Displaced femoral neck fractures: towards better practice
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Introduction and aim of the thesis
General introduction

The increasing elderly population together with the frequent incidence of hip fractures represents a major challenge to health care providers. Depending on type of fracture and the patient’s condition, conservative management of some hip fractures is feasible. In the vast majority of patients operative intervention is necessary. The scale of the future epidemic of hip fracture patients, which is inherently linked to the growing elderly population, mandates trauma and orthopaedic surgeons to study and, if necessary, alter their practice to achieve the best possible clinical outcomes. Based on studies with a high level of evidence, optimal and cost-efficient care can be delivered. This thesis represents an attempt to address the dilemma of the operative management of elderly patients with displaced femoral neck fractures. This section summarizes the rationale behind the studies in this thesis.

Incidence In 1999, 15,286 patients (11,649 women) over 55 years old were treated for a hip fracture in the Netherlands. This has increased to 17,550 in 2003 with an expected national increase of around 5% per year. Displaced femoral neck fractures represented approximately 40% of these hip fractures.\(^1\) The risk of a fall resulting in a hip fracture is 16%-18% for a Caucasian female and 5%-6% for a Caucasian male.\(^2\) In 1990 the estimated global incidence of hip fractures was 1,660,000. This figure is expected to rise to 6,260,000 worldwide in 2050.\(^2\)

The unsolved fracture The displaced femoral neck fracture has been named “the unsolved fracture”.\(^3, 4\) This qualification is still valid as discussion continues about the optimal treatment modality in patients over 60 years old. The two existing treatment strategies are internal fixation (IF), which spares the natural femoral head and cartilage by fixating it with an implant, and arthroplasty, where the femoral head is replaced by an endoprosthesis. Three meta-analyses\(^5, 6, 7\) pooling the data of 17 prospective randomised studies on IF versus arthroplasty for displaced femoral neck fractures identified a trend towards lower early mortality in IF patients. Duration of the operation, perioperative blood loss and risk of deep wound infection were significantly lower in patients treated with IF. These benefits, however, came at the cost of significantly higher rates of operative revision: 28-36% for IF and 10-16% for arthroplasty.\(^5, 6, 7\) The meta-analysis results are of limited use when considering management of individual patients. For meta-analysis purposes all patients were included as being equal, but in daily practice it is unclear which type of patient may benefit from either treatment.
modality. In addition very elderly patients (over 85 years of age) are often excluded from the reviewed randomised studies due to incomplete follow-up. Larger randomised trials may solve the issues of early mortality and functional outcome by subgroup analysis of the involved factors. In the meantime, there is a need for studies to define which patient groups are better served by the different treatment methods. Some crucial factors may be independent of the type of implant and instead depend on individual conditions. Robinson developed an interesting scoring system to quantify the true physiologic status of individual elderly patients. Five individual qualities were quantified: mobility, accommodation, osteoporosis, cognition and medical condition. The developed Physiologic Status Score (PSS) could be a useful guide for selection of the appropriate treatment. Patients with a high PSS received IF and patients with a lower PSS arthroplasty, resulting in very low 2-year revision rates: 5% for IF and 2% for arthroplasty. These revision rates were much lower than the meta-analysis results stated above. This selection based on a quantification of individual patient factors appeared to be a promising strategic refinement in decision-making between IF and arthroplasty and possibly beneficial to the cost of hip fracture treatment for society.

Factors associated with fracture healing

1. Bone density. The displaced femoral neck fracture has been associated with a lower bone density. Osteopenia and osteoporosis are highly prevalent in the elderly population. Cadaveric and retrospective clinical studies have suggested a relationship between lower bone density, less intrinsic stability of internal fixation and worse clinical outcome. Following these findings it was postulated that a measurement of higher bone density may aid in the selection of patients for IF and that patients with low bone density should receive arthroplasty.

2a. Technical considerations during internal fixation. Two essential technical prerequisites to fracture healing must be considered when attempting IF: adequate fracture reduction and adequate internal fixation. Inadequate reduction is a major risk factor for avascular necrosis and unstable fixation. After proper reduction, the Garden Index on the intraoperative image intensified Anterior-Posterior (AP) view should be between 160 and 180 degrees. Valgus reduction of the femoral head on the AP view is acceptable up to 20 degrees. Any degree of varus reduction is unacceptable. In the lateral view the alignment of the femoral head to the shaft should be as close as possible to 180 degrees, with 10 degrees retroversion being acceptable. Correct
insertion of 3 cannulated screws relies on the three-point fixation method: the first screw should be inserted over the inferior calcar and in the lower half of the reduced femoral head. The first point of fixation is the lateral femoral cortex, the second point is the inferior calcar of the collum femoris, preventing varisation of the femoral head, and the third point lies within the femoral head.

In the lateral view a second screw should be positioned cranially to the first, with the shaft resting on the dorsal part of the femoral neck, preventing retroversion of the femoral head. A third screw may be inserted parallel at the same level, but more anterior to the second screw. A sliding hip screw should be inserted into the central or lower half of the reduced femoral head in the AP view. On the lateral view the screw should be positioned in the center, or slightly in the dorsal part, of the femoral head.

2b. Technical considerations during arthroplasty. Either an anterior, lateral or posterior approach to the hip may be performed. A Cochrane review showed similar rates of prosthetic dislocation. When arriving at the joint capsule either a capsulotomy with repair or capsulectomy may be done. Early prosthesis dislocation rates with a posterior approach were reported to be higher (4.8% vs 0.7%) after excision of the capsule. Cementing of the prosthesis stem is the favoured treatment. Meta-analysis shows that cemented prosthesis led to better pain relief and mobility after 1 year (relative risk: 0.51 en 0.60 respectively). Modern uncemented prosthesis are gaining favour, but long term outcome reports are needed. Unipolar and the more expensive bipolar prosthetic heads have both led to similar clinical results (relative risk of dislocation: 1.12).

3. Theoretical consequences and rating of surgical Internal Fixation technique. The association between surgical internal fixation (IF) technique for displaced femoral neck fractures and clinical outcome is poorly reported. It has been stated that technique or experience level of surgeons influences clinical outcome. Whilst retrospective studies have correlated technical performance with outcome, the well described and commonly accepted reduction and implant positioning criteria in the literature have not been subjected to a technical analysis in relation to prospective clinical outcome. Theoretically, rating of IF technique by an independent expert could identify situations in which clinical failure is likely. The possible correlation of independent rating with clinical outcome in displaced femoral neck fracture patients has not been reported. An independent intra- or postoperative poor rating of technique could prompt a preemptive change in clinical strategy as a consequence. (Re-)intervention before clinical
failure could potentially reduce patient discomfort, improve outcome and save costs in terms of hospital bed turnover.

4. Timing of surgery. The displaced femoral neck fracture is the most common cause of avascular necrosis (AVN) of the femoral head. Of the 35% internal fixation failure rate, AVN with collapse of the femoral head is responsible for 8%.\textsuperscript{5,6} Fracture non-union patients do not necessarily have segmental collapse. Union may occur with a necrotic head following revascularization. If no regeneration occurs segmental collapse follows. Before collapse occurs, the necrotic bone has the same physical strength as normal bone and the cartilage receives nutrition from the synovial fluid.\textsuperscript{28}

An alteration in arterial blood supply to and/or venous drainage from the femoral head is the etiology of osteonecrosis. In a displaced fracture all branches from both circumflex femoral arteries are severed. As the blood supply through the medial ligament is insufficient, osteonecrosis probably always occurs. Time to surgery therefore is unlikely to influence this process, which is in line with a recent study showing no association between AVN and time to surgery.\textsuperscript{29}

Controversy exists about the association between time to surgery and postoperative complications,\textsuperscript{30-34} length of hospital stay\textsuperscript{30,31,35-37} and mortality\textsuperscript{30-38} in hip fracture patients. A recent well designed prospective study concluded that early surgery, within 24 hours, was independently associated with a reduced pain and length of hospital stay and probably fewer major postoperative complications was found in healthier patients. No firm conclusions were reported for functional outcomes. It was recommended that in the meantime, patients with a hip fracture who are medically stable should receive early surgery when possible.\textsuperscript{34}

Towards better practice There is growing agreement that clinical practice guidelines are helpful sources of advice, good educational tools and intended to improve clinical care. Clinicians also consider guidelines impractical, too rigid to apply to individual patients, an oversimplification of medicine or that they reduce physician autonomy and increased potential for litigation.\textsuperscript{39} To address these concerns, guidelines should be developed following a scientific method (e.g. American Medical Association method\textsuperscript{40}) which not only involves consulting local physicians, but also national and international peers.

With support from the Ministry of Health, Welfare and Sport the Association of Surgeons of The Netherlands and the Dutch Association of Orthopaedic Trauma
have commenced with the development of a concept clinical practice guideline for elderly hip fracture patients (over 65 years). A multidisciplinary consensus committee was formed consisting of trauma and orthopaedic surgeons, geriatric and nursing home specialists, a physiotherapist and a representative from a patient platform. All the (para)medical specialists had demonstrable clinical and scientific expertise in the field of femoral neck and trochanteric fracture management. In this thesis the development of the concept femoral neck fracture guideline is presented. This concept guideline will be discussed at the annual meeting 2005 of the Association of Surgeons of the Netherlands and will appear on the website for comment before official publication with possible amendments.

References
Aim of the thesis

This thesis aims to study the patient-related indications for two different surgical procedures and the influence of operative technique in displaced femoral neck fracture patients.

In the Netherlands and probably elsewhere, the impression existed that protocolled management for displaced femoral neck fractures varied from hospital to hospital. A sample of 20 university and non-university hospitals received a questionnaire about their protocolled indications for IF and arthroplasty, their protocolled operative technique and postoperative weight-bearing policy. In chapter 2 the management of displaced femoral neck fractures in these hospitals is described.

A previously published study adopting a Physiologic Status Score (PSS) management protocol, which selected patients for either IF or arthroplasty with a cut-off point between treatments set at 20 points, showed very low long term revisional surgery rates. To verify this finding in a multi-center setting, 10 hospitals agreed to participate in a PSS protocol validation study. Hypothetically, displaced femoral neck fracture patients aged between 60 and 90 with a high PSS (≥ 20 points) should benefit from IF and lower PSS patients should benefit from hemiarthroplasty. The benefit is defined as: reduction of the need for revisional procedures and better functional outcome at 2-year follow-up compared with meta-analysis results. The prospective multi-center study in chapter 3 verified the PSS treatment protocol as a pre-operative selection method for the choice between IF and hemiarthroplasty for displaced femoral neck fractures.

Based on the results of in vitro and retrospective clinical studies active patients over 60 years with normal bone density or osteopenia should require less revisions to arthroplasty after IF of a displaced femoral neck fracture compared to similar patients with osteoporosis. A subanalysis of the effect of bone density on clinical outcome after IF in the group of patients with a high PSS (≥ 20 points) was performed and is described in chapter 4. Clinical outcome 2 years after IF was analysed in osteopenic and osteoporotic patients.

Rating of operative technique of IF on the pre-, intra- and postoperative radiographs was performed by a panel of independent experts in the PSS verification study. This rating was potentially subject to interobserver variation, even though the methods of correct reduction and fixation of displaced femoral neck fractures are clearly described in the literature. The width of this possible difference in observer agreement for fracture reduction and sliding hip screw placement is reported in chapter 5. Intra- or
postoperative expert rating of poor technique likely to fail could hypothetically prompt surgeons to pre-emptively change their clinical strategy. If inadequate technical rating by independent experts was indeed correlated with clinical failure, complications and 2-year mortality, (re-) intervention before clinical failure becomes evident could potentially reduce patient discomfort, improve outcome and save costs. The correlation between technical rating and clinical outcome was analyzed in chapter 6.

The time to surgery for hip fracture patients is usually recorded from the time of admission, but the interval to surgery should include the period in which some patients remain immobile at the site of injury for considerable time after their injury and physiological deterioration may occur. There is a perception that relatively healthy patients (ASA I and II class) are operated sooner than patients, which require more preoperative evaluation and preparation. In chapter 7 the possible association between delay to surgery, calculated from the day of injury and from the day of hospital admission, with the development of postoperative complications, length of hospital stay and 1-year mortality rate is determined. A subanalysis of the influence of ASA class on these clinical outcomes was also performed.

National clinical practice guidelines could potentially reduce geographic variances in treatment algorithms and create a basis for a nationally adopted standard treatment, forming a stronger basis for measuring quality of care and comparison with new developments. The development of the concept femoral neck fracture guideline in chapter 8 aimed to answer the following key questions:

- What is the most useful diagnostic test and fracture classification in daily practice?
- Which patient related factors at admission are important when determining form of therapy?
- Which therapeutic strategy is first choice (conservative, operative: internal fixation or arthroplasty) within which timeframe?
- Which morbidity can be expected postoperatively?
- How should patients be managed postoperatively with regard to somatic, cognitive and social recovery?

The methods, results and main conclusions of the studies performed in this thesis are summarized in chapter 9 with a Dutch translation provided in chapter 10.