SURGICAL TREATMENT OF PATIENTS WITH DISPLACED FEMORAL NECK FRACTURES

ASPECTS ON OUTCOME AND SELECTION CRITERIA

RICHARD BLOMFELDT
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Sailing is life........
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ABSTRACT

The optimal treatment for elderly patients with femoral neck fractures, i.e. internal fixation (IF), hemiarthroplasty (HA) or total hip replacement (THR), should be based on the individual patient’s age, functional demands and risk profile. IF is uncontroversial in the treatment of undisplaced (Garden I and II) femoral neck fractures and good results regarding fracture healing, function and the health-related quality of life (HRQoL) can be expected. IF is also the method of choice in young patients with displaced fractures (Garden III and IV) and in patients not medically fit for an arthroplasty.

Recent randomised controlled trials (RCTs) have shown that a primary THR is superior to IF in the relatively healthy, lucid elderly patient with a displaced femoral neck fracture during the first two years after the operation. There are few published reports on the outcome in a longer time perspective. Despite the good results for THR in this patient group, a vast majority of orthopaedic surgeons prefer HA instead of THR. Furthermore, in spite of the high failure rate for IF, the method is still recommended for this patient cohort by some authors. One argument is that if IF fails, there is always the possibility of performing a secondary salvage THR. Patients with severe cognitive dysfunction pose significant challenges to the treating surgeon in several respects, e.g. lack of compliance, problems in assimilating rehabilitation regimens and frequent co-morbidities, so the optimal treatment for this patient cohort is still controversial.

In an RCT with a four-year follow-up period, lucid, elderly patients with an acute displaced femoral neck fracture were randomly allocated to THR or IF. The results confirm that a primary THR, compared to IF, provides a better outcome. The complication and re-operation rates were significantly lower and the outcome regarding hip function and HRQoL were at least as good, even in this longer time perspective.

In a prospective trial with a two-year follow-up period lucid, elderly patients treated for an acute displaced femoral neck fracture were included. The outcome for patients with a primary THR was compared with the outcome for patients treated with a secondary THR after failed IF. Hip function was significantly better in the primary THR group and patients with failed IF later undergoing a secondary THR experienced a significant decrease in HRQoL during the first year of treatment compared with patients in the primary THR group.

In an RCT with a one-year follow-up period, lucid, elderly patients with an acute displaced femoral neck fracture were randomised to a bipolar HA or THR. The results indicate that a THR provides better hip function than a bipolar HA as soon as after one year without increasing the complication rate. There are good reasons to assume that this difference will increase with time.

In an RCT with a two-year follow-up period, patients with severe cognitive impairment and a displaced femoral neck fracture were randomly allocated to treatment by either IF or a unipolar HA (uncemented Austin Moore HA). The mortality rate was very high and the deterioration in ADL function, walking ability and HRQoL was pronounced in both randomisation groups, reflecting the major impact of the severe cognitive dysfunction. The results imply that there does not seem to be any advantage in performing an uncemented Austin Moore HA compared to IF in this selected patient cohort.

The overall conclusion of the thesis is that THR can be recommended as the primary treatment for the relatively healthy, active and lucid elderly patient with a displaced femoral neck fracture. Bipolar HA can be recommended for the most elderly patients with lower functional demands. The optimal treatment for patients with severe cognitive impairment and a displaced femoral neck fracture needs to be further evaluated.
LIST OF PAPERS

This thesis is based on the following papers, which are referred to in the text by their Roman numerals (Studies I-IV).

I  COMPARISON OF INTERNAL FIXATION WITH TOTAL HIP REPLACEMENT FOR DISPLACED FEMORAL NECK FRACTURES. RANDOMIZED CONTROLLED TRIAL PERFORMED AT FOUR YEARS.
Blomfeldt R, Törnkvist H, Ponzer S, Söderqvist A, Tidermark J.

II  DISPLACED FEMORAL NECK FRACTURE: COMPARISON OF PRIMARY TOTAL HIP REPLACEMENT WITH SECONDARY TOTAL HIP REPLACEMENT AFTER FAILED INTERNAL FIXATION. A TWO-YEAR FOLLOW-UP OF 84 PATIENTS.
Blomfeldt R, Törnkvist H, Ponzer S, Söderqvist A, Tidermark J.
Acta Orthopaedica 2006;77:683-643.

III  BIPOLAR HEMIARTHRROPLASTY COMPARED WITH TOTAL HIP REPLACEMENT FOR DISPLACED FEMORAL NECK FRACTURES. A RANDOMISED CONTROLLED TRIAL.
Accepted for publication in Journal of Bone and Joint Surgery (Br).

IV  INTERNAL FIXATION VERSUS HEMIARTHRROPLASTY FOR DISPLACED FRACTURES OF THE FEMORAL NECK IN ELDERLY PATIENTS WITH SEVERE COGNITIVE IMPAIRMENT. A RANDOMISED CONTROLLED TRIAL.
Blomfeldt R, Törnkvist H, Ponzer S, Söderqvist A, Tidermark J.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADL</td>
<td>Activities of daily living</td>
</tr>
<tr>
<td>AVN</td>
<td>Avascular necrosis</td>
</tr>
<tr>
<td>EQ-5D</td>
<td>The five-dimensional scale of the EuroQol</td>
</tr>
<tr>
<td>fx</td>
<td>Fracture</td>
</tr>
<tr>
<td>HA</td>
<td>Hemiarthroplasty</td>
</tr>
<tr>
<td>HHS</td>
<td>Harris hip score</td>
</tr>
<tr>
<td>HRQoL</td>
<td>Health-related quality of life</td>
</tr>
<tr>
<td>IF</td>
<td>Internal fixation</td>
</tr>
<tr>
<td>ns</td>
<td>Not significant</td>
</tr>
<tr>
<td>OA</td>
<td>Osteoarthritis</td>
</tr>
<tr>
<td>RA</td>
<td>Rheumatoid arthritis</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>SF-36</td>
<td>Short Form 36</td>
</tr>
<tr>
<td>SPMSQ</td>
<td>Short Portable Mental Status Questionnaire</td>
</tr>
<tr>
<td>THR</td>
<td>Total hip replacement</td>
</tr>
<tr>
<td>TTO</td>
<td>Time Trade-Off</td>
</tr>
</tbody>
</table>
INTRODUCTION

BACKGROUND

A hip fracture, especially a displaced femoral neck fracture, is probably the most devastating consequence of osteoporosis in the increasing elderly population and a major challenge for health care and society. In the year 2050 6.3 million annual hip fractures are expected to occur worldwide. Femoral neck fractures constitute approximately 50% of all hip fractures and 70-75% of the femoral neck fractures are displaced (Garden III and IV). The population of elderly patients with femoral neck fractures comprises several subpopulations, ranging from the lucid, relatively healthy, active and independently living patient with a long life expectancy to the institutionalised, cognitively impaired and bedridden patient with a substantially shorter life expectancy. There are several treatment modalities for patients with femoral neck fractures, i.e. internal fixation (IF), hemiarthroplasty (HA, unipolar or bipolar) and total hip replacement (THR), each treatment modality having its unique characteristics, advantages and disadvantages.

Internal fixation is uncontroversial in the treatment of undisplaced (Garden I and II) femoral neck fractures. Among patients with undisplaced fractures, the rate of fracture healing complications after IF is in the range of 5-10% in most studies and good results regarding function and the health-related quality of life (HRQoL) can be expected. IF is also the method of choice in young patients with displaced fractures. The rate of fracture healing complications in the younger age group has been less well reported. However, due to these patients’ longer life expectancy and consequently higher risk of revision surgery after an arthroplasty, IF is the preferred method. Most previous studies have used 65–70 years as the lower age limit for arthroplasty, i.e. the upper limit for IF, in patients with displaced fractures, but the optimal age limit is pending. Recently, age 55 has been suggested to be the lower limit for THR.

Among patients with displaced fractures, the rate of fracture-healing complications after IF is considerably higher, being, in most studies with an at least two-year follow-up, in the range of 35-50%. Moreover, many patients experience impaired hip function and a reduced HRQoL despite an uneventfully healed fracture.

The alternative treatment is a primary hip arthroplasty, unipolar HA, bipolar HA or THR. In a recently published international survey of the operative management of displaced femoral neck fractures in elderly patients, there was some consensus that younger patients should be treated with internal fixation and older patients with arthroplasty. The preferred method for the most elderly was HA, unipolar or bipolar, but there was significant disagreement regarding the optimal approach to the management of the active elderly patients between 60 and 80 years of age.

Some of the remaining controversies regarding the optimal treatment for the vast majority of the elderly patients may be partly explained by the long-lasting ambition to find a single surgical method to treat all patients with a displaced fracture of the femoral neck. Therefore, many of the previous studies have included a broad spectrum of patients of varying age with differing functional levels and risk profiles in order to be able to present results that can be generalised to the entire population of patients with displaced femoral neck fractures. How-
ever, the surgical treatment of displaced femoral neck fractures differs from the treatment of many other hip fractures because the available treatment modalities, IF, HA and THR, differ regarding surgical impact, complications and the long-term outcome. There is a growing opinion that the treatment of elderly patients with displaced femoral neck fractures should be individualised, i.e. should include all available surgical options and be based on the individual patient’s age, functional demands and risk profile. Therefore, future trials should be undertaken to identify groups of patients who would be better treated by any of the surgical methods available.

The primary aim of this thesis was to evaluate the different surgical treatment modalities for the relatively healthy, active and independently living patient with a displaced femoral neck fracture (Studies I, II and III) and, furthermore, to evaluate the outcome for the severely cognitively impaired patient with a displaced femoral neck fracture (Study IV). The secondary aim was to define patient selection criteria in order to establish a clinically feasible treatment algorithm.

THE RELATIVELY HEALTHY ELDERLY PATIENT
TOTAL HIP REPLACEMENT VS INTERNAL FIXATION
Recent randomised controlled trials (RCTs) have shown that, for the relatively healthy, active and lucid elderly patient with a displaced femoral neck fracture, a primary THR is superior to IF regarding the need for secondary surgery, hip function and the health-related quality of life (HRQoL). The follow-up period in these trials is limited to two years except in the study by Neander et al. (partly randomised) and Ravikumar et al., in which the follow-up period is 4 and 13 years, respectively. However, none of these trials with a longer follow-up time includes an assessment of the HRQoL.

PRIMARY TOTAL HIP REPLACEMENT VS SECONDARY TOTAL HIP REPLACEMENT AFTER FAILED INTERNAL FIXATION
Despite the high failure rate for IF, in the range of 35-50%, the method has been recommended for this patient cohort by some authors. Firstly, it is often claimed that retaining the patient’s own femoral head will give better hip function than a primary THR. Secondly, if IF fails, there is always the possibility of performing a salvage THR. There are a few studies suggesting that a secondary THR after failed internal fixation will yield results comparable to those of a primary THR. However, both of these studies compare the results of a secondary THR after failed IF with the results of a primary THR in patients with degenerative joint disease, mainly osteoarthritis. To the best of our knowledge, there is only one study comparing primary THR with a secondary THR after failed IF and showing a significantly higher complication rate and an inferior functional outcome in the secondary THR group. This study did not include an assessment of the HRQoL nor any prospective data on patient outcome during the treatment period before the secondary THR.
**TOTAL HIP REPLACEMENT VS BIPOLAR HEMIARTHROPLASTY**

Despite the good results with THR in the relatively healthy, active and lucid elderly patient, a vast majority of orthopaedic surgeons prefer HA instead of THR.\(^2\) Two meta-analyses\(^{20,21}\) identified only a limited number of studies\(^{22,23}\) that evaluate the optimal type of arthroplasty in properly designed RCTs. The overall conclusion was that there is still inadequate evidence to support the choice between different types of arthroplasties.

A recent multicentre RCT comparing IF, bipolar HA and THR concluded that THR was clearly superior to IF and should be regarded as the treatment of choice for the fit elderly patient with a displaced femoral neck fracture.\(^{11}\) There also seemed to be an advantage for THR over bipolar HA, especially in the longer time perspective, but the authors recommended further trials to verify this finding.

**THE SEVERELY COGNITIVELY IMPAIRED PATIENT**

**INTERNAL FIXATION VS UNIPOLAR HEMIARTHROPLASTY**

Delirium (i.e. acute confusion) and dementia are two well-known risk factors in the treatment of hip fracture patients. A common denominator of both these conditions is the presence of cognitive dysfunction, defined as a disturbance in the patient’s mental processes related to thinking, reasoning and judgment. Previous studies indicate that hip fracture patients with impaired cognitive function have an increased risk for general as well as fracture-related complications.\(^{24}\) Despite this knowledge, an assessment of cognitive function is often lacking in nursing and medical records for a substantial number of older people with hip fractures.\(^{25,26}\) Moreover, the routine assessment of cognitive function made by the ward nurses often differs from the assessment obtained with the aid of a validated instrument, especially in patients with impaired cognitive ability.\(^{27}\)

Patients with severe cognitive dysfunction pose significant challenges to the treating surgeon in several respects, e.g. lack of compliance, problems in assimilating rehabilitation procedures and frequent co-morbidities. In patients with an associated displaced femoral neck fracture, this may severely affect the outcome after a hip arthroplasty, as shown in the study by Johansson et al. in which the dislocation rate after a THR was 32% in cognitively impaired patients.\(^{7}\) To the best of our knowledge, there is only one previous study including severely cognitively impaired patients with displaced femoral neck fractures.\(^{28}\) Sixty patients were randomised to either IF or HA (uncemented Austin Moore prosthesis). The Cognitive Screening Test, which is an instrument derived from the Short Portable Mental Status Questionnaire (SPMSQ),\(^{29}\) was used to assess cognitive function. The one-year mortality rate was 43% and the two-year rate was 57%. Functional outcome was reported at the one-year follow-up and among one-year survivors who were walkers before the fracture; only 20% in the HA group and 36% in the IF group were still mobile. There were wound infections in 17% in the HA group and deep infections requiring surgical intervention in at least 3.4%. The general conclusion was that the chance of successful rehabilitation was small regardless of the surgical procedure and that IF was the treatment of choice because it is a minor surgical procedure with less morbidity.
AIMS OF THE STUDIES

STUDY I
The primary aim of the study was to determine if the superior outcome of a primary THR, as compared to IF, for a lucid elderly patient with a displaced femoral neck fracture persists with a four-year follow-up. The secondary aim was to describe the HRQoL (EQ-5D) within this group of patients within the same period of time.

STUDY II
The primary aim of the study was to determine if a primary THR, as compared to a secondary THR after failed IF, yields a better outcome after two years for an active, lucid, elderly patient with a displaced femoral neck fracture. The secondary aim was to describe the HRQoL (EQ-5D) within the group of patients with a failed IF and later undergoing a secondary THR during the treatment period.

STUDY III
The aim of the study was to analyse the outcome regarding hip function and HRQoL (EQ-5D) after a displaced femoral neck fracture in an active, lucid, elderly patient randomised to either a bipolar HA or a THR.

STUDY IV
The primary aim of the study was to compare the outcome in patients with severe cognitive impairment and a displaced femoral neck fracture randomly allocated to either IF or HA. The secondary aim was to describe the HRQoL (EQ-5D) within this defined group of patients.
PATIENTS AND METHODS

ETHICS

All studies were conducted according to the Helsinki Declaration and each protocol was approved by the local ethics committee. In Studies I-III, all patients gave their informed consent to participate. In Study IV, including patients with severe cognitive dysfunction, consent was given for the patients by a close relative or guardian before inclusion.

AGE AND GENDER

In Studies I, II and IV patients aged 70 or older were included. The mean age in Study I was 80 years with 80% of the patients being female; in Study II the mean age was 80 years with 89% being female; in Study IV the mean age was 84 years with 90% of the patients being female. In Study III patients aged 70-90 years were included and the mean age was 81 years with 84% being female.

STUDY I

One hundred and two patients with an acute displaced femoral neck fracture were randomly allocated to THR or IF (Table 1). The inclusion criteria were an acute displaced femoral neck fracture (Garden III and IV), age ≥ 70 years, absence of severe cognitive dysfunction, independent living status and independent walking ability. Patients with pathological fractures, displaced fractures older than 24 hours, and patients with rheumatoid arthritis (RA) or osteoarthritis (OA) were not included. Follow-ups were done at 4, 12, 24 and 48 months.

The results at the 4, 12 and 24-month follow-ups have been reported previously. At the 48-month follow-up (mean 48.8, SD 1.6), 25% of the patients were deceased.

STUDY II

Eighty-four patients with a THR after an acute displaced femoral neck fracture were included (Table 1). Forty-three patients with a primary THR and 8 patients with a secondary THR after failed IF from Study I were included (Table 1). In order to increase the power of the study, another 31 patients with a secondary THR owing to failed IF after a displaced femoral neck fracture were recruited.

All patients satisfied the same inclusion criteria before the primary operation, i.e. a displaced femoral neck fracture (Garden III and IV), age ≥ 70 years, absence of severe cognitive dysfunction, independent living status and independent walking. Patients with pathological fractures, displaced fractures older than 24 hours and patients with RA or OA were not included. Follow-up was performed at 24 months (mean 24.8, SD 3.5) after the THR.
STUDY III

One hundred and twenty patients with an acute displaced femoral neck fracture were randomised to a bipolar HA or a THR (Table 1). The inclusion criteria were an acute displaced femoral neck fracture (Garden III and IV), age 70-90 years, absence of severe cognitive dysfunction, independent living status and independent walking ability. Patients with pathological fractures, displaced fractures older than 48 hours and patients with RA or OA were not included. Follow-ups were done at 4 (mean 4.1, SD 0.6) and 12 months (mean 12.3, SD 1.1). The one-year mortality rate was 5.8%.

STUDY IV

Sixty patients with an acute displaced femoral neck fracture were randomly allocated to IF or unipolar HA (uncemented Austin Moore arthroplasty) (Table 1). The inclusion criteria were an acute displaced femoral neck fracture (Garden III and IV) age ≥ 70 years, severe cognitive dysfunction, i.e. < 3 correct answers on the Short Portable Mental Status Questionnaire (SPMSQ) and independent walking capability. Patients with pathological fractures, displaced fractures older than 24 hours and patients with RA or OA were not included. The patients were reviewed at 4 (mean 4.1, SD 0.4), 12 (mean 12.5, SD 1.1) and 24 (mean 24.9, SD 1.3) months after surgery. At the two-year follow-up 42% of the patients were deceased.

Table 1.
Patient inclusion algorithm for all studies.

<table>
<thead>
<tr>
<th>STUDY I</th>
<th>STUDY II</th>
<th>STUDY III</th>
<th>STUDY IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 102</td>
<td>n = 84</td>
<td>n = 120</td>
<td>n = 60</td>
</tr>
<tr>
<td>IF n</td>
<td>THR n</td>
<td>PrimTHR n</td>
<td>SecTHR n</td>
</tr>
<tr>
<td>49</td>
<td>53</td>
<td>43 From Study I</td>
<td>8 From Study I</td>
</tr>
<tr>
<td>PrimTHR n</td>
<td></td>
<td>33 Matched group</td>
<td>60 THR n</td>
</tr>
<tr>
<td>Matched group</td>
<td></td>
<td>60 Uni-HA n</td>
<td>30 IF n</td>
</tr>
</tbody>
</table>

RANDOMISATION

The randomisation procedures in Studies I, III and IV were performed with numbered, opaque and sealed envelopes.

Study II was only partly randomised: see Table 1 and the Patient and Methods section, Study II.
FRACTURE CLASSIFICATION

All patients included had a displaced femoral neck fracture (Garden III and IV). The Garden classification is shown in Figures 1 and 2.

The valgus-impacted Garden I fracture and the undisplaced Garden II fracture (Figure 1) have the same good prognosis after internal fixation and are referred to as undisplaced femoral neck fractures. The partially displaced Garden III fracture and the fully displaced Garden IV fracture (Figure 2) have the same poor prognosis after internal fixation and are referred to as displaced femoral neck fractures. It should also be emphasised that the Garden classification is based on the anterior-posterior (AP) view. Some dorsal angulation in the lateral view is not uncommon in Garden I fractures.

Figure 1.
Garden’s classification: Undisplaced fractures of the femoral neck.

Figure 2.
Garden’s classification: Displaced fractures of the femoral neck.

CO-MORBIDITY

Co-morbidity was assessed using the Ceder scale. The scale categorises the patients into three groups, graded as A - full health, B - another illness not affecting rehabilitation and C - another illness that affects the rehabilitation.
ANAESTHESIOLOGICAL ASSESSMENT

All patients were examined and cleared by an anaesthesiologist before randomisation. The assessment included a decision as to whether the patient was fit enough for both randomisation procedures.

COGNITIVE FUNCTION

Cognitive function was assessed with the Short Portable Mental Status Questionnaire (SPMSQ). After answering the ten-item mental test (Table 2), the patients were classified into four categories: 8-10 correct answers = cognitive function intact; 6-7 correct answers = cognitive function mildly impaired; 3-5 correct answers = cognitive function moderately impaired and 0-2 correct answers = cognitive function severely impaired.

In Studies I, II and III only patients without severe cognitive function (SPMSQ ≥ 3) were included. In Study IV only patients with severe cognitive dysfunction (SPMSQ <3) were included.

Table 2.
The short Portable Mental Status Questionnaire (SPMSQ).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>What is the date today?</td>
</tr>
<tr>
<td>2.</td>
<td>What day of the week is it?</td>
</tr>
<tr>
<td>3.</td>
<td>What is the name of this place?</td>
</tr>
<tr>
<td>4.</td>
<td>What is your telephone number or, alt. street address?</td>
</tr>
<tr>
<td>5.</td>
<td>How old are you?</td>
</tr>
<tr>
<td>6.</td>
<td>When were you born?</td>
</tr>
<tr>
<td>7.</td>
<td>Who is the prime minister now?</td>
</tr>
<tr>
<td>8.</td>
<td>Who was prime minister before him/her?</td>
</tr>
<tr>
<td>9.</td>
<td>What was your mothers maiden name?</td>
</tr>
<tr>
<td>10.</td>
<td>Subtract 3 from 20 and keep subtracting 3 from each new number, all the way down.</td>
</tr>
</tbody>
</table>

SOCIAL SITUATION

In Studies I, II and III we included only patients from independent living conditions, i.e. own home, old people’s home or block of service flats. In Study IV we also included patients from institutions, i.e. care groups for demented patients or nursing homes.

MOBILITY

All patients included had independent walking capability with or without a walking aids before the fracture.
ADL

The activities of daily living status was assessed with the Katz ADL index. This index is based on an evaluation of the functional independence or dependence of patients in bathing, dressing, going to the toilet, transferring, continence and feeding. ADL index A indicates independence in all six functions and index B independence in all but one of the six functions. Indexes C-G indicate dependence in bathing and additionally one to five more functions.

In order to be able to display the outcome for the highly dependent patients included in Study IV, the ADL index was presented as an ordinal scale from 0 (independent) to 6 (dependent in all functions) and the percentage of patients with the score 6 were displayed.

HIP FUNCTION

In Studies I, II and IV, where we compared the outcome after IF and different types of hip arthroplasties, Charnley’s classification was used to assess hip function. The Harris hip score was used to assess hip function in Study III where we compared the outcome after bipolar HA and THR.

Charnley’s numerical classification defines the clinical state of the affected hip joint in three dimensions: pain, movement and walking ability. Each dimension is graded from 1 to 6 with 1 = total disability and 6 = normal state (Table 3). The mean values were presented in Studies I, II and IV. In Study I we also presented the percentage of patients with the best scores, 5 and 6 and in Study IV the percentage of patients with the worst score, 1.

Table 3.

<table>
<thead>
<tr>
<th>Pain</th>
<th>Movement</th>
<th>Walking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Severe and spontaneous</td>
<td>0-30°</td>
</tr>
<tr>
<td>2</td>
<td>Severe on attempting to walk, prevents all activity</td>
<td>60°</td>
</tr>
<tr>
<td>3</td>
<td>Tolerable, permitting limited activity</td>
<td>100°</td>
</tr>
<tr>
<td>4</td>
<td>Only after some activity, disappears quickly with rest</td>
<td>160°</td>
</tr>
<tr>
<td>5</td>
<td>Slight or intermittent, pain on starting to walk but getting less with normal activity</td>
<td>210°</td>
</tr>
<tr>
<td>6</td>
<td>No pain</td>
<td>260°</td>
</tr>
</tbody>
</table>

The Harris hip score assesses hip function in four dimensions; pain, function, absence of deformity and range of motion. The function dimension is further divided into the following subdimensions: limp, walking distance, walking on stairs, walking aids, dressing, comfort of sitting and use of public transportation. The maximum possible score is 100 (Table 4).
Table 4.
Harris hip score.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Pain</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>II Function</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>III Absence of deformity</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>IV Range of motion</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total score</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

QUALITY OF LIFE

HRQoL was assessed with the EuroQol (EQ-5D). The EuroQol consists of four components, the health status part (EQ-5D), visual analogue scale (EQ-VAS), the valuation part and background data. The first part, the EQ-5D, was used in the studies. The EQ-5D is a standardised non-disease-specific instrument that measures the quality of life in five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each dimension is divided into three degrees of severity: no problem, some problem and major problems.

We used the preference scores (EQ-5D index scores) generated from a large UK population (UK EQ-5D Index Tariff) when calculating the scores for our study populations. A value of 0 indicated the worst possible health state and a value of 1 indicated the best possible health state. This is a divergence from the UK EQ-5D Index Tariff where some health states were given negative scores. However, the appropriate scaling of negative scores is controversial and the same approach was used when generating the values for an age-matched Swedish reference population.

All studies included an assessment of the patients’ HRQoL the week before the fracture. To validate the method of rating the prefracture HRQoL and to analyse recall bias, the EQ-5D index scores prior the fracture were compared with those of the age-matched Swedish reference population (Table 5). In Study I (mean age 80 years, 80% being female) the prefracture EQ-5D index score was 0.83. In Study II (mean age 80 years, 89% being female) the prefracture EQ-5D index score in patients recruited from Study I was 0.81. In Study III (mean age 81 years, 84% being female) the prefracture EQ-5D index score was 0.80. Finally, in Study IV, including only patients with severe cognitive dysfunction (mean age 84 years, 90% being female), the prefracture EQ-5D index score was 0.26.
Table 5.
EQ-5D\textsubscript{index} scores for an age-matched Swedish reference population.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>60-69 (n=387)</th>
<th>70-79 (n=338)</th>
<th>80-88 (n=122)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0.80</td>
<td>0.79</td>
<td>0.74</td>
</tr>
<tr>
<td>Male</td>
<td>0.83</td>
<td>0.81</td>
<td>0.74</td>
</tr>
<tr>
<td>Female</td>
<td>0.78</td>
<td>0.78</td>
<td>0.74</td>
</tr>
</tbody>
</table>

SURGICAL PROCEDURES

INTERNAL FIXATION

Figure 3.
Displaced femoral neck fracture, treated with internal fixation (cannulated screws)

Internal fixation (Studies I and IV) was carried out with the patient on a fracture table. The fractures were reduced by closed methods with the aid of an image intensifier and fixed internally with two cannulated screws (Olmed \textsuperscript{®}, dePuy/Johnson-Johnson, Sweden) (Figure 3). The goals for screw positioning were modified from the recommendations by Lindequist et al.\textsuperscript{38} The reduction was categorised as good (displacement < 2mm, Garden angle 160-175°, posterior angulation <10°), fair (displacement <5mm, Garden angle 160-175°, posterior angulation <20°) or poor (displacement > 5mm, Garden angle < 160° or > 175°, posterior angulation >20°). The screw position was categorised as good if the screw tips were less than 5 mm from the subchondral bone. In the anterior-posterior (AP) projection, the distal screw was aimed to be introduced at the level of the lesser trochanter and to lie on the calcar femorale. The proximal screw was introduced at least 2 cm apart from and parallel to the distal one (the
angle being less than 10°). In the lateral projection, the screws were to be parallel and positioned in the central or posterior third of the femoral head and neck.

The fracture was defined as healed if there were visible trabeculations across the fracture line and no signs of avascular necrosis (AVN). Non-union was defined as an absence of radiographically visible trabeculations across the fracture line, including early redisplacement or progressive displacement. AVN was defined as the presence of a subchondral fracture (crescent line), loss of sphericity of the femoral head or segmental collapse.

HIP REPLACEMENT

Hip replacement was carried out using an anterolateral approach, a modified Hardinge approach, with the patient in the lateral decubitus position.

The THR used in Studies I, II and III was the modular Exeter-stem (Stryker Howmedica, Sweden) with a 28-mm head and an OGEE® acetabular component (dePuy/Johnson-Johnson, Sweden) (Figure 4).

The bipolar HA used in Study III was the modular Exeter-stem (Stryker Howmedica, Sweden), with a 28-mm head and a bipolar head (Bicentric or UHR) (Stryker Howmedica, Sweden) (Figure 5).

The unipolar HA used in Study IV was an uncemented Austin Moore HA (dePuy/Johnson-Johnson, Sweden) (Figure 6).

POSTOPERATIVE MOBILISATION

Patients in all groups were mobilised with full weight bearing as tolerated. The patients who were operated upon with an arthroplasty were informed about mobilisation techniques and were allowed to sit on a high chair immediately after surgery and to abandon the crutches at their own convenience. There were no restrictions after 6 weeks.
PROPHYLACTICS
All patients were given low-molecular-weight heparin (Fragmin®, Pharmacia, Sweden) preoperatively and for approximately 10 days postoperatively. All patients treated with hip replacement were given Cefuroxim 1.5 g (Zinacef®, GlaxoSmithKline, Sweden) preoperatively, followed by two additional doses during the first 24 hours. No prophylactics against infection were given to patients treated with internal fixation.

STATISTICAL METHODS
The statistical software used was SPSS for Windows. In Study I all scale variables were tested for normality with the Kolmogorov-Smirnov test. Student’s t-test was used for parametric scale variables in independent groups. The Mann-Whitney U-test was used for non-parametric scale variables and ordinal variables in independent groups. In Studies II-IV all scale variables and ordinal variables in independent groups were tested by the Mann-Whitney U-test. In all studies nominal variables were tested by the Chi-square test or Fisher’s exact test. In Studies III and IV a Wilcoxon signed-rank test was used to compare scores between follow-ups and between baseline and follow-up, respectively. All tests were two-sided. The results were considered significant at $p < 0.05$. Trend values, $0.05 \geq p < 0.1$, were displayed in Studies I, III and IV; all other values were reported as not significant (ns).
RESULTS

STUDY I

SURGICAL OUTCOME

In the entire study population, the rate of hip complications, 4% for THR and 42% for IF (non-unions, 23%, and AVN, 19%), and the rate of reoperated patients, 4% for THR and 47% for IF (arthroplasties, 34%, and screw removal, 13%), were significantly higher in the IF group (p<0.001, respectively). The differences between the groups regarding reoperation were still highly significant if only major reoperations, i.e. the arthroplasties, were included in the IF group (p<0.001). The four-year mortality rate was 24% in the THR group and 25% in the IF group (ns).

In the THR group one out of 35 patients (3%) available at the 48-month follow-up had had a hip complication and reoperation. This patient sustained a periprosthetic fracture after a new fall 6 weeks after the primary operation and was reoperated upon with internal fixation with an uneventful outcome. There were no hip complications in the THR group between the 24 and 48-month follow-ups and there were no signs of radiological loosening of the components in any of the patients at the final follow-up.

In the group of IF patients available at the 48-month follow-up, 16 out of 37 (43%) had a fracture-healing complication. Thirty-two per cent had undergone reoperation with an arthroplasty and 19% had had their screws removed. Between the 24 and 48-month follow-ups the percentage of fracture healing complications increased from 36% to 42% and the percentage of reoperated patients from 42% to 47%.

FUNCTIONAL OUTCOME AND HRQOL

There were no differences in the ADL index between the groups at the 4, 12, 24 and 48-month follow-ups.

Hip function was generally better in the THR group at the 4, 12 and 24-month follow-ups (Table 6). At the 48-month follow-up the difference in hip function was not significant. Both groups had a marked reduction in walking ability at 48 months as compared to the 12 and 24-month follow-ups. The HRQoL according to EQ-5D (EQ-5D index score) was assessed to be higher in the THR group at each follow-up, but the differences were only significant at 4 and 12 months (Figure 7).

OUTCOME FOR PATIENTS WITHOUT A HIP COMPLICATION AT THE 48-MONTH FOLLOW-UP

Among patients available at the 48-month follow-up, 97% of those in the THR group and 57% of those in the IF group remained without hip complications (p<0.001). The absolute figures for hip function and HRQoL among these patients were in favour of the THR group, although not statistically significant.
Table 6.
Hip function according to the Charnley score for all patients available at each follow-up (4 months, n=95; 12 months, n=92; 24 months, n=84; 48 months, n=72). 1 = total disability, 6 = normal state.

<table>
<thead>
<tr>
<th></th>
<th>THR Mean</th>
<th>IF Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td>5.7</td>
<td>4.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>12 months</td>
<td>5.3</td>
<td>4.5</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>24 months</td>
<td>5.6</td>
<td>4.7</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>48 months</td>
<td>5.5</td>
<td>5.2</td>
<td>=0.088</td>
</tr>
<tr>
<td>Movement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td>5.0</td>
<td>4.7</td>
<td>ns</td>
</tr>
<tr>
<td>12 months</td>
<td>5.0</td>
<td>4.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>24 months</td>
<td>4.9</td>
<td>4.5</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>48 months</td>
<td>4.7</td>
<td>4.5</td>
<td>ns</td>
</tr>
<tr>
<td>Walking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td>4.3</td>
<td>3.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>12 months</td>
<td>4.6</td>
<td>3.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>24 months</td>
<td>4.5</td>
<td>3.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>48 months</td>
<td>3.8</td>
<td>3.5</td>
<td>ns</td>
</tr>
</tbody>
</table>

Figure 7.
HRQoL (EQ-5D index score) for all patients available at each follow-up (before fracture, n=102; 4 months, n=94; 12 months, n=92; 24 months, n=84; 48 months, n=72). 0 = worst possible health state, 1 = full health.
STUDY II

SURGICAL OUTCOME
There were no differences in general complications and hip complications between the groups. The indication for the secondary THR was non-union in 29 of 41 patients and avascular necrosis (AVN) in the remaining 12 patients. The mean time elapsed between IF and the secondary THR was 11 months. Among patients in whom the indication for the reoperation was non-union, the mean time elapsed was 8 months and, in patients with AVN, 16 months.

FUNCTIONAL OUTCOME AND HRQOL
There were no significant differences in ADL between the groups at follow-up. Hip function was significantly better in the primary THR group and the HRQoL was assessed to be slightly higher in this group although not statistically significantly (Table 7).

As the 43 patients with a primary THR and 8 of the patients with a secondary THR were recruited from the same randomised controlled trial comparing primary THR and IF, prospective data were available on HRQoL during the first 2 years after the primary operation in this selected group, including follow-ups at 4, 12 and 24 months. The patients with failed IF experienced a significant decrease in HRQoL (EQ-5D index score) during the first year compared with patients in the primary THR group (Figure 8).

Table 7.
Hip function according to the Charnley hip score and HRQoL (EQ-5D index score) at the 24-month follow-up after a primary THR (n=43) or secondary THR (n=41) after failed IF.

<table>
<thead>
<tr>
<th></th>
<th>Primary THR</th>
<th>Secondary THR</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean (SD)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip total score</td>
<td>15 (2.3)</td>
<td>13 (2.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>-Hip score pain</td>
<td>5.6 (1.1)</td>
<td>4.7 (1.6)</td>
<td>0.005</td>
</tr>
<tr>
<td>-Hip score movement</td>
<td>4.9 (0.7)</td>
<td>4.5 (0.9)</td>
<td>0.01</td>
</tr>
<tr>
<td>-Hip score walking</td>
<td>4.5 (1.5)</td>
<td>3.7 (1.3)</td>
<td>0.04</td>
</tr>
<tr>
<td>HRQoL: EQ-5D index score</td>
<td>0.70 (0.28)</td>
<td>0.68 (0.20)</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Figure 8.
HRQoL (EQ-5D index score) for patients with a primary THR (n=43) or IF later undergoing a secondary THR (n=8) during the first two years after the primary operation.
STUDY III

SURGICAL OUTCOME
The duration of surgery was longer in the THR group, 102 versus 78 min, and the intraoperative blood loss was increased, 460 ml versus 320 ml, although this was not reflected in an increased need for blood transfusions.

There were no significant differences between the two groups regarding hip complications. There were no dislocations in any of the groups.

The number of general complications before the 4-month follow-up did not differ between the groups. The overall one-year mortality rate was 5.8%. In the HA group, it was 5.0%, and, in the THR group, 6.7% (ns).

FUNCTIONAL OUTCOME AND HRQOL
There were no differences in ADL or living conditions between the groups at any of the follow-ups.

Hip function was significantly better in the THR group at both follow-ups (Table 8). There was a trend towards an increasing difference in the HHS score between the 4 and 12-month follow-ups in favour of the THR group (p=0.07). This finding was supported by a significant improvement in the HHS score in the THR group between the 4 and 12-month follow-ups (p<0.005) while there was no significant improvement in the HA group.

The HRQoL (EQ-5D index score) is displayed in Figure 9. The values at both follow-ups were in favour of the THR group, although they were not statistically significant.

Table 8.
Hip function (HHS scores (mean (SD)) for all patients available at each follow-up (4 months, n=116; 12 months, n=111). * 2 missing values.

<table>
<thead>
<tr>
<th>4 months</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HA*</td>
</tr>
<tr>
<td>Total score</td>
<td>77.5 (12.4)</td>
</tr>
<tr>
<td>I. Pain</td>
<td>40.0 (6.6)</td>
</tr>
<tr>
<td>II. Function</td>
<td>28.8 (8.7)</td>
</tr>
<tr>
<td>III. Absence of</td>
<td>4.0 (0)</td>
</tr>
<tr>
<td>deformedity</td>
<td></td>
</tr>
<tr>
<td>IV. Range of</td>
<td>4.7 (0.3)</td>
</tr>
<tr>
<td>motion</td>
<td></td>
</tr>
</tbody>
</table>
Figure. 9
HRQoL (EQ-5D index score) before fracture and for all patients available at each follow-up (before fracture, n=120; 4 months, n=116; and 12 months, n=111). *1 missing value in each group. **2 missing values in the HA group and 1 in the THR group.
STUDY IV

SURGICAL OUTCOME

Forty-two per cent of the patients died during the two-year observation period, 43% in the IF group and 40% in the HA group (ns).

The total rate of hip complications in the HA group was 23% and the rate of reoperated patients was 13%. The total rate of hip complications in the IF group was 30% and the rate of reoperated patients was 33%. There was a trend towards an increased number of reoperated patients in the IF group compared to the HA group (p=0.067), but the total number of required surgical procedures did not differ significantly.

FUNCTIONAL OUTCOME, HRQOL AND LIVING STATUS

The outcome regarding ADL status is shown in Table 9. The deterioration in ADL function between prefracture and the 24-month follow-up was highly significant in both groups (p<0.005) with 54% of the patients totally dependent at the final follow-up.

<table>
<thead>
<tr>
<th>Table 9.</th>
<th>ADL status among randomisation groups according to Katz for all patients before the fracture (n = 60) and for all patients available at each follow-up (n = 51 at 4 months; n = 42 at 12 months; n = 35 at 24 months). 0 = independent in all functions, 6 = dependent in all functions. Mean values and the percentage of patients with the score 6 (worst possible) are displayed. All = all patients.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HA Mean Score 6</td>
</tr>
<tr>
<td><strong>ADL</strong></td>
<td><strong>Before fracture</strong></td>
</tr>
<tr>
<td></td>
<td><strong>At 4 months</strong></td>
</tr>
<tr>
<td></td>
<td><strong>At 12 months</strong></td>
</tr>
<tr>
<td></td>
<td><strong>At 24 months</strong></td>
</tr>
</tbody>
</table>

The outcome regarding the Charnley hip score is shown in Table 10. There was a trend towards worse walking capability in the HA group at the final follow-up. The deterioration in walking capability between prefracture and the 24-month follow-up was considerable and highly significant in both groups (p<0.001) with 60% of the patients bedridden or wheelchairbound at the final follow-up.

There was an increasing difference in HRQoL according to the EQ-5D (EQ-5D index score) in favour of the IF group from the 12-month follow-up, and the difference became highly significant at the 24-month follow-up (Figure 10). The decline in the mean EQ-5D index score for two-year survivors on comparing the prefracture status to the 24-month follow-up was 0.07 (ns) in the IF group, compared to 0.20 (p<0.001) in the HA group.
Table 10. Hip function among randomisation groups according to the modified Charnley score (n = 51 at 4 months; n = 42 at 12 months; n = 35 at 24 months). 1 = total disability, 6 = normal state. Mean values and the percentage of patients with the score 1 (worst possible) are displayed. * Movement was not assessed at the 4-month follow-up. ** 1 missing value; *** 2 missing values. All = all patients.

<table>
<thead>
<tr>
<th></th>
<th>HA</th>
<th>IF</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pain</strong></td>
<td>Mean</td>
<td>Score 1</td>
<td>Mean</td>
</tr>
<tr>
<td>At 4 months</td>
<td>4.9</td>
<td>4%</td>
<td>4.3</td>
</tr>
<tr>
<td>At 12 months</td>
<td>4.7</td>
<td>4%</td>
<td>4.9</td>
</tr>
<tr>
<td>At 24 months</td>
<td>4.8</td>
<td>6%</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Movement</strong></td>
<td>Mean</td>
<td>Score 1</td>
<td>Mean</td>
</tr>
<tr>
<td>At 12 months**</td>
<td>3.7</td>
<td>0%</td>
<td>3.3</td>
</tr>
<tr>
<td>At 24 months***</td>
<td>3.1</td>
<td>6%</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Walking</strong></td>
<td>Mean</td>
<td>Score 1</td>
<td>Mean</td>
</tr>
<tr>
<td>Before fracture</td>
<td>3.8</td>
<td>0%</td>
<td>4.0</td>
</tr>
<tr>
<td>At 4 months</td>
<td>2.3</td>
<td>23%</td>
<td>2.4</td>
</tr>
<tr>
<td>At 12 months</td>
<td>2.1</td>
<td>44%</td>
<td>2.3</td>
</tr>
<tr>
<td>At 24 months</td>
<td>1.3</td>
<td>72%</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Figure 10. HRQoL for all patients before the fracture (n = 60) and for all patients available at each follow-up (n = 51 at 4 months; n = 42 at 12 months; n = 35 at 24 months). A value of 0 indicates the worst possible health state and a value of 1 indicates full health.
GENERAL DISCUSSION

The overall aim of this thesis was to evaluate the outcome after surgical treatment of a displaced femoral neck fracture in the lucid, relatively healthy, active and independently living patient (Studies I-III) and the severely cognitively impaired patient (Study IV).

In Studies I-III, we investigated the outcome after IF, bipolar HA and THR and, in Study IV, the outcome after IF and unipolar HA.

THE RELATIVELY HEALTHY ELDERLY PATIENT (STUDIES I-III)

TOTAL HIP REPLACEMENT VS INTERNAL FIXATION (STUDY I)

Compared to the 24-month follow-up, the rate of hip complications in the IF group continued to increase from 36% to 42% and the reoperation rate increased from 42% to 47%. The increase in hip complications was due to AVN detected in a number of patients after the 24-month follow-up, resulting in a total rate of AVN in 19% of the patients and non-unions in 23%. This increase was in contrast to the outcome in the THR group where the rate of hip complications and reoperations remained unchanged at a low level of 4% each. The fracture reduction and screw position, according to the current state of the art, was optimal in the vast majority of patients and the figures for the outcome in the IF group at the 24-month follow-up is equal to or better than those in most other studies. This is confirmed by the meta-analysis by Lu-Yao et al., where the hip complication rate was 49%, non-unions, 33%, and AVN, 16%. A large meta-analysis has been published discussing the choice of implant selection including nearly 5000 patients. Screws, as used in our study, appear to be superior to pins, but there is no clinical evidence that the use of three or more screws is superior to the use of two screws. In our opinion, we have good reason to state that our results are representative of what can be expected after internal fixation of displaced femoral neck fractures in elderly patients using the current technique and with optimally performed surgery. Moreover, the finding of increased complication and reoperation rates after two years may indicate that studies on patients with femoral neck fractures treated with IF must last longer than two years in order to detect all fracture healing complications.

There were no additional complications in the THR group between the 24 and 48-month follow-ups. The dislocation rate remained low, 2%, and at par with what can be expected after an elective THR in patients with osteoarthritis or rheumatoid arthritis. This low rate compares favourably with all other RCTs on primary THR in patients with femoral neck fractures in which the dislocation rate was between 9% and 22%. The surgical approach was trochanteric osteotomy in the study by Jonsson et al. and posterolateral in all others. The explanation for the low rate of dislocation is probably the inclusion criteria prescribing the selection of patients with independent walking ability, independent living conditions and, most importantly, without severe cognitive dysfunction. In the study by Johansson et al. the dislocation rate was 32% in patients with mental dysfunction compared to 12% in lucid patients. The use of a validated instrument, e.g. the SPMSQ used in this study, to assess cognitive function is advantageous, especially when trying to implement the findings of clinical...
studies in future treatment protocols. Additionally, we believe that the anterolateral approach, compared to the posterolateral one, has obvious advantages regarding stability of the hip joint, which is of crucial importance in this patient population with this particular diagnosis. This notion is difficult to prove scientifically, although it is partly supported by the findings of Studies I and III, compared to those of previous studies using the posterolateral approach,\textsuperscript{7-9,23} as well as by other studies.\textsuperscript{41,42}

The four-year mortality rate of 25% in both groups is lower than the two-year mortality rate in most studies where the patients were unselected regarding walking ability, living conditions and cognitive function.\textsuperscript{4} The figure is in sharp contrast to that in Study IV with patients selected for independent walking ability but with severe cognitive dysfunction (SPMSQ<3) randomized to IF or primary HA (uncemented Austin Moore prosthesis) in which the two-year mortality rate was 42%. The expected longer survival in this selected group of patients emphasises the importance of a primary procedure with long durability.

THR seems to provide long-lasting good function. Hip function was significantly better and the decline in HRQoL was less pronounced among patients in the THR group compared to those in the IF group at the 4, 12 and 24-month follow-ups, but the differences were no longer significant at the 48-month follow-up. The figures for pain in the hip in the IF group were markedly improved between the 24 and 48-month follow-ups, probably reflecting the fact that the majority of the patients with hip complications had been reoperated upon. All patients with a non-union and 56% of those with an AVN had had an arthroplasty, in 11 out of 12 patients a THR. Additionally, 19% of the patients had had their screws removed. Among patients with an uneventfully healed fracture, 24% required a screw removal. There was an obvious deterioration in walking ability and HRQoL between the 24 and 48-month follow-ups in both groups, probably reflecting the natural course of ageing, the increased frequency of co-morbidities and new fractures of the lower extremity. Eighteen per cent of all patients sustained a new fracture of the lower extremity, predominately hip fractures.

In an RCT comparing IF with THR, it is inevitable that the difference in hip function and HRQoL will decrease with time (intention-to-treat analysis) due to the significant proportion of salvage arthroplasties in the IF group. Therefore, it is important to evaluate the overall outcome, i.e. the need for revision surgery, hip function and HRQoL, during this relatively long time period, rather than exclusively focusing on the outcome at the final follow-up. Four years is a substantial portion of the remaining lifetime for these elderly patients.

The opinion that an uneventfully healed displaced femoral neck fracture treated with IF will provide a better outcome compared to an arthroplasty does not seem to be true when IF is compared with a primary THR in relatively healthy elderly lucid patients. In the group of patients with uneventful outcomes, the absolute values for hip function and HRQoL were better in the THR group although this was not statistically significant at the 48-month follow-up. Primary THR seems to provide at least as good hip function and HRQoL in the four-year perspective even when compared to patients with uneventfully healed fractures after IF.

The limited number of patients in this study is a weakness regarding statistical power with respect to hip function and HRQoL, especially in the long-term perspective with a reduced number of patients due to the mortality rate. On the other hand, the power is good enough to confirm the vast difference in the rate of hip complications and reoperations. Considering this major difference in hip complications and reoperations, it may be sufficient to conclude that
THR is at least as good at four years with regard to hip function and HRQoL. Moreover, the fact that the research was not blinded to the type of surgical intervention is also a limitation. However, the questionnaires for most of the outcome variables, i.e. Katz ADL index, living conditions, hip function and HRQoL, were posted to the patients a week before the scheduled follow-up visit. The questionnaires were self-completed and the nurses’ task at the follow-up included mainly checking that all questions were completed. The percentage of patients lost to the 48-month follow-up was limited, namely 5%. Their outcomes are reported and the fact that they did not attend the final follow-up should not affect the interpretation of the results.

**PRIMARY TOTAL HIP REPLACEMENT VS SECONDARY TOTAL HIP REPLACEMENT AFTER FAILED INTERNAL FIXATION (STUDY II)**

The finding of better hip function in the primary THR group is not surprising and is in agreement with a previous study on comparable groups. The patients with failed IF have to undergo a prolonged period of increased pain, impaired walking ability, and a decreased range of motion that may lead to immobilisation and subsequent muscular atrophy. Additionally, the previous surgical procedure and fracture healing complication may lead to local changes in the hip region such as scarring, shortening of the femoral neck, synovitis and, in some cases, secondary osteoarthritis due to AVN. These local changes are probably the explanation for the finding of increased perioperative bleeding and an increased need for postoperative blood transfusions in the secondary THR group. In contrast to our study, McKinley et al. also found an increased frequency of superficial wound infections and postoperative dislocations in the secondary THR group. Moreover, they found an increased risk for prosthetic revision, with 10% of revisions in the primary THR group and more than 30% in the secondary THR group in a 10-year perspective. The main indication for revision arthroplasty was mechanical loosening. This is in contrast to the finding of the Swedish National Hip Arthroplasty Register where the prosthetic survival after a THR due to hip fracture, both primary and secondary, is comparable in patients with OA and RA. Possible explanations for their finding of an increased risk for prosthetic loosening of the femoral component in the secondary THR group may be difficulties in positioning the stem optimally and the decreased possibility of pressurising the cement due to the remaining screw holes after IF.

The patients with a failed IF may have to wait a considerable time before their secondary THR. The mean duration was more than 8 months in patients with non-union and almost 16 months in patients with AVN. This reflects the time it takes to properly diagnose a fracture healing complication in patients with femoral neck fractures, but it may also partly reflect the waiting time for revision surgery. The significant deterioration in HRQoL in patients with fracture healing complications before revision surgery has previously been presented with EQ-5D index scores down to 0.30 in a comparable patient group. The decrease in the present study was less pronounced probably because some of the patients had already had their secondary THR before the four-month follow-up. This particularly prolonged period of decreased quality of life is especially unfortunate in these elderly patients with a limited life expectancy. Therefore, it is important that we select a primary surgical procedure that minimises the number of reoperations and provides the best possible quality of life during the patients’ remaining years.
The patients in the secondary THR group displayed inferior hip function compared to the patients in the primary THR group, but also compared to patients with an uneventfully healed fracture after IF. This corresponds with the findings in a case control study by Nilsson et al.,\textsuperscript{44} in which the outcome was assessed with the Nottingham Health Profile (NHP). However, this is not an argument for performing IF as the primary procedure in this patient cohort considering the high failure rate after IF.\textsuperscript{4,12} The two-year failure rate in our RCT comparing primary THR with IF\textsuperscript{14} was 36% in the IF group, compared to 4% in the primary THR group.

The comparison between primary THR and secondary THR after failed internal fixation is difficult to make within an RCT although, to our knowledge, this has been partly done for the first time in this study. The matched case-control group of patients with secondary THR may be a selection of patients not perfectly comparable to the primary THR group. However, the two groups in the present study were fully comparable regarding all inclusion criteria as assessed before the primary operation. Furthermore, the indications for a revision arthroplasty are nearly always relative and are aimed at improving the patient’s functioning and would most probably lead to a selection of healthier patients. All of the patients in the secondary THR group had to undergo a second orthopaedic and anaesthesiological assessment in which the indication for the salvage THR was balanced against surgical risks. Anyway, although it is not likely, if there was a negative selection to the secondary THR group, this might partly explain the differences between groups regarding walking ability but, in our opinion, it could not explain the significant difference regarding pain in favour of the primary THR group.

Another weakness of this study is the limited number of patients, although the power seems appropriate to detect the differences in hip function between groups. In our opinion, the groups are comparable and we believe that the findings are amenable to generalisation.

TOTAL HIP REPLACEMENT VS BIPOLAR HEMIARTHROPLASTY (STUDY III)

The difference in the Harris Hip Score (HHS) was in favour of the THR group on both follow-up occasions, increased with time and already showed a clinically relevant difference in hip function after one year. This difference was equally distributed between the pain and function dimensions of the HHS score. The explanation for the generally lower values in the function dimension of the HHS score in our study, compared to studies on patients with THR after degenerative joint disease, probably reflects the older age and more frequent comorbidities in our hip fracture population. Even before the fracture, 17% of our patients used walking aids for other reasons than hip disorders and 4% of them sustained a new fracture of the lower extremity during the follow-up. Our findings of increased pain and reduced walking ability after HA, as compared to THR, confirm the results of a recent RCT\textsuperscript{11} and are in conformity with a previous review of the literature on outcomes and cost effectiveness after surgical treatment of displaced femoral neck fractures.\textsuperscript{45}

The finding of better hip function in the THR group as early as at 4 months may be somewhat surprising since it seems to be a common opinion among orthopaedic surgeons that the outcome following a bipolar HA is comparable to that after a THR, at least in the shorter time perspective.\textsuperscript{3} However, there are studies showing that the bipolar HA already functions as a unipolar HA a few months (3-12) after surgery.\textsuperscript{46,47} Early wear on the acetabular cartilage
may be one explanation of the difference in hip function between THR and HA in our own and previous studies.\textsuperscript{11}

Considering the previously demonstrated good long-term outcome for THR in patients with osteoarthritis (OA) and rheumatoid arthritis (RA), as well as in patients with femoral neck fractures,\textsuperscript{9} it is likely that the good hip function in the THR group will be relatively stable over time. In addition, the results from the Swedish Hip Arthroplasty Registry, showing an implant survival probability for primary THRs in patients with hip fractures comparable to those in OA or RA patients,\textsuperscript{43} indicate that most of the primary THRs in these elderly patients will last throughout their remaining life span provided that there are not any early complications. This is in contrast with the HA group, where there is a potential risk for deteriorating hip function, especially in the most active patients and in those with the longest survival time,\textsuperscript{11} which is an important factor to consider when selecting the type of arthroplasty in this patient cohort.

There were no dislocations in any of the groups in our study. The absence of dislocations even in the THR group is in conformity with Study I and Study II. This finding is in contrast to most previous RCTs on primary THR in patients with femoral neck fractures utilising the posterolateral approach, where the dislocation rate has ranged between 13% and 22%.\textsuperscript{7-9,23} The explanation for our low dislocation rate is probably a combination of the strict inclusion criteria, adequately trained surgeons and the anterolateral surgical approach.

The inclusion criteria prescribed the selection of patients with independent walking ability, independent living conditions and, most importantly, without severe cognitive dysfunction, i.e. a cohort of relatively healthy, active elderly patients who, theoretically, are the target population for the THR procedure.

Compared to the posterolateral approach, the anterolateral approach has advantages with regard to the stability of the hip joint, which is of crucial importance in hip fracture patients. Our findings of a low dislocation rate after the anterolateral approach in the present study and in Studies I and II are supported by a multicentre RCT comparing IF, bipolar HA and THR in which the dislocation rate in patients who had their arthroplasty performed with an anterolateral approach was 1% compared to 29% in those who were operated upon using a posterior approach\textsuperscript{11} and also by a recent meta-analysis discussing the stability of the hip after hemiarthroplasty.\textsuperscript{48} Interprosthetic dissociation may be an added problem for the reduction procedure in certain bipolar HAs necessitating open reduction. In the meta-analysis by Varley and Parker, 12% of the dislocations in the bipolar HA group were interprosthetic dissociations.\textsuperscript{48} However, most modern bipolar surgical systems have a more stable construct to prevent dissociation between the inner and the outer head.

The risk for dislocation may be one reason why orthopaedic surgeons generally hesitate to recommend THR even in active elderly patients.\textsuperscript{3} Another reason could be that, in some health care systems, the IFs and HAs are performed by surgeons specially trained in trauma treatment while the THRs are performed by surgeons specially trained in hip arthroplasty and not routinely treating patients with acute femoral neck fractures. However, the result of the present study, Studies I- II and another recent study\textsuperscript{11} imply that general orthopaedic surgeons with adequate training and using careful patient selection and an anterolateral surgical approach can achieve good results and low dislocation rates with a primary THR.
The superior hip function in the THR group was reflected in higher HRQoL values, a difference in the EQ-5D index score in the range of 0.05-0.06, although not statistically significant. Probable explanations for this finding could be that the difference in hip function was perceived to be limited and therefore did not significantly influence the HRQoL or that the HRQoL is influenced by several other factors besides hip function, e.g. co morbidities, resulting in a higher variability in the EQ-5D index score. Finally, there may be a true difference in HRQoL in favour of the THR group that could not be verified due to insufficient power of the study in that regard.

The duration of surgery was longer in the THR group (mean difference 24 min) and the intraoperative blood loss was increased (mean difference 140 ml), proving that a THR is a more extensive surgical procedure. However, the increased blood loss and longer operating time did not increase the number of general complications or the mortality rate. In fact, the low overall incidence of complications and the overall good functional outcome in both groups imply that both these methods are safe in this patient cohort. Moreover, the reasonably good outcome in the HA group regarding hip function and HRQoL indicates that a bipolar HA constitutes sufficient treatment for the most elderly patients with lower functional demands and a shorter life expectancy.

The strict inclusion criteria are one of the cornerstones of the study, clearly defining the population to whom the results can be generalised. Moreover, the use of validated outcome instruments and the high follow-up rates, 100% at 4 months and 98% at 12 months, increase the validity of our conclusions. The study also has some limitations. All clinical variables except hip motion were assessed by an unbiased observer, but the fact that this observer was not blinded to the type of surgical intervention may introduce a risk of bias. Furthermore, a one-year follow-up may be considered too short a follow-up period. However, in previous studies on arthroplasty after femoral neck fractures, hip function seems to reach its peak after one year.\textsuperscript{Study I, 11} With the passage of time, there is a gradual deterioration in function and HRQoL probably reflecting the natural course of ageing, the increased frequency of co-morbidities and new fractures of the lower extremity in this patient cohort. Moreover, THR and bipolar HA represent two different types of hip arthroplasty. Besides the in principle different types of articulation, there are major differences regarding the amount of surgical impact, the risk for dislocation, the mode of failure etc.

\textbf{THE SEVERELY COGNITIVELY IMPAIRED PATIENT (STUDY IV)}

The main finding of this study was the very high mortality rate and the extreme deterioration in ADL function, walking ability and HRQoL in this strictly selected group of patients regardless of the surgical procedure. The effect of the selection criteria, i.e. the severe cognitive dysfunction, profoundly influenced and partly overshadowed the effect of the randomisation procedure. However, the randomisation resulted in a better outcome regarding HRQoL and a trend towards better walking capability in the IF group that must be balanced against a trend towards fewer patients reoperated upon in the HA group, although this is not reflected in the total number of reoperations required. Furthermore, IF is a minor surgical procedure with a significantly shorter operating time and need for postoperative blood transfusions.

In spite of their severe mental dysfunction, all of our patients were independent walkers before the fracture and nearly half of them came from independent living conditions. There-
fore, it was reasonable to assume that the outcome of the fracture treatment would have a ma-
jor impact on the future living conditions of these already vulnerable patients. For a reliable
assessment of cognitive function, a validated instrument is needed. We used the SPMSQ in
this and our previous trials with hip fracture patients and have found it suitable for use in
clinical practice as well as in research.

The two-year mortality rate of 42% is significantly higher than reported in previous studies
where the patients were unselected regarding cognitive function. In a review of studies on IF
in patients with femoral neck fractures with at least a two-year follow-up, the median mortal-
ity rate was 28%. For comparison, in Study I the two-year mortality rate was 15%. The only
differences in inclusion criteria between Study I and Study IV were the level of cognitive
function according to the SPMSQ and that Study IV also allowed inclusion of patients from
institutions. Severe cognitive dysfunction is probably a good predictor for mortality as well as
for the outcome in general.

In two-years survivors, 54% of the patients were totally dependent in ADL function and
60% of them were bedridden or bound to a wheel-chair regardless of the surgical procedure.
This finding probably reflects the natural course of the dementia/cognitive impairment and
the difficulty for these patients to assimilate rehabilitation and could also indicate inadequate
rehabilitation resources for this specific group of patients. The deterioration in walking capa-
ibility was gradual between all follow-ups. This is the exact opposite of what we found in
Study I where the patients in both groups gradually improved their walking capability up to
the 24-month follow-up.

The overall fracture healing complication rate of 41% in the IF group in two-year survivors
is comparable to that in most other studies. An interesting fact is that all patients with frac-
ture healing complications were reoperated on during the study period. This implies that a
scheduled follow-up after IF is also indicated for patients with cognitive dysfunction. A frac-
ture-healing complication could otherwise easily be overlooked, which may in turn lead to
unnecessary pain and discomfort in these patients with obvious difficulties in communicating
their problems.

It is a well known fact that an uncemented HA gives inferior results compared to THR in
active patients with a long life expectancy. In the 13-year follow-up of patients randomised to
IF, hemiarthroplasty (uncemented Austin Moore prosthesis) and THR, the revision rate was
33%, 24% and 7%, respectively. Hip function according to the Harris hip score was best in
the THR group and worst in the hemiarthroplasty group. In a recent RCT, IF and the unce-
mented Austin Moore hemiarthroplasty were compared in patients with displaced femoral
neck fractures aged > 70 years but unselected regarding walking ability, living conditions and
cognitive function. The conclusion drawn was that elderly patients should generally be
treated with arthroplasty because of a lower reoperation rate. However, the outcome regard-
ing pain and walking ability was similar in both groups and clearly worse than what can be
expected after a THR in an active, lucid elderly patient. But a THR cannot be recom-
manded for patients with severe cognitive impairment due to the high dislocation rates.
The dislocation rate after HA is lower. In spite of our patients’ severe cognitive dysfunction,
there were no prosthetic dislocations, indicating that this risk is limited in HA when using the
anterolateral approach, a finding also supported by previous studies.
Five out of seven hip complications in the HA group were due to a new fall, a wound rupture in one patient and periprosthetic fractures in four patients. This propensity for falling was further displayed by the large number of new fractures involving the lower extremity in both groups. In total, 12 out of 60 (20%) patients sustained a new fracture of the lower extremities, including periprosthetic fractures, during the study period. Deep infections in two patients (6.7%) were the reason for six out of eight reoperations in the HA group. This is more than twice the rate of deep infections reported by Parker et al. and probably reflects the inclusion of older, more fragile and possibly malnourished patients.

Can we improve these results with a modern cemented HA? A meta-analysis of arthroplasties for femoral neck fractures indicates that a cemented prosthesis may reduce pain and result in better mobility. The use of gentamycin-cement and a more stable implant may reduce the risk of deep infections and the stability of a cemented implant may also reduce the risk of periprosthetic fractures. In a prospective cohort study of elderly patients with signs of mental changes (manifest dementia or prolonged confusion) and/or institutionalisation (nursing or old people’s home), Rogmark et al. reported 2.9% deep infections and 19% superficial infections using a cemented HA. The one-year mortality rate was 28%, which is equal to the one-year mortality rate in our study, but the outcome regarding walking ability seemed to be better. On the other hand, their study population is not comparable to the population of our study with only 46% of their patients showing signs of mental changes. Moreover, cognitive function was not assessed with a validated instrument, thereby increasing the difficulty of assessing the severity of the cognitive dysfunction.

The prefracture HRQoL (EQ-5D index score) for all patients was 0.26, which is extremely low compared to this age group in the Swedish reference population, i.e. 0.74, and our previous studies on patients with femoral neck fractures without severe cognitive function, where the value was in the range of 0.78 to 0.83. The EQ-5D index score was significantly worse in the HA group than in the IF group at the final follow-up and there was also a significant decline in the mean EQ-5D index score on comparing the prefracture status to the 24-month follow-up in the HA group. In contrast to our previous studies, owing to the severely impaired cognitive function, it was necessary to collect data via a proxy report, i.e. from someone who knows the patient well. A close relative or caregiver was asked to rate how he or she thinks the patient would rate his or her health if he or she were able to communicate. There is generally good proxy-patient agreement for concrete, observable variables, e.g. walking ability or ADL, but not so good for non-observable variables: e.g. pain or anxiety/depression. However, in patients with dementia and severe cognitive dysfunction, this is the only way to assess the outcome, not only regarding the HRQoL but also for such variables as living status, ADL status and the pain and walking dimension of the Charnley hip score.

This approach has also been used previously for the EQ-5D in patients with dementia.

The limited number of patients in Study IV is a weakness with regard to statistical power. On the other hand, this is a strictly selected group of patients with a thorough two-year follow-up and only one patient was lost at the 12-month follow-up. We believe our findings are amenable to generalisation, not only regarding the reported differences between randomisation groups, but also regarding the general outcome for this selected group of patients.
CONCLUSIONS

STUDY I
The results of this study confirm that a primary THR, compared to IF, provides a better outcome for a lucid, elderly patient with a displaced femoral neck fracture in a four-year perspective. The complication and reoperation rates were significantly lower and the outcome regarding hip function and HRQoL (EQ-5D) were at least as good.

STUDY II
The study showed that patients with a fracture healing complication after IF will have a significant deterioration in the HRQoL (EQ-5D) during the treatment and that the secondary THR yielded an inferior outcome compared with a primary THR. On the other hand, for the patient with a fracture healing complication, a secondary THR seems to be a safe salvage procedure with a good outcome, although not with a hip function outcome that is fully comparable to that after a primary THR.

STUDY III
The results of this study indicate that a THR gives better hip function compared to a bipolar HA as soon as after one year without increasing the complication rate. There are good reasons to assume that this difference will increase with time.

STUDY IV
Patients with severe cognitive impairment and an associated displaced femoral neck fracture showed an extremely high mortality rate and a pronounced deterioration of ADL function, walking ability and HRQoL (EQ-5D) regardless of the surgical procedure. There did not seem to be any obvious advantage in performing an uncemented Austin Moore HA as compared to IF in this patient cohort. The surprisingly high complication rate and inferior outcome in the HA group may partly be explained by the design and uncemented fixation of the Austin Moore HA.

OVERALL CONCLUSION
THR can be recommended as the primary treatment for the relatively healthy, active and lucid elderly patient with a displaced femoral neck fracture. Bipolar HA can be recommended for the most elderly patients with lower functional demands. The optimal treatment for patients with severe cognitive impairment and a displaced femoral neck fracture needs to be further evaluated.
CLINICAL IMPLICATIONS

PATIENT SELECTION CRITERIA

Based on the results of previous studies, as presented in this thesis, and the studies included in this thesis, we suggest the following six patient selection criteria for choosing between the different treatment modalities in patients with femoral neck fractures. We will discuss each of these six steps individually.

1. Fracture type: i.e. undisplaced (Garden I and II) vs displaced (Garden III and IV).
2. Age: i.e. < 65 years of age vs ≥65 years of age.
3. Walking ability: i.e. non-ambulant vs ambulant.
4. Anaesthesiological assessment: i.e. not optimised for arthroplasty < 24 hours vs optimised for arthroplasty < 24 hours.
5. Cognitive function: i.e. severe cognitive dysfunction (SPMSQ <3) vs no severe cognitive dysfunction (SPMSQ ≥3).
6. Functional demands reflected by age: i.e. age 65-79 years vs age ≥80 years.

1: FRACTURE TYPE

The rate of fracture healing complications after IF in patients with undisplaced femoral neck fractures (Garden I and II) is in the range of 5-10% in most studies with an adequate follow-up and good results regarding function and HRQoL can be expected. Consequently we perform IF in all patients with undisplaced femoral neck fractures, except in those with symptomatic osteoarthritis (OA) or rheumatoid arthritis (RA) affecting the fractured hip and in patients with pathological fractures. Patients with undisplaced fractures constitute approximately 25-30% of all femoral neck fractures.

Before selecting the treatment modality for patients with displaced (Garden III and IV) femoral neck fractures, constituting 70-75% of all patients with femoral neck fractures, we continue to step 2.

2: AGE

The aim of assessing age is to estimate the patient’s expected mean survival time. Patients with hip fractures have an increased mortality rate during the first year after the fracture but after one year the mortality rate is comparable to that of the general population. The expected mean survival time in relation to age and gender in Sweden is displayed in Table 11. These figures give an impression of the requested durability of the chosen surgical procedure in the elderly patients.
Table 11.
The expected mean survival time in years in relation to age and gender.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>24.9</td>
<td>21.4</td>
</tr>
<tr>
<td>65</td>
<td>20.6</td>
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</tr>
<tr>
<td>90</td>
<td>4.4</td>
<td>3.5</td>
</tr>
</tbody>
</table>

The rate of fracture healing complications after IF in the younger age group is less well reported; however, due to the patients’ longer life expectancy and consequently higher risk for revision surgery after an arthroplasty, IF is the preferred method. Most previous studies have used 65–70 years as the upper limit for IF,\(^6\)\(^-\)\(^{10,57}\) but the optimal age limit is pending. Recently, 55 years has been suggested.\(^11\)

We perform IF in patients with displaced femoral neck fractures under the age of 65 except in those with symptomatic OA or RA affecting the fractured hip, those with pathological fractures and those with severe renal insufficiency and hyperparathyroidism.

Patients with displaced fractures < 65 years of age constitute approximately 10% of all patients with displaced femoral neck fractures in Stockholm (Stockholm Hip Fracture Group, unpublished data).

Before selecting the treatment modality for patients aged ≥65 years with displaced fractures, we continue to step 3.

3: **Walking Ability**

Non-ambulant patients aged ≥65 years with displaced fractures constitute approximately 3% of all patients with displaced femoral neck fractures in Stockholm (Stockholm Hip Fracture Group, unpublished data).

We perform IF on all of these patients because it is the least demanding surgical procedure for the patient. The rate of fracture healing complications in this selected cohort of patients is not well reported, but there is good reason to assume that the need for revision surgery is lower than in ambulant patients. A primary resection arthroplasty, i.e. the Girdlestone procedure, or a unipolar HA may be considered. However, these are more demanding surgical procedures compared with IF and could always be considered as salvage procedures in case of symptomatic fracture healing complications in non-ambulant patients.

Before selecting the treatment modality for ambulant patients aged ≥65 years with displaced fractures, we continue to step 4.
4: **ANAESTHESIOLOGICAL ASSESSMENT**

Ambulant patients aged ≥65 years with displaced fractures, considered by the attending anaesthesiologist not to be optimised for an arthroplasty procedure within 24 hours, are treated with IF. The cementing procedure during arthroplasty introduces an increased risk of perioperative complications especially in elderly patients with pre-existing cardiovascular conditions and a fracture diagnosis, and therefore it is important that the patient’s general medical condition can be optimised in the acute setting. Based on the results of a previous study and Study IV, the uncemented Austin Moore HA is only indicated as a salvage procedure after failed IF in extremely frail patients. The modern pressfit un cemented prosthetic stems may be a good alternative in the future but, so far, there is no convincing scientific evidence supporting their use in elderly osteoporotic hip fracture patients. We have chosen a time limit of 24 hours for this preoperative assessment since a longer waiting time introduces an additional risk for complications due to the immobilisation. There is also a risk that the assessment, even after a longer period of time, will result in non-approval for arthroplasty and by that time the risk for fracture-healing complications after IF will have further increased. All patients with displaced fractures treated with primary IF are scheduled for a follow-up visit including a radiographic control at 4 months and, in case of a fracture-healing complication, they will be electively converted to an arthroplasty.

Ambulant patients aged ≥65 years with displaced fractures not optimised for arthroplasty < 24 hours constitute 10-15% of all patients with displaced femoral neck fractures in Stockholm (Stockholm Hip Fracture Group, unpublished data).

Before selecting the treatment modality for ambulant patients aged ≥65 years with displaced fractures optimised for arthroplasty within 24 hours, we continue to step 5.

5: **COGNITIVE FUNCTION**

We use the SPMSQ for assessing cognitive function. The SPMSQ is a 10-item questionnaire for assessing cognitive function with good validity and reliability and is considered to be quick and easy to administer. We use the cut-off level of fewer than 3 correct answers (SPMSQ < 3) or 3 or more correct answers (SPMSQ ≥ 3) in order to distinguish between patients with and without severe cognitive dysfunction. The patient’s cognitive status according to the SPMSQ is assessed at admission to the orthopaedic ward and always before surgery.

Cognitive dysfunction, assessed by using this cut-off level of the SPMSQ, has been reported to be a good predictor of mortality. However, in the study by Svensson et al., cognitive function was a good predictor of independent living at one year, but not for mortality. In contrast to our recommendation, the cut-off level of > 7 correct answers was used, i.e. the outcome for patients without signs of cognitive dysfunction was compared with that of patients displaying different levels of cognitive impairment. Using this higher cut-off level may be hazardous as it has been shown that the level of cognitive function fluctuates during the hospital stay. These fluctuations are most pronounced in patients with moderate and mild cognitive impairment on admission, whereas the fluctuation in cognitive function in patients assessed as lucid or severely cognitively impaired at admission are usually minor.
Patients with SPMSQ < 3 are not the target population for THR. This patient cohort has an increased risk for prosthetic dislocations after THR \(^7\) and also a markedly increased mortality rate.\(^{26,64,\text{Study IV}}\) For the time being, our recommended treatment for this patient cohort is IF. However, the surprisingly high hip complication and reoperation rates and the inferior outcome regarding walking ability and HRQoL in the HA group in a previous study\(^{28}\) and \textit{Study IV} may partly be explained by the design and uncemented fixation of the Austin Moore HA.

In our opinion, the role of a modern cemented HA in this selected patient group needs to be evaluated in future prospective trials. The use of an uncemented HA may reduce the reoperation rate although it may not improve the extremely poor outcome regarding ADL, walking ability or mortality. Therefore, we are currently performing an RCT comparing IF with uncemented HA.

Ambulant patients aged ≥ 65 years with displaced fractures optimised for arthroplasty < 24 hours with SPMSQ < 3 constitute 15-20% of all patients with displaced femoral neck fractures in Stockholm (Stockholm Hip Fracture Group, unpublished data).

Before selecting the treatment modality for ambulant patients aged ≥65 years with displaced fractures optimised for arthroplasty within 24 hours and with SPMSQ ≥ 3, we continue to step 6.

6: \textbf{FUNCTIONAL DEMANDS REFLECTED BY AGE}

A primary THR has been shown to yield good results regarding the need for revision surgery, hip function \(^6\text{--}10,14\) and HRQoL \textit{Studies I--III} for the active and lucid elderly patient with a displaced femoral neck fracture. We therefore recommend THR for ambulant patients aged 65-79 years with displaced fractures, optimised for an arthroplasty within 24 hours and with SPMSQ ≥ 3. These patients, constituting approximately 20% of all patients with displaced femoral neck fractures in Stockholm (Stockholm Hip Fracture Group, unpublished data), often have relatively high functional demands and their expected survival time is relatively long, indicating that they are the target population for THR.

For patients aged ≥ 80 years, ambulant, optimised for an arthroplasty within 24 hours and with SPMSQ ≥ 3, we recommend bipolar HA. These patients, constituting approximately 40% of all patients with displaced femoral neck fractures in Stockholm (Stockholm Hip Fracture Group, unpublished data), have lower functional demands and their expected survival time is shorter. The reasonably good outcome in the HA group regarding hip function and HRQoL in \textit{Study III} indicates that a bipolar HA with its more limited surgical impact and lower overall dislocation rate\(^{12}\) constitutes sufficient treatment for these patients. However, there are, not yet, to the best of our knowledge, any RCTs with longer follow-up time comparing a modern cemented unipolar HA with a bipolar HA. The bipolar HA may have some advantages in optimising offset and reducing acetabular wear that justify its higher cost. We are currently performing an RCT comparing a modern cemented unipolar HA with bipolar HA in this patient cohort.
TREATMENT ALGORITHM

Based on our assessment of patient selection criteria, we currently use the treatment algorithm presented in Fig 11. It has been shown to be feasible even in a very busy clinical practice treating approximately 1200 hip fractures a year. After the introduction of the algorithm our rate of revision surgery has diminished considerably and hopefully our patients benefit from a better outcome.

There are two points that need to be emphasised before recommending such a treatment algorithm. The rationales for these are presented in the General Discussion section.

- We are convinced that the anterolateral approach significantly reduces the risk of prosthetic dislocation after arthroplasty in patients with femoral neck fractures. Although some surgeons in our department prefer the posterolateral approach for patients with OA or RA, we all use the anterolateral approach for patients with femoral neck fractures, both primarily and secondarily after failed internal fixation.

- Cognitive dysfunction should be considered a major risk factor in the selection of the surgical method. Patients with severe cognitive dysfunction are difficult to identify in routine health care without the systematic use of a validated instrument. By using the recommended cut-off level in the SPMSQ and based on one routine assessment made by a nurse at admission to the orthopaedic ward, we have been able to identify patients with severe cognitive dysfunction and predict their poor outcome regarding walking ability, ADL function, mortality and an increased risk for prosthetic dislocation after THR.
Figure 11.
Algorithm for treating femoral neck fractures (Department of Orthopedics Stockholm Söder Hospital, Sweden).
IMPLICATIONS FOR FUTURE RESEARCH

There is increasing evidence that the treatment of elderly patients with displaced femoral neck fractures benefits from the individualised approach in which the selection of the surgical method is based on the individual patient’s age, functional demands and risk profile. However, the results of recent studies are interpreted differently around the world and in certain institutions and healthcare systems there are obvious obstacles to fully adapting to this approach. Especially the use of THR in the primary treatment of patients with displaced femoral neck fractures seems to introduce logistic problems.

Obviously, there are still a number of controversies to solve. In our opinion, the following controversies need to be assessed regarding the treatment of patients with femoral neck fractures.

- The outcome after IF in younger patients, aged 15-69 years, in order to find the optimal lower age limit for THR.
- The optimal treatment for patients with severe cognitive dysfunction.
- Are there any differences between a modern cemented unipolar HA and a bipolar HA?
- Could a modern pressfit uncemented prosthetic stem, compared to a cemented stem, reduce the perioperative risks and surgical impact and still yield comparable results regarding the need for revision surgery, hip function and HRQoL?
ABSTRACT IN SWEDISH

Den optimala behandlingen för äldre patienter med lårbenshalsfraktur, intern fixation (IF), hemiplastik (HA) eller total höftledsplastik (THR), bör baseras på den individuella patientens ålder, funktionskrav och riskprofil. Valet av IF är okontroversiellt vid behandlingen av icke felställda lårbenshalsfrakturer, vid behandling av unga patienter med felställda frakturer och hos patienter som av medicinska skäl inte klarar en primär höftplastikoperation.


I en RCT med fyra års uppföljning randomiserades vitala, äldre patienter med felställd lårbenshalsfraktur till THR eller IF. Resultaten bekräftade att THR ger ett bättre resultat jämfört med IF. Andelen höftkomplikationer och reoperationer var signifikant lägre och resultaten med avseende på höftfunktion och livskvalitet var minst lika bra även i detta längre tidsperspektiv.

I en prospektiv studie med två års uppföljning inkluderades vitala, äldre patienter som var behandlade för en felställd lårbenshalsfraktur. Vi jämförde resultaten hos patienter behandlade med en primär THR med resultaten efter reoperation med THR (sekundär THR) pga. frakturlåkningskomplikation efter IF. Höftfunktionen var signifikant bättre i gruppen som fått en primär THR och de patienter som fått en sekundära THR upplevde en uttalad sänkning av livskvalitet under första året efter IF.


I en RCT med två års uppföljning randomiserades patienter med en uttalad kognitiv svikt och en felställd lårbenshalsfraktur till IF eller unipolär HA (ocementerad Austin-Moore). Oavsett randomiseringsgrupp, så var mortaliteten mycket hög och försämringen i ADL-funktion, gångförmåga och livskvalitet mycket uttalad, vilket avspeglar vilket starkt inflytande den svåra kognitiva svikten och dess orsaker har på patientens prognos. Resultaten indikerar att det inte finns några fördelar med att utföra en ocementerad Austin-Moore plastik jämfört med IF hos denna selekterade patientgrupp.

Den övergripande konklusionen av denna avhandling är att THR kan rekommenderas som primär behandling hos den vitala, äldre patienten med en felställd lårbenshalsfraktur. Bipolär HA kan rekommenderas hos de äldsta med lägre funktionskrav. Den optimala behandlingen av patienter med svår kognitiv svikt behöver evalueras ytterligare i framtida RCT.
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