REVIEW ARTICLE

Fractured Neck of Femur—Internal Fixation Versus Arthroplasty

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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. Hemiprotheses 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 peri-operative 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

FIGURE 1

Fractured neck of femur, classification according to Garden (I–IV): a) Garden type I, impacted fracture: the trabecular bones of the head of femur are positioned at an angle of more than 160° relative to the medial cortex. b) Garden type II: complete but non-displaced fracture. c) Garden type III: head tilted but still contact between the fragments. d) Garden type IV: head of femur assumes upright position but is dislocated.

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 antibiotic 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

Figure 2: Alignment index 180/180: Garden type I fracture in the anteroposterior aspect impacted by 20%. Normally the trabecular bones are positioned at an angle of 160° (dotted line) against the vertical line. No dislocation to the side

Figure 3: Dislocated fractured neck of femur Garden type IV; tilting of the head of femur into its original position; the trabecular bones assume their original parallel position to the neck of femur but are dislocated sideways. Substantial tilting in the lateral radiographic aspect

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

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

TABLE

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

Garden types I and II	Treatment	
Non-dislocated (consider axial images) or impacted	Functional/prophylactic osteosynthesis	
Garden types III and IV	Treatment	Patient group
Dislocated	Osteosynthesis	Young
	Total endoprosthesis	Elderly
	Dual-head prosthesis	Very elderly
	Osteosynthesis	Age related dementia, bedridden, Sernbo III
Decision criteria in dislocated fractures in middle age		
Osteosynthesis	Degree of activity Bone quality Can the bones be repositioned? (Garden types III or IV) Coxarthrosis	Endoprosthesis
Sprightliness/biological age (modified after Sernbo, 2002 [9])		
I	II	III
Own home	Sheltered home	Home for the elderly
1 walking cane	2 walking canes/wheeled walking frame	Wheelchair/bed
Alert	Slight confusion	Severe confusion

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

Figure 5: Fracture gap intraoperatively and scar 2 weeks postoperatively after minimally invasive implantation of hip endoprosthesis in a sprightly 94 year old man

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 cardiopulmonary 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.

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REFERENCES

1. Bundesgeschäftsstelle Qualitätssicherung: Qualitätsreport 2007. www.bqs-qualitaetsreport.de/2007/ergebnisse/leistungsbereiche/hueft_femur/basis
2. Bergmann G, Graichen F, Rohlmann A, et al.: Loads acting on orthopaedic implants. Measurements and practical applications [Die Belastung orthopädischer Implantate. Messungen und praktische Anwendungen]. *Orthopäde*. 2007; 36: 195–6, 198–200, 202–4.
3. Garden RS: Low-angle fixation in fractures of the femoral neck. *J Bone Joint Surg Br* 1961; 43: 647–63.
4. Barnes R, Brown JT, Garden RS, Nicoll EA: Subcapital fractures of the femur—a prospective review. *J Bone Joint Surg* 1976; 58B: 2–24.
5. Rogmark C, Carlsson A, Johnell O, Sernbo I: A prospective randomised trial of internal fixation versus arthroplasty for displaced fractures of the neck of the femur. *J Bone Joint Surg [Br]* 2002; 84B: 183–8.
6. Füchtmeier B, Hente R, Maghsudi M, Nerlich M: Reposition der Schenkelhalsfraktur des jüngeren Menschen. Valgus- oder anatomische Reposition? *Unfallchirurg* 2001; 104: 1055–60.
7. Parker MJ, Gurusamy K: Internal fixation versus arthroplasty for intracapsular proximal femoral fractures in adults. *Cochrane Database Syst Rev* 2006; (4): CD001708.
8. Parker MJ, Khan RJK, Crawford J, Pryor GA: Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. *J Bone Joint Surg* 2002; 84: 1150–5.
9. Rogmark C, Carlsson A, Johnell O, Sernbo I: A prospective randomised trial of internal fixation versus arthroplasty for displaced fractures of the neck of the femur. *J Bone Joint Surg* 2002; 84B: 183–8.
10. McKinley JC, Robinson CM: Treatment of Displaced Intracapsular Hip Fractures with Total Hip Arthroplasty: Comparison of primary arthroplasty with early salvage arthroplasty after failed internal fixation. *J Bone Joint Surg Am* 2002; 84: 2010–5.
11. Smekta R, Endres HG, Dasch B, et al.: The effect of time-to-surgery on outcome in elderly patients with proximal femoral fractures. *BMC Musculoskelet Disord* 2008; 9: 171.
12. Smekta R, Grams A, Pientka L, Schulze-Raestrup U: Guidelines or state civil codes in the management of femoral neck fracture? An analysis of the reality of care provision in North Rhine-Westphalia [Leitlinie oder Landrecht bei der Versorgung der Schenkelhalsfraktur?] *Dtsch Arztebl Int* 2008; 105(16): 295–302.
13. Baker RP, Squires B, Gargan MF, Bannister GC: Total Hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck. A randomized, controlled trial. *J Bone Joint Surg Am* 2006; 88: 2583–9.
14. Ravikumar KJ, Marsh G: Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur—13 year results of a prospective randomised study. *Injury* 2000; 31: 793–7.
15. Squires B, Bannister G: Displaced intracapsular neck of femur fractures in mobile independent patients: Total hip replacement or hemiarthroplasty? *Injury* 1999; 30: 345–8.
16. Macaulay W, Pagnotto MR, Iorio R, Mont MA, Saleh KJ: displaced femoral neck fractures in the elderly: Hemiarthroplasty versus total hip arthroplasty. *J Am Acad Orthop Surg* 2006; 14: 287–93.
17. Blomfeld R, Törnqvist H, Eriksson K, Söderqvist A, Ponzer S: A randomized controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. *J Bone Joint Surg* 2007; 89B: 160–5.

18. Leidinger W, Hoffmann G, Meierhofer JN, Wölfel R: Reduction of severe cardiac complications during implantation of cemented total hip endoprostheses in femoral neck fractures. *Unfallchirurg*. 2002; 105: 675–9.
19. Sendtner E, Boluki D, Grifka J: Current state of doing minimal invasive total hip replacement in Germany, the use of new implants and navigation—results of a nation-wide survey. *Z Orthop Unfall* 2007; 145: 297–302.
20. Van Dortmont LM, Douw CM, van Breukelen AM, Laurens DR, Mu Wereldsma JC, van Vugt AB: Outcome after hemi-arthroplasty for displaced intracapsular femoral neck fracture related to mental state. *Injury* 2000; 5: 327–31.
21. Blomfeldt R, Törnkvist H, Ponzer S, Söderqvist A, Tidermark J: Internal fixation versus hemiarthroplasty for displaced fractures of the femoral neck in elderly patients with severe cognitive impairment. *J Bone Joint Surg* 2005; 87B: 523–9.
22. Leuchte S, Riedl K, Wohlrab D: Immediate post-operative advantages of minimally invasive hip replacement—results of symmetry and load from the measurement of ground reaction force. *Z Orthop Unfall* 2009; 147: 69–78.
23. Hannan EL, Magaziner J, Wang JJ, Eastwood EA, Silberzweig SB, Gilbert M, et al.: Mortality and locomotion 6 months after hospitalization for hip fracture. Risk factors and risk-adjusted hospital outcomes. *JAMA* 2001; 285: 2736–42.
24. Smektala R, Wenning M, Paech S, Windhorst T: Schenkelhalsfraktur – Resultate externer Qualitätssicherung an 32000 Patienten. *Z ärztl Fortbild Qual sich (ZaeFQ)* 2001; 95: 209–18.
25. Stöckle U, Lucke M, Haas NP: Der Oberschenkelhalsbruch. *Dtsch Arztebl* 2005; 102(49): A3426–34.

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E-REFERENCES

- e1. Zlowodzki M, Bhandari M, Keel M, Hanson BP, Schemitsch E: Perception of Garden's classification for femoral neck fractures: an international survey of 298 orthopaedic trauma surgeons. *Arch Orthop Trauma Surg* 2005; 125: 503–5.
- e2. Lakshmanan P, Sharma A, Lyons K, Peehal JP: Are occult fractures of the hip and pelvic ring mutually exclusive? *J Bone Joint Surg (Br)* 2007; 89B: 134–6.
- e3. Parker MJ, Handoll HH, Bhargava A: Conservative versus operative treatment for hip fractures (Cochrane Review). In: *The Cochrane Library* 2002; Oxford: Update Software.
- e4. Gillespie WJ, Walenkamp G: Antibiotic prophylaxis for surgery for proximal femoral and other closed long bone fractures. In: *Cochrane Database Syst Rev* 2002.
- e5. Gillespie WJ: Extracts from „clinical evidence“: hip fracture. *BMJ* 2001; 322: 968–75.
- e6. Kujath P, Bouchard R, Scheele J, Esnaashari H: Neues in der perioperativen antibiotischen Prophylaxe. *Chirurg* 2006; 77: 490–8.
- e7. Toh EM, Sahni V, Acharya A, Denton JS: Management of intracapsular femoral neck fractures in the elderly; is it time to rethink our strategy? *Injury* 2004; 35: 125–9.
- e8. Zlowodzki M, Weening B, Petrisor B, Bhandari M: The value of washers in cannulated screw fixation of femoral neck fractures. *J Trauma* 2005; 59: 969–75.
- e9. Maruenda JI, Barrios C, Gomar-Sancho F: Intracapsular hip pressure after femoral neck fracture. *Clin Orthop Relat Res* 1997; 340: 172–80.
- e10. Moran CG, Wenn RT, Sikand M, Taylor AM: Early mortality after hip fracture: is delay before surgery important? *J Bone Joint Surg Am* 2005; 87: 483–9.
- e11. Raaymakers EL: Fractures of the femoral neck: a review and personal statement. *Acta Chir Orthop Traumatol Cech* 2006; 73: 45–59.
- e12. Breusch S, Parsch D: Zementiertechnik – State of the art. In: Carsten Perka Hartmut Zippel: *Trends und Kontroversen in der Endoprothetik des Hüftgelenks*. Reinbek: Einhorn-Press-Verlag 2002.
- e13. Thomas P, Schuh A, Eben R, Thomsen M: Allergie auf Knochenzementbestandteile. *Orthopäde* 2008; 37: 117–20.
- e14. Johansson T, Jacobsson SA, Ivarsson I, Knutsson A, Wahlstrom O: Internal fixation versus total hip arthroplasty in the treatment of displaced femoral neck fractures: a prospective randomized study of 100 hips. *Acta Orthop Scand* 2000; 71: 597–602.
- e15. Handel M, Brettschneider J, Köck FX, Anders S, Perlick L, Sell S: Risk factors associated with heterotopic ossifications in primary total hip arthroplasty. *Z Orthop Ihre Grenzgeb* 2004; 142: 564–70.
- e16. Statistisches Bundesamt, Statistisches Jahrbuch 2008. www.destatis.de/jetspeed/portal/cms/Sites/destatis/SharedContent/Oeffentlich/Al/IC/Publikationen/Jahrbuch/Gesundheit,property=file.pdf
- e17. X Jiang H, Majumdar SR, Dick DA, et al.: Development and initial validation of a risk score for predicting in-hospital and 1-year mortality in patients with hip fractures. *J of Bone and mineral research* 2005; 20: 494–500.
- e18. Ohman C, et al.: Ein neues Modell der sektorübergreifenden Datenzusammenführung und Evaluation am Beispiel der Schenkelhalsfraktur. *Zeitschrift für ärztliche Fortbildung und Qualität im Gesundheitswesen* 2005; 99(8): 547–54 .
- e19. Smektala R, Grams A, Pientka L, Schulze Raestrup U: Guidelines or state civil codes in the management of femoral neck fracture? An analysis of the reality of care provision in North Rhine-Westphalia [Leitlinie oder Landrecht bei der Versorgung der Schenkelhalsfraktur?] *Dtsch Arztebl Int* 2008; 105(16): 295–302.