Femoral Neck Fractures in the Elderly

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Abbreviations

ASA	American Society of Anesthesiologists
DHS	Dynamic hip screw
HA	Hemiarthroplasty
HHS	Harris hip score
IF	Internal fixation
OTA	Orthopedic Trauma Association
THA	Total hip arthroplasty

Introduction: Definition of Elderly and Epidemiology

The incidence of femoral neck fractures has consistently increased because of the aging population [1, 2]. In 1990, 1.66 million hip fractures occurred, and new conservative estimates project 6.26 million hip fractures in 2050 [1]. This increase represents a significant burden and challenge to the healthcare system, as the estimated cost of a hip fracture is around $21,000 in the first year [3]. The lifetime risk for a fracture of the hip at age 50 in the U.S. is 17.5% for women and 6% for men; in other countries, it varies from 11.4–22.9% and 3.1–10.7%, respectively [2, 4].

Major obstacles for an evidence-based treatment approach for this fracture are the heterogeneity of the patient population and the exact definition of an elderly patient. Some studies define elderly as age ≥60 , while others quote ≥65, and yet others ≥70. Some studies exclude patients ≥85 or ≥90 as too frail and not representative, whereas others emphasize their inclusion as being very important.

Furthermore, nearly one-third of hip fracture patients suffer from dementia or other mental conditions. These comorbidities significantly affect outcome, and thus should be grouped into their own sub-group to further understand their rehabilitative potential [5]. Unfortunately, as most studies exclude patients with dementia or other cerebral comorbidities, only limited recommendations can be offered for this cohort. Owing to the copious literature on femoral neck fractures, we attempted to compile a concentrated evidence-based algorithm; however, because of the sheer magnitude of the literature, our review may be occasionally selective and biased.

The main focus of this chapter is on elderly, active, and lucid patients ≥65 years old with femoral neck fractures. Separate recommendations for the other cohorts are provided within the chapter. Furthermore, we highlight the main recommendation in an algorithm at the end of the chapter.

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For better legibility and understanding, the chapter is subdivided into three parts: stable versus unstable fracture, where stable fracture means an impacted, undisplaced femoral neck fracture of Garden type I or II, and unstable means a displaced femoral neck fracture, Garden type III–IV. In the last part, the patient's blood management is discussed, as it is a crucial factor in this patient cohort.

Stable Fractures

Conservative Treatment versus Osteosynthesis

Particularly in the elderly, there are good reasons to prevent surgical procedures and the anesthesia that goes with them: cardiovascular disease, pulmonary disease, multimorbidity, and local factors such as mycosis or other skin problems. It is indisputable that displaced femoral neck fractures have to be repaired surgically, [6] but the question remains whether stable femoral neck fractures can be treated conservatively (Figs. 6.1a–f and 6.2a–d). Unfortunately, the existing data do not support a clear treatment protocol, although most authors recommend percutaneous osteosynthesis. In 1996, Cserháti et al. [7] published a series of 247 undisplaced femoral neck fractures, predominantly Garden I. A total of 122 patients were primarily treated non-operatively, and 125 underwent primary operative stabilization—mostly with three cancellous screws and an "inverted key-hole plate." The results were significantly better for hospital stay (1 week shorter) and beginning full weight-bearing (11 days earlier) in the surgery group. Moreover, just one-quarter of the conservative patients were able to walk unaided at the time of discharge vs. two-thirds of the surgically treated group. Within 6 weeks, 20% of the conservative group required another operation due to displacement. Furthermore, there were slightly more survivors in the operation group after 1 year, though this was not significant.

Another interesting approach to this field was published by Buord et al. in 2009 [8]. They treated 57 Garden I fractures in patients age 65 and older (the mean was 82), with a standardized

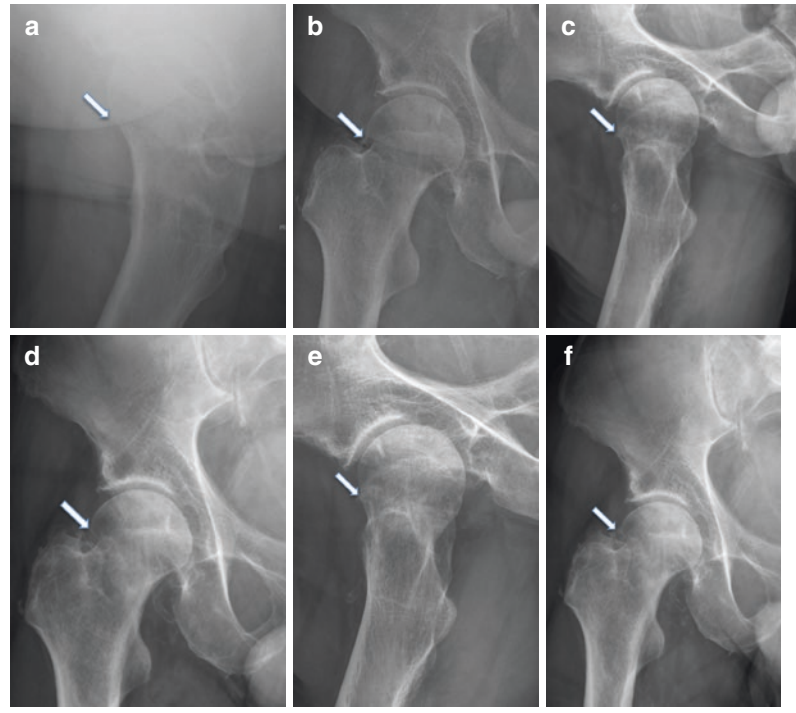

Fig. 6.1 Stable femoral neck fracture on the right side in a moribund patient, axial view (**a**) and pelvis ap (**b**). Patient was bedridden due to spinal stenosis and multiple cardiovascular diseases. (**c**) and (**d**) showing the same patient after 3 months and (**e**) and (**f**) after 6 months. The fracture is healed, the patient has no pain. Arrows indicate the fracture

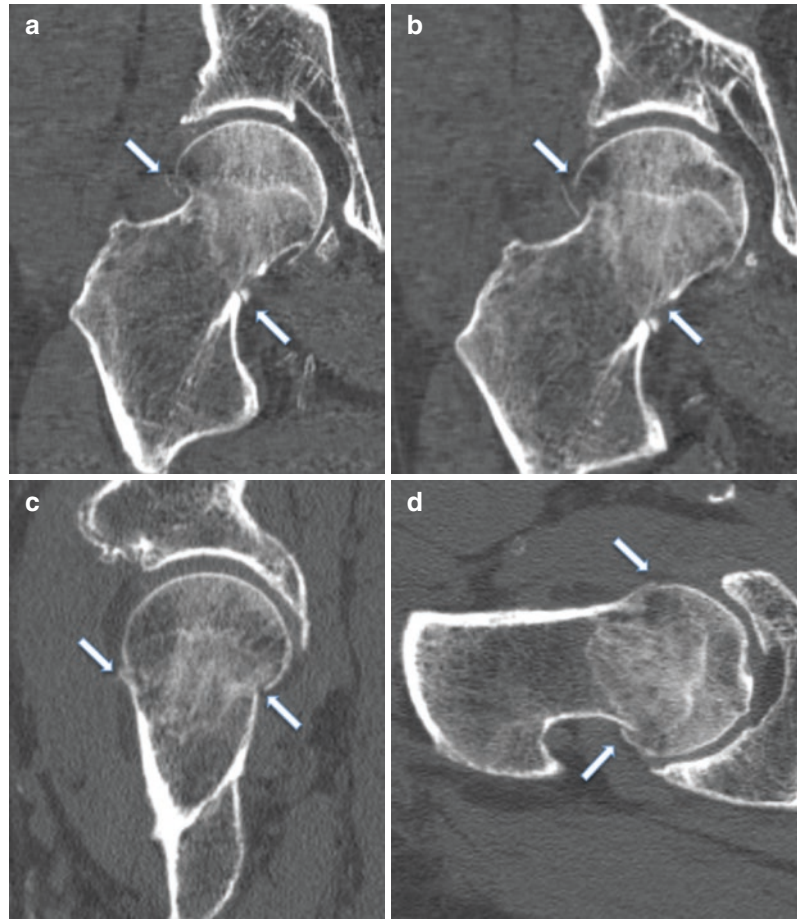

Fig. 6.2 CT-scan of the right hip from the same patient as in Fig. 6.1, (**a**) and (**b**) showing the frontal, (**c**) the sagittal, and (**d**) the axial plain at the time of injury. Arrows indicate the fracture

"early functional training" with full weight bearing and frequent radiographic follow-up on post-injury days 2, 7, 21, and 45, and months 3, 6, and 12 to evaluate the predictive factors of displacement and the results of the functional training. If displacement occurred, then arthroplasty was performed. One-third of the patients had a displacement at a mean of 10 days; in fact, they reported comparable results in the functional successful vs. the arthroplasty group with Parker Score (6.9 vs. 7) and Harris Hip Score (HHS) (82 vs. 85), but one has to admit that the arthroplasty "control" group was the failed functional training group. Unfortunately, they were unable to identify predictive parameters for displacement, such as age, gender, side, fracture type, inclination angle, degree of outward displacement, sagittal displacement, and general status. In view of the missing predictive values and the disadvantages of secondary arthroplasty after primary osteosynthesis, [9] the approach with this trial-and-error management could be an option for borderline patients, as early mobilization has multiple advantages. However, as long as there is no clear evidence for this kind of treatment, conservative treatment should be an individual decision, especially for moribund patients, and the standard should be the osteosynthesis.

Type of Implant for Osteosynthesis in Stable Femoral Neck Fractures

Choosing the type of implant leads directly to the next step. Usually, there are two implant types that are feasible: two or three parallel cannulated screws, and fixed-angle devices such as the

sliding hip screw (SHS) or cephalomedullary nails [6, 10–13]. Most authors prefer cannulated screws, as they are a fast, inexpensive method.

In 112 consecutive patients, Krastman and colleagues reported positive results for stable and undisplaced femoral neck fractures if treated with two cannulated screws, but the patient collective was very heterogeneous due to age and fracture type [6]. In addition, Manohara concluded that the cancellous screw fixation for undisplaced femoral neck fractures in the elderly is associated with relatively few complications and revision rates [11]. However, he found longer hospital stays and a higher mortality rate in the >75 years patient collective.

Unfortunately, there is no significant evidence-level study comparing the outcome of the two internal fixation (IF) methods, especially not in the elderly. In 2008, Liporace et al. tried to compare the fixed-angle devices with cannulated screws in 76 displaced high vertical femoral neck fractures (Pauwels Type 3, Orthopaedic Trauma Association (OTA) type 31 B2.3) and found a non-union rate of 19% in the cannulated screw treated group vs. 8% in the fixed-angle device group, although this was not significant [14]. Siavashi et al. demonstrated significantly better results for the DHS compared to the cannulated screws after 1 year in the young with no fixation failure in the DHS group vs. an 18% failure rate in the cannulated screw group ($p < 0.001$) [15]. It seems that the fixed-angle devices provide better stability, but further research is necessary, since any comparative study is in displaced and/or young patients. Figure 6.3a–d shows an example of DHS fixation.

However, there are some interesting considerations regarding the biomechanics, which allows for cautious recommendations. First of all, the question remains whether two screws are enough,

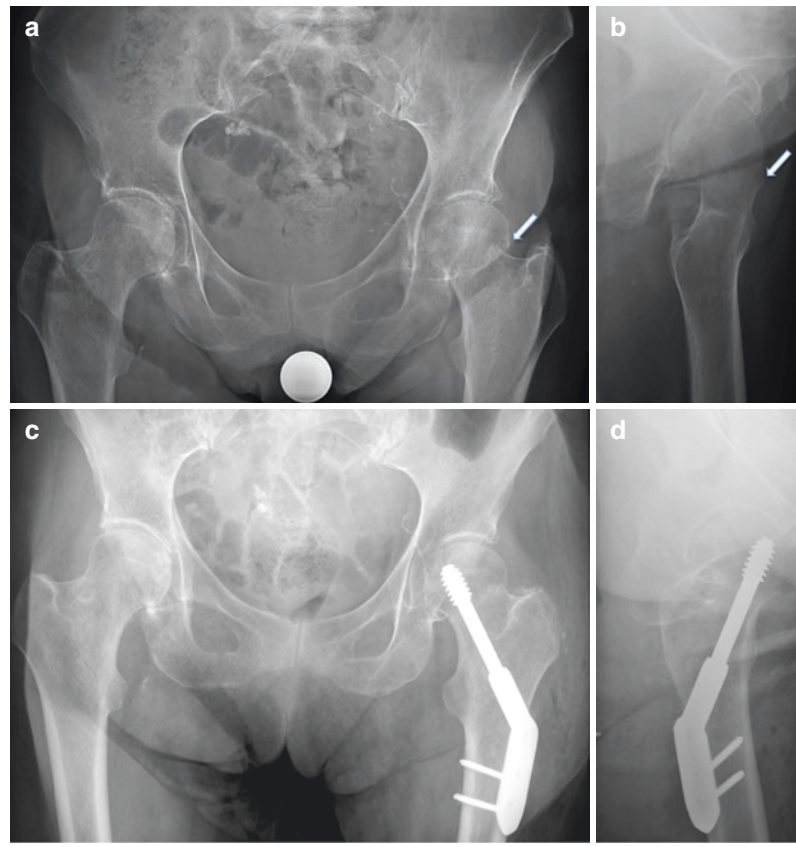

Fig. 6.3 Garden II femoral neck fracture in an active patient on the left side with a posterior tilt of 30° (see Fig. 6.5), pelvis ap (**a**) and axial view (**b**). Same patient after treatment with DHS, pelvis ap (**c**) and axial view (**d**). Arrows indicate the fracture

or whether a third one is necessary. Maurer et al. tested, in a cadaveric model, the anterior loading, incremental axial loading, and cycling loading of two and three screws in two matched pairs of human cadaveric femurs with femoral neck fractures and found that three screws yield better results, with greater resistance to anterior loading, less inferior femoral head displacement, and less superior gapping at the osteotomy site [16]. Furthermore, Yang and colleagues evaluated the influence of the relative screw position of three screws in young patients with femoral neck fractures and found a significantly better union rate for the "inverted triangle configuration" (91 vs. 77%, $p = 0.018$) (Fig. 6.4a–d) which means one screw placed distally near the calcar femoris, and two screws parallel above it anteriorly and posteriorly to form an inverted triangle [17].

As it is known that for trochanteric fractures, the so-called "tip-apex" distance of the sliding hip screw should be less than 25 mm [18], one could assume similar results for the femoral neck fracture, but there is as yet little data on the exact screw position in relation to the head for the undisplaced femoral neck fractures [19]. In 2009, Palm et al. described the posterior tilt for the undisplaced femoral neck fractures [13]. They treated 113 patients ≥60 years old with Garden I

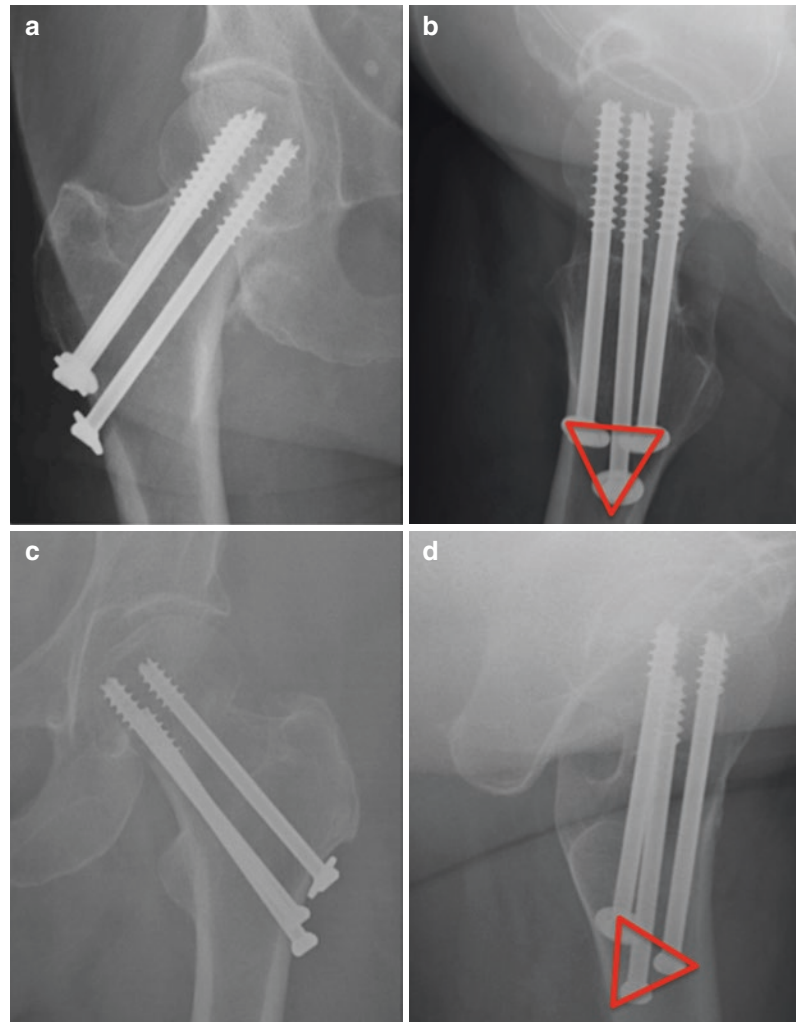

Fig. 6.4 Stable femoral neck fracture on the right side treated with three cannulated screws in the inverted triangle, hip ap (**a**) and axial view (**b**). One screw lies in a steep angle near the calcar femoris, two screws are parallel above it, forming an inverted triangle highlighted in (**b**). In (**c**) and (**d**) there is a stable femoral neck fracture on the left side treated with three cannulated screws not lying in the preferred triangle configuration

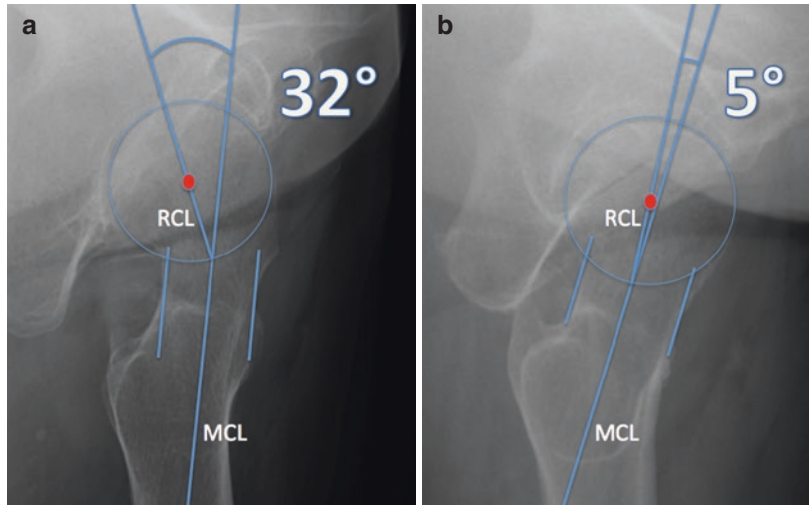

Fig. 6.5 Stable femoral neck fracture on the right side, axial view (**a**). A posterior tilt of 32° is shown. In (**b**) there is a stable femoral neck fracture on the right side, axial view, a posterior tilt of 5° is shown. The posterior tilt is the angle between the mid-collum line (MCL) and the radius collum line (RCL) defined at the line from the head center to the crossing of the MCL with the radius of the head [13]

and II fractures with two cannulated screws and found that the posterior tilt (Fig. 6.5a, b) was a predictor for reoperation with a rate of 14/25 to 12/88 if the posterior tilt was ≥ 20° ($p < 0.001$). Clement and colleagues proved that the posterior tilt ≥20° was an independent predictor of internal fixation failure in 162 elderly patients; moreover, they found the ASA (American Society of Anesthesiologists) grade to be an independent predictor for failure [12]. The reason for this finding is not clear; one possible explanation could be the higher rate of osteoporotic bone. In a biomechanical in vitro study, Paech et al. found better results for polymer-augmented sliding hip screws in osteoporotic bone with a decrease of failure in terms of cut-out [20]. However, there are still no studies regarding cement-augmented cannulated screws for femoral neck fractures.

Overall, the implant situation is not clear, and in some ways disappointing. There are some new implants, such as the angular stable multiple screw fixation (Targon FN) that has yielded good results, [21] but other studies have shown no difference for this implant against cannulated screws [22]. In our opinion, the treatment of the stable femoral neck fracture in the elderly should be pragmatic: If there is no posterior tilt and good bone stock, then three cannulated screws in an inverted triangle should be used. If there is poor bone stock and/or posterior tilt ≥20°, then a sliding hip screw with additional anti-rotational screw should be used, augmented with bone cement eventually, depending on the bone quality.

Unstable Fractures

Internal Fixation vs. Arthroplasty

Although there have been multiple discussions on the best implant for femoral neck fractures in the young patient, it is beyond dispute that a primary reduction and fixation should be obtained in a timely, acceptable manner [23]. In the elderly population, the discussion on the best strategy for displaced femoral neck fractures has been going on for ages. The general considerations are about early mobilization, failure rate, functional outcome, mortality, and socioeconomic costs. Since many patients in this group have numerous diseases, and since internal fixation is mostly performed with a sliding hip screw or 2–3 cancellous parallel screws, it is understandable that surgeons perform such small, fast operation [24, 25]. Many studies have shown that internal fixation takes less operating time, there is less blood loss and fewer needs for transfusion [25, 26]. However, the problems occur post-operatively (Fig. 6.6a–h): high failure rates with the necessity for reoperation in 30–43% [9, 24, 25, 27], compared with

6–11% for hemiarthroplasty (HA) [9, 28, 29], and there is a high rate of avascular necrosis of the femoral head in the internal fixation group [9]. Despite these data, internal fixation is still a common treatment for patients with severe comorbidities—and especially dementia. One reason could be the expected higher mortality of hemiarthroplasty (HA) vs. internal fixation (IF), but many studies could not confirm this in active elderly patients [9, 25, 27]. A small exclusion has to be made: Parker et al. found a tendency towards improved survival after IF in patients aged 90 or above, and in those with a low mobility score, although this was not statistically significant [26]. Figure 6.7a–d shows the treatment of a displaced femoral neck fracture with HA.

As nearly one-third of the patients with femoral neck fracture suffer from dementia or other mental deficiencies, in following the post-operative treatment protocols, the question emerges as to whether this group would benefit. However, Olofsson et al. found no differences in mortality between patients

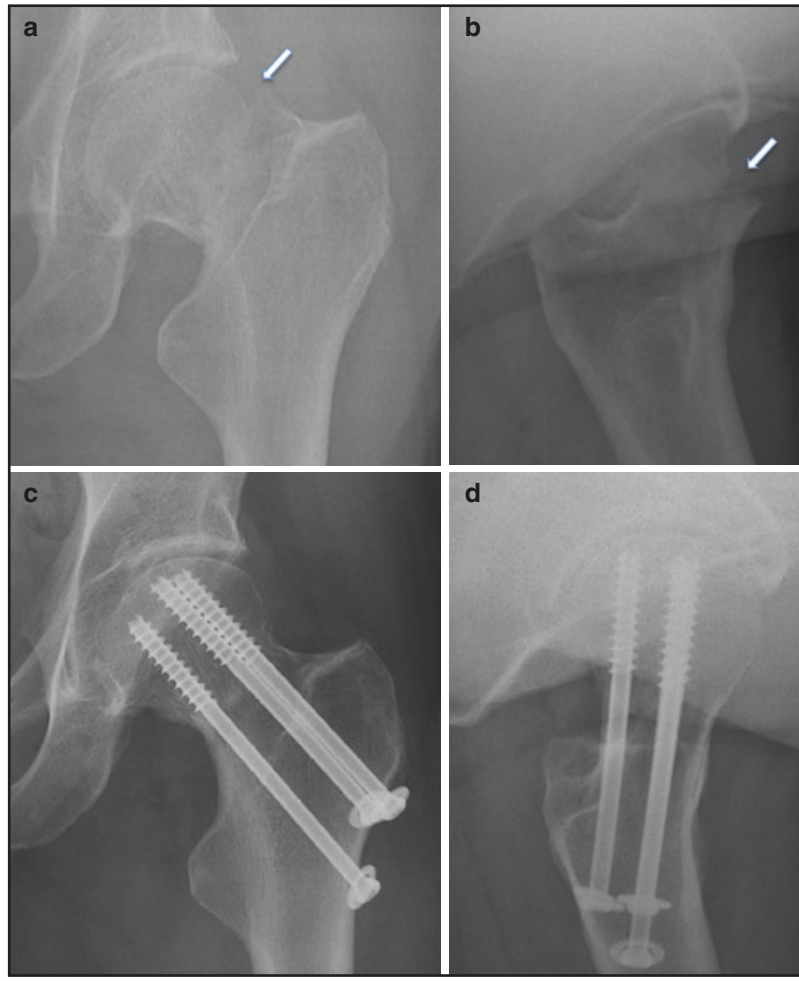

Fig. 6.6 Unstable and displaced femoral neck fracture on the left side, hip ap (**a**) and axial view (**b**), arrows indicate the fracture. Treatment was with three cannulated screws, (**c**) showing the post-operative hip ap view (**d**) the axial view. Although the treatment was done in an adequate technique, there was internal fixation failure after 6 weeks with shortening and a bad functional result (**e**, **f**). Arrows indicate the screw movement in relation to the washer. After 6 months (**g**, **h**), the fracture is still visible and the head collapses, resulting in a revision with hemiarthroplasty

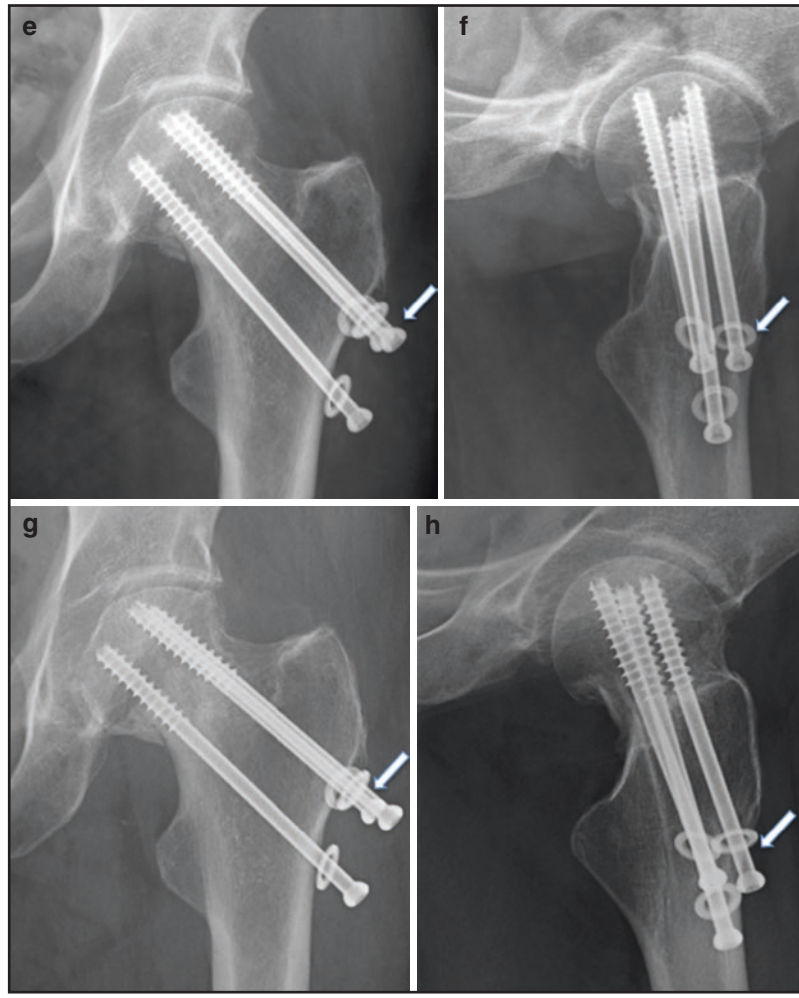

Fig. 6.6 (continued)

with or without dementia treated with IF or arthroplasty, and all patients with arthroplasty had better functional results after 4 months and 1 year [5]. In 2014, Johansson published long-term results of 146 fractures and included 38% mentally impaired patients in his study [30]. The failure rate for the IF was very high, with 55% for the lucid and only 16% for the mentally impaired, whereas failure was defined as early redisplacement, non-union, symptomatic segmental collapse, or severe infection. For arthroplasty, the failure rates were 5% and 16% respectively, whereas failure was defined as two dislocations or more, implant loosening, severe infection, or a periprosthetic fracture. Most of the complications occurred within the first 2 years. Unfortunately, this study has a high bias due to patient loss. After 2 years, only 50% of the mentally impaired patients were still alive, and after 5 years 13% ($n = 7$); this makes interpretation of the data on the mentally impaired very difficult. Further research is needed to highlight this large, increasing patient population, although the trend is toward arthroplasty even in this cohort.

With regard to functional outcome, many studies show either equal [24] or better results for arthroplasty [9, 25, 26, 31, 32]. Furthermore, a secondary arthroplasty after failed IF seems to have worse results for hip function [33].

Blomfeldt et al. compared the outcomes of 43 patients with a primary hip due to femoral neck fractures with 41 patients with secondary arthroplasty due to IF failure; both the hip function and the health-related quality of life were significantly better after hip arthroplasty [33]. In contrast, Parker et al. found in one of the largest long-term studies (with 455 patients), no difference in the outcomes of IF vs. HA after 11 years [26]. Due to the study design, uncemented stems were used, and no THA control group was evaluated. Also Ravikumar and Marsh showed—in 290 patients after 13 years—equally poor outcomes with regard to function for IF and HA, but they had good functional results for the total hip arthroplasty (THA) group, which will be discussed in the HA vs. THA section [27].

Some studies dealt with the socioeconomic outcome and performed a cost effectiveness analysis of IF vs. HA or THA. Obviously, the sheer costs of the implants and the shorter operating time for IF speak for themselves, but if one keeps the higher failure rate and necessity for reoperations in mind, this recommendation may change. Bjørnelv et al. made a cost effectiveness" analysis alongside a randomized, controlled trial in Norway, and found that besides a better health-related quality of life for HA, there were higher

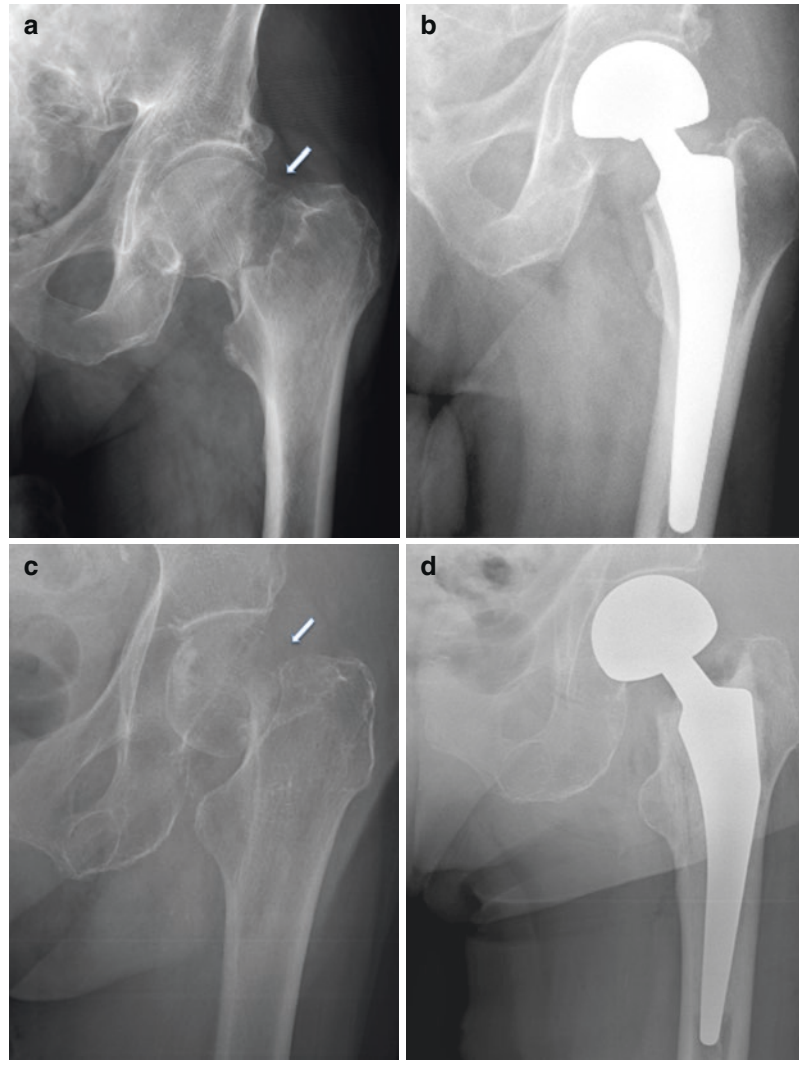

Fig. 6.7 Unstable and displaced Garden III femoral neck fracture in active patients with no radiological osteoarthritis on the left side **(a)** before and **(b)** after surgery with hemiarthroplasty with cemented stem and bipolar head. (**c**) and (**d**) showing the same for a Garden IV femoral neck fracture. Arrows indicate the fractures

overall costs for IF in comparison with HA [34], whereas Johansson and colleagues found no difference in the costs for 143 patients receiving either THA or IF in addition to better results for the THA group for the Harris Hip Score [35].

To summarize, regarding the actual evidence on unstable femoral neck fractures in view of treatment with internal fixation or arthroplasty, one has to conclude that the internal fixation with the high failure rate and the worse functional and health-related results cannot be recommended as the implant of first choice for the active elderly. In our opinion, an HA or THA should be performed for the elderly and active, whereas the internal fixation can be considered to be a fast and gentle tool for moribund and bedridden patients. For the active mentally impaired elderly, there is no clear evidence as yet, but the tendency is towards hemiarthroplasty.

Uni- vs. Bipolar Head

As noted, the HA still remains the "work horse" in the treatment of displaced femoral neck fractures in the elderly. However, depending on the region and economic considerations, the decision to use a uni- or bipolar head varies. The basic idea to use a bipolar head is the reduction of the acetabular erosion, as the movement mainly takes place in the bipolar head rather than in the joint, and thereby reduces pain levels and increases the clinical outcome [36, 37]. Unfortunately, the evidence in the existing literature varies as much as the real treatment. In a randomized control trial study of 120 patients, Hedbeck and colleagues found that at a mean age of 86 years, there was an almost identical clinical outcome after 1 year, but a significantly higher incidence of acetabular erosion in the unipolar HA group. As they found trends towards worse Harris Hip Scores (HHS) in patients with acetabular erosion, they concluded that a bipolar HA should be the preferred treatment [37]. In contrast, Calder et al. reported no difference in clinical outcomes and complication rates between both groups [36]. They evaluated 250 patients with a median age of 85, and found significantly better results for the unipolar group in view of the return to pre-injury state, in comparison to the bipolar group. In summary, current evidence is not able to provide a conclusive recommendation for or against unipolar or bipolar hemiarthroplasties in octogenarians.

But the question remains of whether the "young" old patients would benefit from a bipolar head. It was again Calder et al. evaluating a questionnaire from a randomized control trial of a group of 110 patients age 65–79 who were treated with either hip screw, unipolar, or bipolar arthroplasty [38]. The bipolar arthroplasty group showed a trend towards better results in almost all questionnaire values in this patient collective. But in 2001, Davison et al. showed in a prospective, randomized control trial of the treatment of 280 displaced fractures of the femoral neck (187 patients had had arthroplasty, and 93 sliding hip screws) in patients aged 65–79, that there was no advantage to the bipolar over the unipolar head [24]. So again, there is no clear evidence for or against one of the two options. Theoretically, younger patients would have a higher acetabular erosion rate due to longer survival, although the existing literature does not support the use of the four times higher costs of bipolar head in the 65 to 79-year-old age group [39]. Moreover, the actual trend goes toward total hip arthroplasty in this group, under certain circumstances.

Cemented vs. Uncemented Stem

Today, there are many studies that deal with this subject, and there is convincing evidence in favor of cemented or uncemented stems. The reason for choosing cement, or an uncemented implant, depends mostly on the surgeons' experience, education, and personal preference. Surgeons who use uncemented implants are afraid of the revision surgery, and the rare, but severe cardiopulmonary effects of cement in this patient cohort; the other group (who use cement) may worry about early loosening with pain and worsening function [40]. Figved and colleagues found no difference in HHS scores after 3 and 12 months in 220 patients (112/108 cemented/uncemented stems, 83.4/83.0 years) [41]. Also, DeAngelis

et al. found no differences in mortality and various activities of daily living post-operatively and after 12 months in a prospective control trial with 125 fractures [42]. However, there are many more studies that show better results for the cement group in this cohort. It seems that cemented stems have better function and mobility results in the short-term [43], that the patients have statistically less pain, lower rates of complication [44], and lower periprosthetic fracture rates [45]. Furthermore, the results regarding walking ability, the use of walking aids, and activities of daily living were statistically better [40]. In 2010, a Cochrane Systematic Review dealing with this topic was published [39]. Many studies were included, but most had weaknesses in form and content. Nevertheless, the Cochrane Review corroborated the better results for cemented stems.

In the last few years, new models of the hydroxyapatite-coated stems have come on the market, and it remains to be seen whether they are associated with similar results. In 2014, Bell and colleagues showed, in a case-control study of nearly 180 patients, better results for the hydroxyapatite-coated Corail stem (DePuy Ortho- paedics Inc., Warsaw, Indiana) in view of further surgery, less operating time, and lower peri-prosthetic fracture rates in comparison with a cemented Exeter stem (Stryker Howmedica, Newbury, United Kingdom) [46]. Whether this is a really new way, or just a trend, cannot be assessed yet. Hence, the recommendation today should be a cemented stem for treating femoral neck fractures in the elderly.

Hemiarthroplasty vs. Total Hip Arthroplasty

As highlighted above, arthroplasty is the recommended treatment for active patients with unstable femoral neck fractures. However, the question increasingly emerges about whether active patients should receive a THA (Fig. 6.8a–d) rather than an HA. Van den Bekerom et al. found in 252 patients (>70 years) who had either cemented HA (n = 137) or THA (n = 115), that there were no differences in the modified HHS, revision rate of the prosthesis, local and general complications, or mortality [47]. Furthermore, they reported lower intra-operative blood loss for HA (7% > 500 ml) than for THA (26% > 500 ml), shorter surgery for HA (12% > 1.5 h vs. 28% > 1.5 h). and no dislocations of any HA, but 8 dislocations of the THA during their 1- and 5-year follow-ups. Because of the dislocation rate, they concluded that they would not recommend THA for these patients in the absence of advanced radiological osteoarthritis or rheumatoid arthritis of the hip [47]. But is the higher dislocation rate a factor for recommendation, or should we rather ask the patients whether they are satisfied? In 2013, Leonardson et al. showed—in a national survey of 4467 patients—better results for those below and above 70 years of age who were treated with THA; they had less pain and more satisfaction compared with those treated with IF or HA [48]. This shows the conflict in the debate about the best strategy for or against THA pretty well. Finally, it is a question of outcome parameter definition.

But maybe osteoarthritis itself is an indication for THA? A recent study by Boese and colleagues addressed this question in 126 elderly patients treated with HA. They saw no significant differences in the HHS score (p = 0.545), the timed up and go test (p = 0.298), the Tinetti test (p = 0.381), or the Barthel Index (p = 0.094) between patients with preoperative Kellgren and Lawrence grades 3 or 4 osteoarthritis and patients with grades 0–2 after 12 months [49]. Unfortunately, they had only a short-term follow-up that included 40% of the initial patients, thereby substantially limiting the evidence. After all, the question still seems to be unsolved.

The theoretical idea for THA rather than HA is that acetabular erosion due to HA lowers the outcome in comparison to THA in the long run, and one could assume that an already degenerated joint has a worse outcome with hemiarthroplasty, but there is only scant secondary data that deals with this. It was Ravikumar et al. who presented one of the largest long-term studies for THA in femoral neck fractures [27]. They evaluated the difference for IF, HA and THA in 290 patients over 13 years and found revision rates of 33% for

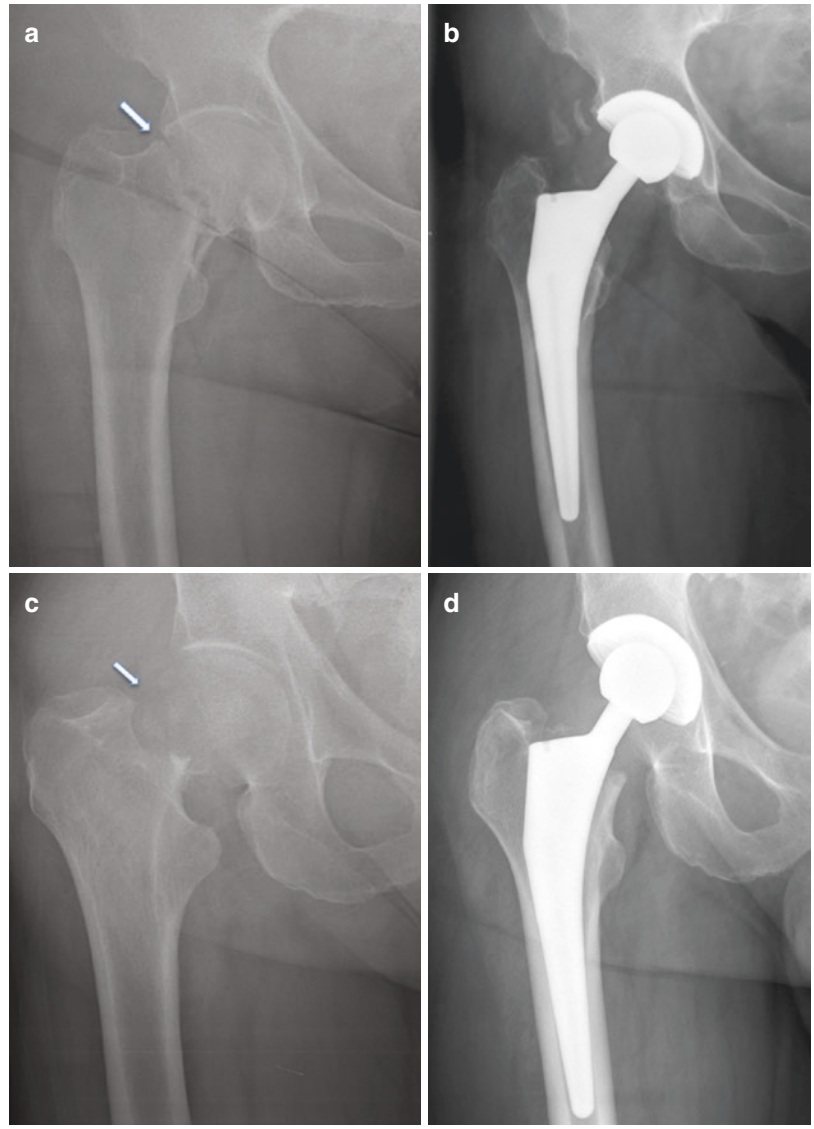

Fig. 6.8 Unstable and displaced Garden III femoral neck fracture in active patients with no radiological osteoarthritis on the right side before (**a**) and after (**b**) surgery with THA. (**c**) and (**d**) showing the same for a Garden IV femoral neck fracture. Arrows indicate the fractures

IF, 24% for HA, and only 6.75% for THA. The dislocation rate was 13% for HA and 20% for THA, whereas the HHS score was 62 (IF), 55 (HA), and 80, which was much better for THA. Furthermore, the IF and HA had poor results in pain and mobility levels. However, one limitation remains: the HA group had an uncemented stem in contrast to the THA group; this probably affects the outcome, but it seems that the THA has better results in the long-term in active patients. In addition to this, Macaulay et al. showed no difference in pain levels and functional outcome for HA vs. THA in 41 patients after 6 months, but the THA group was better in pain levels, the timed "Up & Go" Test, and functionally independent life after 12 months [50]. Moreover, Keating and colleagues reported better results for THA in comparison to IF or HA after 24 months in 298 patients [31]. Additionally, they undertook a cost effectiveness analysis and found—after evaluating all complications and readmissions—a cost advantage of £3000 per patient for THA vs. HA.

In 2009, Heetveld et al. published a meta-analysis of all accessible studies with the focus of IF vs. arthroplasty and HA vs. THA for displaced femoral neck fractures [51]. They concluded that THA should be considered in any elderly active patient and in patients with pre-operative osteoarthritis or rheumatoid arthritis, but to date, no high-powered study has compared HA with THA in the long run, even though in 2011 Hedbeck and colleagues published a Level I randomized controlled trial with 120 elderly patients (60 HA vs. 60 THA), with a follow-up at 12, 24, and 48 months [52]. At 12 months, the THA had better hip function in the HHS score (mean score: 87 vs. 78, $p < 0.001$), and this increased up to 4 years (mean score: 89 vs. 75, $p < 0.001$). Furthermore, the health-related quality of life had a tendency to better values for the THA after 12 and 24 months, becoming significant at 48 months ($p < 0.039$).

To summarize the results: THA is a good option for active lucid elderly patients with displaced femoral neck fracture, since in the long run the outcome parameters of the HA decreases. But one possible influence parameter is not yet highlighted, neither in this chapter nor in the literature: the surgeon's experience. As most femoral neck fractures will be treated by a traumatologist with possibly less experience with THAs than HAs, the recommendation for or against THA as the treatment of choice for a certain patient has to be made individually, and it must include the surgeon's experience.

Patient Blood Management

Transfusions

A critical aspect in the treatment of elderly patients with femoral neck fractures is preoperative anemia and intraoperative blood loss. Many of the patients in this cohort have cardiovascular disease and few possibilities for compensation, so the relevance for the outcome seems obvious. Potter et al. found in their 2014 review that *anemia* at the time of hospital admission in patients with hip fractures was associated with increased mortality (RR 1.64, $p < 0.0001$), with anemia defined at <100 g/L hemoglobin [53]. The transfusion itself had no influence on mortality, but the transfusion level at <80 vs. <100 g/L led to a relative risk from 1.67 ($p = 0.05$) for myocardial infarction. In 2011, Carson et al. published the largest randomized control trial study, with 2016 hip fracture patients at cardiovascular risk, in which they found no difference in mortality between a liberal-strategy group that received transfusions of red blood cells at <100 g/L or a restrictive-strategy group that only received a transfusion for symptoms of anemia or at the physician's discretion at <80 g/L [54]. Furthermore, there were no significant differences in mortality or the inability to walk at the 60-day follow-up. In 2015, Brunskill et al. addressed this matter within the context of a Cochrane Collaboration Review and found, with low-quality evidence, no difference in mortality, functional recovery, or post-operative morbidity between a liberal-strategy and restrictive-strategy group in patients who had hip fracture treatment [55]. Overall, there are low-evidence levels for a clear preference of restrictive or liberal transfusion strategies, but it seems reasonable to undertake a restrictive strategy in the transfusion of red blood cells both during and after hip fracture treatment. Patients with chest pain and/or a history of cardiovascular disease should receive transfusions rather verified to clinical symptoms and severity of cardiovascular disease than to a hemoglobin level of <80 g/L.

Delay Due to Anticoagulants

As mentioned, most elderly patients with femoral neck fractures have additional diseases, and so it is not surprising that a relevant percentage of the patients take platelet inhibitors or other anticoagulants, such as warfarin [56, 57]. Patients treated with warfarin are a relevant proportion (about 8%) of patients with hip fractures, but it is beyond dispute that the warfarin has to

be antagonized with vitamin K or fresh-frozen plasma prior to surgery [57], although for platelet inhibitors like aspirin or clopidogrel, it is not that clear. A major problem is the long-lasting effect of the drugs, and the only reasonable possibility to antagonize them would be a platelet transfusion. One question could be: Can we wait with surgery until the effect of the platelet inhibitors is gone? Maheshwari et al. evaluated the 1 year mortality and complications in 30 patients with proximal femoral fractures on clopidogrel [58]. After a mean of 8.4 days' delay, they found that there was still a need for transfusion in 7 patients, and post-operative complications in 43% of them. A multi-regression analysis showed that delaying surgery ($p = 0.03$) was the only independent predictor of one-year mortality. Thus, waiting does not seem to be an option. Manning and colleagues found in 32 patients with femoral neck fractures who take aspirin, that there was a higher transfusion rate but no effect on peri-operative blood loss, or change in hemoglobin concentration or hematocrit, in comparison to 57 patients who did not take aspirin [56]. Moreover, the transfusion rate seems to be an effect of a pre-operative lower hemoglobin concentration and hematocrit.

But perhaps it is possible to identify the patients with a high risk of bleeding by measuring the platelet function. It was Thaler et al. who reported the effects of measuring it in 462 patients with hip fractures, 120 of them with platelet inhibitors (98 aspirin, 22 clopidogrel) [59]. They found no difference in mortality, major bleeding, red blood cell requirement, or drainage blood loss. Moreover, they reported no correlation of the peri-operative blood loss with either a history of platelet inhibitor intake or measured platelet function. In 2012, Hossain et al. showed that in 102 patients (50 vs. 52) with or without clopidogrel and femoral neck fracture treated with HA, there was no difference in pre- and post-operative hemoglobin, ASA grade, comorbidities, operating time, transfusion requirements, length of hospital stay, wound infection, hematoma, and reoperation rate [60]. Overall, there are no clear disadvantages found in the literature for early operation in this cohort, but there are clear disadvantages for delay. Related to these findings, a delay in surgery due to platelet inhibitors intake does not seem reasonable.

Summary and Recommendations

In consideration of the restrictions mentioned in the introduction, the actual recommendations for treating femoral neck fractures in the elderly can be summarized thus:

1. Stable fractures:
   - The standard should be three cannulated screws with the inverted triangle technique.
   - If there is poor bone stock and/or posterior tilt ≥20°, then a sliding hip screw with an additional anti-rotational screw should be used.
   - Augmentation with bone cement in osteoporotic bone.
   - Conservative treatment according to individual decision, especially for moribund patients.
2. Unstable fractures:
   - Hemiarthroplasty with cemented stem for physically or mentally impaired elderly patients.
   - Unipolar head for very elderly patients is possible.
   - Bipolar head rather for the "younger' elderly," but no clear recommendation.
   - Pre-operative osteoarthritis or rheumatoid arthritis: THA.
   - THA for active and mentally healthy elderly patients.
3. Patient blood management:
   - Restrictive strategy for transfusion (<80 g/L hemoglobin level).
   - Early surgery with antagonizing warfarin.
   - Early surgery independent of platelet inhibitors.

For the future, there are still many challenges to further randomized studies with enough power.

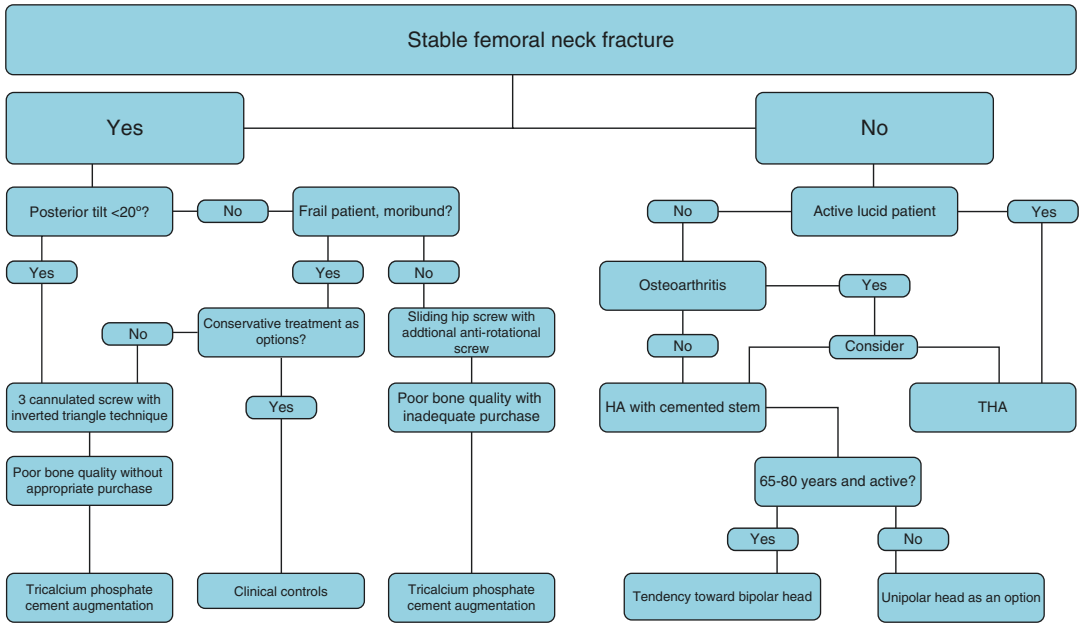

Fig. 6.9 Simplified algorithm for femoral neck fractures in the elderly on the basis of the existing evidence data. It has no claim for completeness as this is not possible due to the many influences described in the text, but it could influence the decision of the surgeon facing the problem in the OR

The focus must be on the various patient cohorts and the outcomes in the long run, especially in patient-related outcomes such as satisfaction, mobility, pain level, and function. Nevertheless, the surgeon facing the problem in the OR still has to consider many individual factors—such as age, ASA grade, general condition, or the drugs taken. With that in mind, we developed a treatment algorithm that may help make the decision (Fig. 6.9).

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The alterations/artwork in the x-rays, as well as the algorithm, were generated by the authors.

The authors declare that there is no conflict of interest, and that no benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this chapter.

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