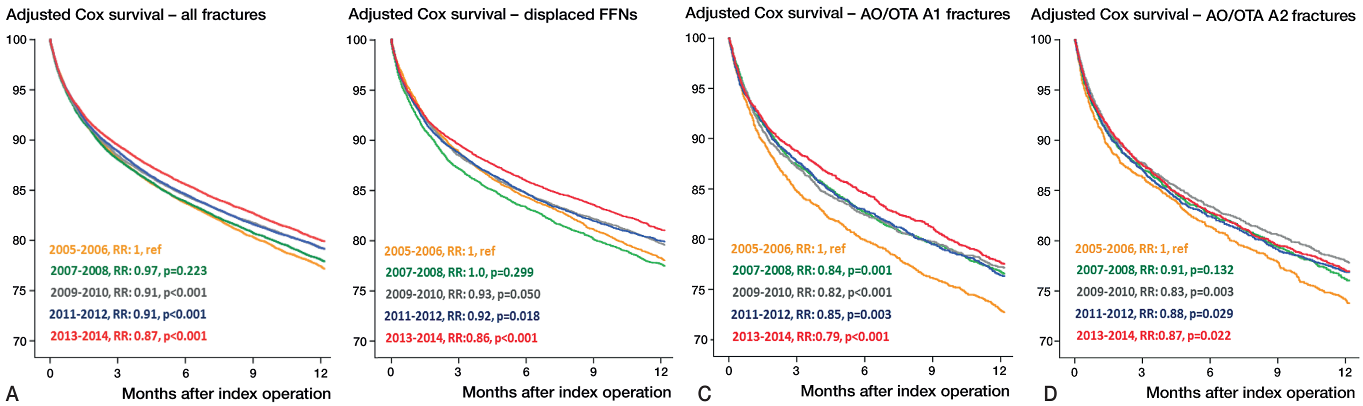

Figure 3. 1-year mortality. Cox survival curves adjusted for differences in age group, sex, and ASA-class

Mortality

No statistically significant difference in unadjusted 1-year risk of death between the first study period (2005–2006) compared with the last study period (2013–2014) were found either for all fractures or for any specific fracture type (Table 4, see Supplementary data). However, when adjusting for differences in age-group, sex, and comorbidity (ASA score) the 1-year mortality in the last time period was lower for all fractures (RR: 0.87 (95% CI: 0.83–0.91)), displaced FFNs (RR 0.86 (0.80–0.93)), AO/OTA A1 trochanteric fractures (RR: 0.79 (0.71–0.88)), and AO/OTA A2 trochanteric fractures (RR: 0.87 (0.77–0.98)) when compared with the first study period (Table 4, see Supplementary data) (Figures 3A–D).

Discussion

We found a substantial change in surgical treatment of hip fractures in Norway during the first decade of national hip fracture registration. During these years more displaced FFNs were treated with arthroplasty at the expense of screw fixation. Further, trochanteric fractures, in particular AO/OTA A3 type fractures, and subtrochanteric fractures, were more frequently treated with IM nails at the expense of sliding hip screws. The change in treatment for displaced FFNs resulted in fewer reoperations after these fractures. However, a similar reduction in reoperations after the other fracture types was not found. The 1-year mortality after displaced FFNs and trochanteric fractures was reduced during the study period.

During the 10-year time period arthroplasty became the dominant treatment for displaced FFNs. This is in line with trends in other countries, and most probably a result of several studies concluding that arthroplasty is superior to IF for these fractures (Rogmark and Johnell 2006, Gao et al. 2012, Jiang et al. 2015). The superiority of HA over IF for the displaced FFNs was shown in a Norwegian randomized controlled study in 2007 (Frihagen et al. 2007), and the NHFR reported similar national results 3 years later (Gjertsen et al. 2010). The knowledge from these 2 studies may have contributed to the change in treatment methods at a national level. For the undisplaced FFNs arthroplasties were rarely used during the earlier time periods. However, a small increase was observed in the last study period. One reason for such an increase could be the awareness of posterior tilt as a risk factor for reoperation (Palm et al. 2009, Dolatowski et al. 2016). Traditionally, only displacement in the AP view has been considered when deciding the treatment of FFNs. It has more recently been advocated to treat fractures with more than 20 degrees of posterior tilt with an arthroplasty (Palm et al. 2009, Dolatowski et al. 2016). The Garden classification, which is used in the NHFR dataset, classifies these fractures as undisplaced despite displacement in the lateral view. Further, an ongoing randomized controlled multicenter study performed at several hospitals in Norway comparing osteosynthesis and hemiarthroplasty for undisplaced FFNs might also partly explain the increased use of arthroplasty for these fractures in the last study period. An increasing portion of FFNs was classified as displaced during the studied 10-year period. The reason for this is unclear, but a change in surgeons' classification practice for FFNs during the study period may be one explanation.

2 large register studies on extracapsular hip fractures have been performed by the NHFR during the 10-year period investigated in the present study (Matre et al. 2013a, b). The first study found that a sliding hip screw (SHS) resulted in a lower risk for reoperation after trochanteric AO/OTA A1 fractures than IMN (Matre et al. 2013a). The second study investigated AO/OTA A3 fractures and subtrochanteric fractures and found lower risk for reoperation and better functional outcome after IMN compared with SHS (Matre et al. 2013b). Monitoring the treatment in the NHFR has shown a large increase in use of IMN for the A3/subtrochanteric fractures, in particular after the results of the above study were published. The use of IMNs for AO/OTA A1 fractures also increased, but much less than seen for the AO/OTA A3 fractures/subtrochanteric fractures. This increase is not supported by the findings of Matre et al. (2013a) and might explain the lack of improvement for

trochanteric fractures. Further, the observed increase in use of IMNs for trochanteric fractures was smaller than what has been reported in other studies (Anglen and Weinstein 2008, Rogmark et al. 2010).

We found a decrease in number of reoperations after displaced FFNs during the study period. This can be attributed to the increased use of arthroplasty in the treatment of these fractures. We suspected a decrease in reoperations also after A3 trochanteric/subtrochanteric fractures, as the proportion of these fractures treated with IMN increased during the period studied, but that was not found. The reason for this is unclear.

The 1-year mortality was reduced for displaced FFNs and for trochanteric fractures. Repeated surgery after hip fractures may increase the risk of new complications and may also, at least temporarily, increase both morbidity and mortality for the patients. Accordingly, a reduction in number of reoperations may explain higher survival of patients. The results confirm that despite more extensive prosthesis surgery for patients with displaced FFNs during the study period the mortality for these patients has decreased. In the last decade there has been increased focus on the entire perioperative treatment of hip fracture patients in Norway. Specialized hip fracture units and orthogeriatric cooperation in the treatment of these patients has been established (Watne et al. 2014, Prestmo et al. 2015). This may also have contributed, at a national level, to better survival of patients.

Our study is not a randomized controlled study and confounders may therefore exist.

We are aware that underreporting of reoperations probably exists in the NHFR, in particular reoperations for minor complications such as pain from the hardware and reoperations for superficial infection and dislocation of prostheses. In addition, closed reductions of dislocated THAs are not registered in the NAR and were, accordingly, not included in our study. We have no indication that the completeness of reporting of reoperations to the NHFR and NAR has changed during the period studied.

The strength of our study is the high number of patients, and that we present average results on a national level. National registration has proved to be a useful way of monitoring the treatment of hip fractures.

In summary, surgeons in Norway have adapted results from recent studies and changed their surgical practice in the treatment of hip fractures during the first 10 years of national registration. More extensive surgery, in particular with more use of arthroplasties for displaced FFNs, has improved the surgical outcome by reducing the number of reoperations after hip fracture surgery and reduced the mortality for patients with hip fractures.

Supplementary data

Tables 2–4 are available as supplementary data in the online version of this article, http://dx.doi.org/ 10.1080/17453674.2017.1344456

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The study was planned and designed by all authors. JEG and ED performed the statistical analyses. JEG drafted the manuscript. All authors participated in the interpretation of results and revision of manuscript.

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