SUMMARY

Background: Surgery is the treatment of choice for fractured neck of femur. For middle-aged patients (aged ca. 40 to 65), there is considerable debate over the indications for arthroplasty or internal fixation. The choice of surgical technique varies widely from one region to another. In this article, we discuss the main criteria that should be used in making this decision.

Methods: We selectively reviewed the literature on the diagnosis and treatment of fractured neck of femur, including the current guideline of the German Society for Trauma Surgery (Deutsche Gesellschaft für Unfallchirurgie, DGU) and recent findings from the field of health services research.

Results: The treatment of middle-aged patients with dislocated fractures should be based on rational decision-making. The patient’s level of activity before the accident should be judged in terms of his or her previous mobility, independence in daily activities, and mental status. Internal fixation is recommended if the fracture can be adequately repositioned, the bone is of good quality, and there is no evidence of osteoarthritis. Fractures that are more than 24 hours old should be treated with total hip arthroplasty. Hemiprostheses are appropriate for very old patients. Physically frail, bedridden, and/or demented patients should undergo internal fixation of the fracture. For non-displaced or impacted fractures, functional treatment (i.e., prophylactic securing of the fracture with screws or nails) is indicated. Rapid diagnosis and a short time in bed before surgery lower the rate of complications. Internal fixation with preservation of the femoral head should ideally be performed within the first 6 hours of trauma, and within the first 24 hours at most.

Conclusion: Despite the increasing scarcity of resources, treatment should still be based on well-founded clinical guidelines. Minimally invasive surgery enables better function in the early postoperative phase and can thereby lower complication rates. An interdisciplinary concept for the postoperative care of elderly patients also has a major effect on the outcome.

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Fractured neck of femur does not only bear a high risk of mortality within the first 6 months after surgery, but often the patient’s independence is at risk as a result of the injury.

In 2007, Germany’s Federal Office for Quality Assurance (Bundesgeschäftsstelle Qualitätssicherung, BQS) registered more than 96,000 fractures of the proximal femur; in 2006, more than 50,000 of these were fractures of the neck of femur. Only 0.6% of the patients were younger than 40 years of age, 62% were older than 80 (1). According to the classification of the American Society of Anesthesiologists (ASA), more than 70% of patients were categorized as having a perioperative risk of severity grade 3 (at least one serious comorbidity) or worse.

Current therapeutic approaches aim to restore patients’ mobility, if possible to its preoperative level, by means of an endoprosthesis (arthroplasty) or osteosynthesis (internal fixation). In young patients with fractured neck of femur osteosynthesis should always be the preferred option, whereas in older patients, endoprosthesis should be favored. For middle aged patients (40–65 years), the indication is the subject of much controversial discussion and has to be defined for each patient individually. This article explains the relevant criteria that should inform the decision making process.

Methods

We conducted a selective literature search for diagnostic evaluation and treatment of fractured neck of femur. In the data evaluation we took into account the current guideline from the German Society of Trauma Surgery and recent insights gained in health services research.

Biomechanics

The neck of femur is the region between the head of femur and the trochanteric mass; it is situated within the articular capsule.

The biomechanical understanding of the proximal femur has historically been formed by Pauwels; the classification of fractures named after him takes into account the angle the fracture line forms with the horizontal line. In Pauwels type II (fracture angle 30° to 50°), the fracture and contact area is smallest, in type I the resulting force is more likely to lead to a compacted fracture, in type III the predominance of the shearing forces triggers a slipped fracture. Garden added to this
model, which was explained with pushing and pulling forces, by observing the fine structures of the proximal femur and interpreting the screw-shaped arrangement of the trabecular bones dynamically. This explains the enormous resilience against the actual shear forces that occur in everyday life. Later studies by Bergmann (2), which used sensor prostheses on the hip joint, gave credence to this idea. The direction of the maximum forces is almost unchangeable (independently of the type of activity). The large muscles surrounding the hip are needed to transform the shear forces into pressure along the load-bearing medial trabecular bones. In elderly patients in a poor general condition, these muscles are weakened. In addition to the reduced bone quality, this functional aspect should be borne in mind in terms of the pathogenesis of fractured neck of femur.

In 1961, Garden published his classification based on the direction and the extent of the dislocation (3) (Figure 1). In addition to the alignment of the fracture line, this is an important aspect. A third important criterion that he described was the quality of the repositioning. The trabecular bones should be physiologically aligned after repositioning, which should also be the case for the lateral aspect (Figure 2).

Garden I describes a stable fracture with impaction in valgus, Garden II refers to non-displaced fractures. In Garden III the femur head is displaced in varus, and in Garden IV it is completely displaced. The anatomical correlate of Garden IV is the destruction of the supporting cervical posterior cortex that is required for repositioning (Figure 3).

The distinction between Garden III and IV is not an easy one to make (e1), hence the usual practice is to differentiate between non-dislocated (Garden I, II) and dislocated (Garden III, IV) fractures.

In Garden’s prospective study in 1976 (4), only 1% of 1503 fractures were Garden type II; Garden III and IV combined accounted for 80%, both in equal proportions. No fundamental difference was found in groups of types III and IV with regard to the result (necrosis of the head of femur and pseudarthrosis). A newer form of fracture of the head of femur is a fracture in patients with a prosthetic surface implant (Figure 4).

Clinical picture
The externally rotated shortened leg of a patient in a supine position who is unable to walk makes for an easy diagnosis; the history is typical, on examination a bruise/hematoma is visible. The patient will report hip pain, occasionally radiating into the knee joint. The patient is unable to lift the extended leg.

Differential diagnoses
In elderly people, differential diagnoses include—further to contusion—fractures of the pelvic ring and lumbar spine. In younger patients who have experienced high-velocity trauma, fracture of the head of femur or acetabular bone, or hip luxation should be considered. Femoral fractures in a more distal position are also among possible differential diagnoses.

Diagnostic evaluation
In order to include the listed differential diagnoses, a radiograph of the entire pelvic region, showing the pelvis with axial projection of the affected hip, should be obtained. Inability to walk after a fall and persisting problems without confirmed fractures on the pelvic radiograph may be the result of an occult fracture. In this constellation, the magnetic resonance (MRI) scan shows a fractured neck of femur in 40.5% of cases, and fracture of the pubic ramus with or without sacral involvement in a quarter of cases (e2). If an occult fracture is suspected, a control radiograph after 3–5 days, a computed tomography scan, or an MRI scan should be obtained to confirm whether such a fracture is present. A szintigram is not required.

Therapeutic indications
Conservative treatment
Conservative treatment is the treatment of choice only for stable impacted fractures (Garden I) in elderly people as long as the axial scan does not show any relevant tilting of the femur head. Patients should be mobilized while bearing weight but according to their level of pain, the subsequent tilting manifests as an inability to lift the leg in an extended position while lying down. Garden even reported a 50% risk of pseudarthrosis if the lateral tilting is more than 20°. Prophylactic...
fixation with screws is thus recommended, even if the degree of tilting is less pronounced.

Extension treatment is counterproductive in the conservative therapeutic approach and has no positive effects even if surgery is planned (e3).

**Surgical treatment**

Surgical treatment is the method of choice. For middle aged patients (40–65 years), the indication for osteosynthesis or endoprosthesis is the subject of much controversial discussion. The decision criteria are shown in the Table and follow the guidelines of the German Society of Trauma Surgery (Deutsche Gesellschaft für Unfallchirurgie, DGU). In individual cases, the guidelines allow for individual therapeutic options. The table section “sprightliness” provides an additional way to categorize patients.

**Evidence base**

The evidence base is divergent and includes meta-analyses of randomized controlled trials (RCTs) (evidence level Ia), RCTs (Ib), controlled studies (II), case-control studies (III), and reports and opinions (IV). Thromboembolism prophylaxis and antibiotic prophylaxis are supported by good evidence (level Ia), as is the recommendation for osteosynthesis in frail or bedridden patients, or in those affected by senile dementia. RCTs (Ib) support the 24 hour limit, the higher reoperation rate, and the lower blood loss owing to osteosynthesis. Controlled studies (II) support lower blood loss for hemiprostheses, for example, as well as the inferiority of hemiprostheses compared with total endoprostheses (TEP) from the third year after the operation.

Any surgical procedure to treat fractured neck of femur should be accompanied by perioperative antibiotic treatment; a once-only dose is sufficient (e4). This reduces the rate of wound infections and nosocomial infections (e5). An increased risk of infection—for example, owing to diabetes, obesity, or prior surgery—cannot be reduced, even by prolonged administration of antibiotics. Rather, this approach triggers an increase in adverse effects, complications, and anti-biotic resistance (e6).

**Osteosynthesis**

**Repositioning**

A requirement for successful osteosynthesis is the exact repositioning of the fracture in both lines. A slight valgus position may be acceptable. In younger patients, the valgus position results in a better healing process and fewer necroses of the femoral head, but after several years it will also increase the rate of arthritis (6).

**Osteosynthesis techniques**

The most common method is internal fixation using three cannulated bone screws. The first screw is supported in the medial caudal position by the calcar bone in order to prevent tilting into a varus position. The second screw secures the fixation from the dorsal position at mid-level. This is the critical zone for stabilizing the head at the sagittal level. The third screw is positioned in a cranial-ventral position to the second. Fracture compression is guaranteed only if the screws are placed at strict parallels to each other. There have been reports, however, that the number and position of the screws do not influence the outcome (e7). Placing washers is recommended (e8) to keep the screws in place. The dynamic hip screw (DHS) as an implant with stable angles may be preferred in a Pauwels III scenario.

**Timing of the operation**

Osteosynthesis preserving the head of femur is an emergency procedure and needs to be performed within 6 hours. The pressure resulting from bleeding into the articular capsule will increase after this point in time. It is highest in an extended position and when the leg is rotated inwards and lowest in the opposite position, the so called “antalgic” position. Relieving the
hemarthrosis often results in a pressure drop in a scenario where the vascular circulation is already disrupted anyway (e9).

### Results

A meta-analysis showed for osteosynthesis that the surgical procedure took less time, incurred less blood loss, and resulted in fewer wound infections (7) than arthroplasty. Garden and others reported a rate of pseudarthrosis of 33% for Garden type III/IV patients and a rate of necrosis of the head of femur of 28% for a cohort of more than 1500 patients with fracture of the neck of femur. Very old age, severe dislocation, and insufficient repositioning are the main risk factors. Newer studies have described a similar failure rate (8) and, compared with total endoprosthesis, the same result in terms of pain and mobility. Other studies have reported notably poorer functioning and a high proportion of patients with pain (9).

A possible complication associated with internal fixation is subtrochanteric fracture, which is problematic because of its mechanical and vascular instability.

In young patients in whom healing is not progressing as expected, valgus intertrochanteric osteotomy is still an option.

If osteosynthesis has failed and the patient has subsequently received an endoprosthesis, the functional result for the patient is poorer. The rates of infection, luxation, and revision are higher than after primary TEP (10).

### Endoprosthesis

#### Timing of the surgery

A rapid diagnosis and short preoperative bed rest reduce complications such as pressure sores, thromboembolism, and pneumonia, but do not affect mortality (11). Scientific evidence shows that a maximum time interval to surgery of 48 hours should not be exceeded (12). The result is also influenced by the time interval between the accident and a confirmed diagnosis (e10). In 2007, 13% of patients waited for surgery for more than 48 hours (BQS report) (1).

#### Hemiarthroplasty or total endoprosthesis

The available options are the replacement of just the femoral part of the hip joint with a unipolar or bipolar prosthetic head (dual head) or else total endoprosthesis. The prosthetic head entails a higher risk of possible protrusion (13). The TEP delivered better results after three years and in the longer term with regard to pain and function (14, 15, 16); the revision rate is 6% after 13 years compared with 33% for osteosynthesis and 24% for hemiprosthesis. Duration of surgery, blood loss, and the risk of early postoperative luxation are lower if merely the head is replaced (17). The failure rate for hemiarthroplasty (loosening of the prosthesis and degeneration of the acetabulum) is lower after the 75th year of life (e11). When coxarthrosis related changes are present, a hemiprosthesis is contraindicated.

### Cement

The use of bone cement is partly determined by the bone quality that becomes apparent during the operation. The risk associated with cement use—fat embolism and right heart strain (18)—have to be considered, particularly in patients with reduced physiological resources. Modern cementing techniques are obligatory (preservation of the region of subchondral sclerosis, cement plug restrictors, pressure flush, retrograde filling, vacuum technique) (e12). Currently, 65% of hip

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**TABLE**

**Therapeutic indications for fractured head of femur and assessment of sprightliness/biological age**

<table>
<thead>
<tr>
<th>Garden types I and II</th>
<th>Treatment</th>
<th>Patient group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-dislocated (consider axial images) or impacted</td>
<td>Functional/prophylactic osteosynthesis</td>
<td></td>
</tr>
<tr>
<td>Garden types III and IV</td>
<td>Treatment</td>
<td>Patient group</td>
</tr>
<tr>
<td>Dislocated</td>
<td>Osteosynthesis</td>
<td>Young</td>
</tr>
<tr>
<td></td>
<td>Total endoprosthesis</td>
<td>Elderly</td>
</tr>
<tr>
<td></td>
<td>Dual-head prosthesis</td>
<td>Very elderly</td>
</tr>
<tr>
<td></td>
<td>Osteosynthesis</td>
<td>Age related dementia, bedridden, Sernbo III</td>
</tr>
</tbody>
</table>

**Decision criteria in dislocated fractures in middle age**

<table>
<thead>
<tr>
<th>Osteosynthesis</th>
<th>Degree of activity</th>
<th>Bone quality</th>
<th>Can the bones be repositioned? (Garden types III or IV)</th>
<th>Coxarthrosis</th>
<th>Endoprosthesis</th>
</tr>
</thead>
</table>

**Sprightliness/biological age (modified after Sernbo, 2002 [9])**

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own home</td>
<td>Sheltered home</td>
<td>Home for the elderly</td>
</tr>
<tr>
<td>1 walking cane</td>
<td>2 walking canes/wheeled walking frame</td>
<td>Wheelchair/bed</td>
</tr>
<tr>
<td>Alert</td>
<td>Slight confusion</td>
<td>Severe confusion</td>
</tr>
</tbody>
</table>

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Figure 4: Fractured neck of femur after resurfacing arthroplasty. The guide pin of the prosthesis prevents the head from moving back into its original position, similar to toughening of the synovial capsule.
prostheses are implanted cement-free (19). A contact allergy to cement components (mostly gentamicin) was found in one quarter of patients with an allergic reaction to the implant (e13).

Dementia
A patient’s mental state has a significant influence on mortality and the functional result (20, 21). Reported luxation rates in demented patients are as high as 32% (e14). Osteosynthesis is the guideline conform treatment in these patients.

Approach
The dorsal approach is the dominant standard procedure in Germany (42%). 77% of surgeons report using minimally invasive surgery (MIS). It follows that 34% of all total hip endoprostheses in Germany are implanted by using MIS (19).

The early functional advantages of minimally invasive surgery (22) mostly meet the needs of patients with fractured neck of femur. Our own studies have shown less blood loss and a lower risk of luxation compared to open surgery (Figure 5).

Aftercare
Fixated fractures of the femoral neck in young patients necessitate a reduced weight load postoperatively—differentiated by type of fracture and radiographically monitored recovery period—for up to 6 weeks. In elderly patients, mobilization is undertaken carrying their full weight.

After implantation of total endoprosthesis, bending the hip by more than 90° (very low seating position, putting on shoes) should be avoided, as should adduction movements, inward rotation after dorsal approach, and outward rotation after anterolateral approach. According to the BQS report for 2007, the proportion of cases of luxation after total hip arthroplasty was 0.9%.

Until the patient’s mobility has been fully restored, thromboprophylaxis should be given; after endoprosthesis this generally means a period of 4–5 weeks (guidelines of the American College of Chest Physicians [ACCP] and guidelines of the Association of the Scientific Medical Societies in Germany [Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften, AWMF]). Men with a high body mass index (BMI), reduced preoperative mobility, a lengthy surgical procedure, and pre-existing large osteophytes benefit from prophylactic treatment for heterotopic ossifications using non-steroidal anti-inflammatory drugs (NSAIDs) for the same time period (e15). Contraindications—such as renal failure or hypertensive cardiovascular disease—will need to be borne in mind, and prophylaxis against gastrointestinal ulcers should be given.

The mean length of inpatient stay in Germany in 2006 was 8.1 days for injury related diagnoses; this number has been falling for years (e16). The aftercare that crucially determines the prognosis is provided in rehabilitation units (23) and subsequently in the outpatient setting.

Mortality and morbidity
Large cohort studies—for example, a study in North Rhine-Westphalia that included 32 000 patients (24) and one in Canada that included 3981 patients (e17)—have reported a hospital death rate of 6%.
Mortality within the first year postoperatively was 30%. Elderly men with multiple comorbidities are at particularly high risk.

People in homes for the elderly constitute a high risk group for immobility. Rehabilitation measures significantly improve their likelihood of survival (e18). The problems of treating fractured neck of femur in elderly people are not a function of the type of surgical procedure but what is crucially important are the subsequent therapeutic measures and social reintegration (25).

**Today’s healthcare situation**

In the area covered by the Westphalia-Lippe State Medical Association, some 32 000 patients with fracture of the neck of femur were treated in the time period 1993–1999 (24). Only 6.3% of patients were younger than 60 years. The proportion of patients who had surgery rose from 93% to 96% in those 7 years. Hemiarthroplasty (femoral head prosthesis) was the most commonly used procedure (40.9%), followed by total endoprosthesis (34.1%). Of patients older than 60, 78.4% received a total endoprosthesis, compared with 30.3% of those younger than 60. Depending on the dislocation, however, 48.7% of younger patients with Pauwels type III fractures received a primary endoprosthesis.

The rate of postoperative complications, especially cardiorespiratory complications, fell from 30% to 22% in the period under observation.

Another study from North-Rhine Westphalia (e19) showed that the choice of surgical method and the timing vary widely between regions. The range of osteosynthetic procedures was 19% to 78.6%. Contrary to the guidelines, in some regions “head preserving” procedures in younger patients are undertaken only after a delay.

**Conflict of interests statement**

The authors declare that no conflict of interest exists according to the guidelines of the International Committee of Medical Journal Editors.

**KEY MESSAGES**

- The indication for osteosynthesis or endoprosthesis in fractures of the neck of femur should be based on the radiographic diagnosis and patient based factors. The guidelines will aid the decision.
- Radiography supported diagnosis provides information about the fracture level (Pauwels) and the extent of dislocation (Garden) and about the options for repositioning, degree of osteoporosis, and possible signs of coxarthrosis.
- Patient based factors include independence, mobility, and mental state.
- In persisting problems, occult fractures will need to be ruled out by using radiography, computed tomography, and magnetic resonance imaging.
- Important factors affecting prognosis include a short preoperative bed rest, no delay in planned hemi-arthroplasty, and interdisciplinary organization of geriatric aftercare.

**REFERENCES**


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Corresponding author
Dr. med. Ernst Sendtner
Asklepios Klinikum Bad Abbach
Orthopädische Klinik für die Universität Regensburg
Kaiser-Karl-V.-Allee 3
93077 Bad Abbach, Germany
ernst.sendtner@web.de

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Ernst Sendtner, Tobias Renkawitz, Peter Kramny, Michael Wenzl, Joachim Grifka

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