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Enhanced Screw Fixation in Osteoporotic Proximal Femoral Fracture: Augmentation vs Without Augmentation. Literature Review

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Abstract

Introduction and purpose: Osteoporosis is a common cause of proximal femoral fractures, which also are called hip fractures. The incidence of osteoporosis is increasing and becoming widely population disease. The division of proximal femoral fractures is based on anatomy, which includes trochanter, neck and head of femur fractures. There are the most severe osteoporotic fractures with a high mortality and disability. Therefore, decreased thickness in osteoporosis implies mechanical difficulties with treatment. Treatment is dependent on the appropriate scales, related to the anatomical division of hip fractures. It contains appropriate fixation with sliding hip screw with plate or nailing. In other cases, especially in elderly patients with symptomatic hip arthritis, total hip arthroplasty may be considered.

Aim of the study: Proximal femoral fractures in osteoporotic patients are not only associated with difficulties in treatment, but more importantly with high mortality and disability. This is why further development of treatments is so important. In the following work, it is shown up-to-date methods of treatment proximal femoral fractures. Furthermore, promising method with enhanced screw fixation with augmentation is shown with particular attention to safety and good functional results.

Material and methods: Review of studies available through sources on PubMed, Google Scholar, and the National Library of Medicine.

Conclusions: Proximal femoral fractures vary significantly in treatment depending on the division by anatomy. In addition to anatomy, it is important to consider age and co-morbid symptomatic hip arthritis in treatment. The cement augmentation of the proximal femoral nail antirotation increases the implant stability in osteoporotic proximal femoral fractures. Moreover, cement augmentation is safe method of treatment with good fracture healing.

Keywords

Proximal femoral fractures, Osteoporotic fracture, Hip fracture, cement augmentation, enhanced nail fixation, enhanced screw fixation, Osteoporosis, trochanter fractures, femoral head fractures, acetabular fracture, femoral neck fractures, Pertrochanteric fractures,

postmenopausal women, cephalomedullary nail, proximal femoral nail antirotation, fracture healing

INTRODUCTION

Definitions

Osteoporosis is one of the main causes of proximal femoral fractures[1]. According to WHO definition, it is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration with a consequent increase in bone fragility with susceptibility to fracture. In other words, it leads to decreased thickness in cortical bone due to increase of bone diameter and increased Haversian canal area[1]. All in all, decreased thickness implies mechanical difficulties with treatment, which are described as less “working length” of implants.[2] There are also changes in cancellous bone, which are described as broken cross links and trabecular thinning. Regardless of the definition of osteoporosis, it is known that the essence of osteoporosis is fractures. There is no uniform definition of osteoporotic fractures. The most common definitions are as follows: a fracture in an adult over 40 years of age after a minor trauma that would not be suffered by a healthy skeleton; a fracture in the course of vital activities accompanied by a fall from a height no greater than one's own body; - a pathological fracture occurring spontaneously without any appreciable trauma (a definition true especially for vertebral fractures).[3] Based on the location of osteoporotic fractures, the most common distinctions are: fractures of the hip (hip fractures-hip fx); fractures of the spine (spine fractures-spine fx); fractures other than the hip and spine (non-Hip nonSpine fractures-nHnS fx) - mainly the radius bone, then the humerus, clavicle, scapula, femur, shin bones and pelvis. [4] Fractures of the proximal end of the femur, which are commonly referred to as hip fractures, are the most severe osteoporotic fractures (25% of people recover and walk, 25% of people die, 50% of people remain dependent or with reduced function)[5]. Therefore further development of treatments is so important. The division of proximal femoral fractures is based on anatomy. A distinction is made between fractures of the trochanter, neck and head of the femur. There are two types of trochanter fractures: pertrochanteric (simple and multifragmentary) and intertrochanteric. Femoral neck splits into three types subcapital, transcervical and basicervical. Last but not the least, there

are fractures of femoral head, which are divided into split and depression of head. In serious injuries there could be combined injuries, which are classified into fractures of femoral neck with greater trochanter, femoral neck and head with hip dislocation and femoral head with posterior wall. [6]

Scales used to describe Proximal Femoral Fracture

Pipkin classification is the most commonly used classification for femoral head fractures. Originally, the classification system was based on AP radiographs, however, many fractures will be re-classified depending on CT appearances. This classification distinguishes 4 subtypes depending on the involvement of the weight-bearing portion of femoral head and a coexisting fracture of the femoral neck or acetabulum: 1) Fracture below fovea/ ligamentum (small) and does not involve the weight-bearing portion of the femoral head – Type I; 2) Fracture above fovea/ ligamentum (larger) and involves the weight-bearing portion of the femoral head - Type II; 3) Type I or II with an associated femoral neck fracture and high incidence of avascular necrosis - Type III; 4) Type I or II with associated acetabular fracture (usually posterior wall fracture) - Type IV. [7]

The Garden and Pauwels scales are the best-known scales for assessing femoral neck fractures. Garden's classification is based on AP radiographs of the hip, but many fractures will need re-classification depending on CT appearances. Four types of fractures are included, incomplete and valgus impacted (Type I), complete and nondisplaced (Type II), complete and partially displaced (Type III), and complete and fully displaced (Type IV). With time, clinicians have simplified the Garden classification by grouping femoral neck fractures as either nondisplaced or displaced, as displacement is what most often guides treatment options. The treatment of femoral neck fractures varies based on the Garden classification.[8]_The Pauwels classification, which was introduced in 1935, was the first biomechanical classification for femoral neck fractures. This classification, which is still frequently used at present, calculates the angle between the fracture line of the distal fragment and the horizontal line to determine shearing stress and compressive force. The classification is described as follows: 1) up to 30° and compressive forces are dominant (Type I); 2) 30°–50°and shearing force occurs and may have a negative effect on bone healing (Type II); 3) 50° and more and under these circumstances, shearing force is predominant and is associated with a significant amount of varus force which will more likely result in fracture displacement and varus collapse. (Type III) [9]

Pertrochanteric fractures are divided into two types according to AO classification: simple (31A1) and multifragmentary fractures (31A2). The simple ones are further divided into isolated single trochanter fracture (31A1.1), 2-part fracture (31A1.2) and fracture with lateral

wall intact (31A1.3). Multifragmentary pertrochanteric fractures are distinguished with 1 intermediate fragment (31A2.2) and with 2 or more intermediate fragments (31A2.3).[6]
The Jensen and Michaelsen's modification of Evans classification and AO/OTA classification are the best-known scales for assessing intertrochanteric fractures. According to the Jensen and Michaelsen's modification of Evans classification[10, 11] fractures of proximal femur are classified into 5 groups: 1) 2 non-displaced fragments – Type I; 2) 2 displaced fragments – Type II; 3) 3 fragments and loss of posterolateral support – Type III; 4) 3 fragments and loss of medial support – Type IV; 5) loss of posterolateral and medial support – Type V. Intertrochanteric fractures are classified by AO/OTA as 31A3. They are often called reverse oblique fractures. This fracture type is subdivided: 1) 31A3.1 – simple oblique fracture; 2) 31A3.2 – simple transverse fracture; 3) 31A3.3 – wedge or multifragmentary fracture. The most common fracture type is 31A3.3 multifragmentary. [6]

Epidemiology

The incidence of osteoporosis is associated with an increasing trend due to the aging of the human population. Approximately 40% Caucasian women over the age of 50 will suffer at least one osteoporotic fracture for the rest of their lives. [12] Location of fractures changes with age. The most common osteoporotic fractures at ages 50-55 are fractures of the distal end of the radius bone, but at ages 65-70 vertebral fractures takes a lead. While in the oldest people hip fractures rank first. [5] Among hip fractures, the first spot takes femoral neck fractures, followed by pertrochanteric fractures. Fractures of the femoral head are rare, and are most often avulsion fractures - they occur following detachment of part of the head by the ligament of the femoral head during traumatic dislocation of the hip joint (a fragment of the head with the ligament remains in the acetabulum, the rest of the head becomes dislocated) [6]

Sings and symptoms

There will be no symptoms in the early stages of osteoporosis and they usually go unnoticed for decades.[13] That is why it is so important to recognize the symptoms of poor bone quality: multiple vertebral compression fractures; previous hip, radial or shoulder fractures; end-stage renal disease and steroid or anticonvulsant therapy. Moreover, there are the classified main risk factors such as age over 65, slim build, low body weight, presence of osteoporosis in the mother, a history of osteoporotic fracture, early natural or surgically induced menopause, chronic use of medications from steroid group, low calcium supply, low exposure to light, vitamin D3 deficiency, sedentary lifestyle, prolonged immobilization, smoking, alcoholism, excessive coffee drinking and malnutrition.[14] On the other hand, in the late stage, there are symptoms including bone pain, reduced mobility, deepening of thoracic kyphosis, and reduced height. Symptoms of osteoporotic fracture are the same as others fractures like pain especially when trying to move, swelling, hematoma, loss of

function of the limb, pathological mobility of the bones, disruption of the limb's axis in displaced fractures. A proximal femoral fracture in the vast majority of cases is associated with severe pain in the hip region, increasing when attempting to move. In clinical examination points out shortening of the limb with positioning in external rotation and adduction. Most of the patients are unable to walk. In particular, pertrochanteric fractures are associated with larger blood loss (often about 500 ml). On the other hand, femoral neck fractures have bleeding limited only to a small intra-articular space. [15]

Diagnostics

The diagnosis of primary osteoporosis should be established on the basis of: 1) the World Health Organization (WHO) densitometric criteria for postmenopausal women (which have also been adopted for older men), measurement of BMD by DXA technique T-score ≤ -2.5 SD at the femoral neck or at an alternative location - the lumbar vertebrae; 2) occurrence of low-energy fracture in postmenopausal women and men above 50 years of age at typical locations and T-score < -1.0 (in some cases, osteoporosis cannot be confirmed by BMD measurement); 3) The above criteria do not exclude the possibility of diagnosing osteoporosis in patients of either sex with risk factors in younger age groups on the basis of other criteria, including the Z-score < -2, interpreted as BMD below that expected for sex and age. It should be noted that although the finding of a high or very high risk of fractures using the FRAX calculator presents the existence of osteoporosis and is a reason for therapeutic intervention, still the gold standard is the measurement of BMD by the DXA technique and/or the occurrence of low-energy fractures as mentioned above. [16] In the vast majority of cases, proximal femoral fractures are visible on a X-ray imaging. Diagnostic difficulties may arise in wedged fractures of the femoral neck with the proximal fracture " knocked" into the distal one, or when spontaneous compression of the fragments occurs in fractures with a horizontal fracture gap. In case of doubt, it is recommended to take an x-ray in adduction and abduction. CT scans enhance diagnosis by more accurately imaging the course of the fracture gap. [14]

TREATMENT METHODS

Fractures of the trochanter

Treatment of fractures of the trochanter varies depending on the type of fracture. Isolated single trochanteric fractures are rare and commonly treated nonoperatively. Undisplaced small avulsion of the greater trochanter may be treated nonoperatively.[17] If the abductor muscle insertion pulls the fragment proximally, reduction and fixation is necessary to avoid impairment of abductor muscle. [18, 19] MRI is recommended to verify a true isolated greater trochanteric fracture and exclude any pertrochanteric fracture. Simple two-part

pertrochanteric fractures are stable after reduction and fixation, mostly because of the excellent contact of the fracture surfaces and lack of comminution. They may be treated with sliding hip screw and plate or a cephalomedullary nail. [20] Simple extramedullary sliding devices like the dynamic hip screw (DHS) consists of lag screw or blade and plate fixed with screws. Correct position of lag screw or blade is essential in order to gain reduction and fixation. The thread of the lag screw needs to end in the trabecular bone structures to gain enough purchase. It is important that the lag screw comes to lie in the centre of the head-neck axis or slightly inferior to it. This allows for increased depth of the screw. [18, 20] The advantage of this treatment is fracture stability, on the other hand the disadvantage is that may cause excessive sliding and failure by cut-out if intraoperative/ postoperative lateral wall fracture occurs. A pertrochanteric fracture without a distal extension or without another fracture distally can be treated successfully with a cephalomedullary nail. [18] The trochanteric femoral nail advanced (TFNA) device is an intramedullary nail that uses a spiral blade or lag screw to obtain fixation in the femoral head. In order to achieve therapeutic success, it is important to anatomically realigned the fracture before implant insertion. Primary cause of treatment failure is based on inadequate reduction. As for the lag screw setting is the same as for the DHS, it must be set centrally or slightly inferior to head-neck axis. The advantages of this treatment are small incision and restoration of intramedullary strut, on the other hand the disadvantages are that it requires anatomical reduction and it is higher risk for varus or fish-mouth open deformity during nail insertion. Treatment of pertrochanteric fracture with posteromedial involvement is based on sliding hip screw, nailing and sliding hip screw with trochanter stabilization plate. Intertrochanteric fractures tend to be unstable after reduction and fixation because both cortices are involved. Intramedullary nailing is recommended to treat these fractures. It provides most stable fixation. Alternatively, a 95 degree-blade plate may be used to treat acute fractures in young patients or in revision surgery. When it comes to all types of fractures of the trochanter, it is important to remember that elderly patients will not mobilize easily with restricted weight bearing. Therefore, procedures allowing for immediate weight bearing as tolerated with walking aids should be selected whenever possible. Intramedullary nailing may give more stability for immediate weight bearing as tolerated. [18] In case of symptomatic hip arthritis, total hip arthroplasty may be considered.

Femoral neck fractures

In subcapital fractures with only slight displacement or impaction, there is a significant risk that the fracture will displace. For this reason, most of these fractures are stabilized with screws or a femoral neck system. Nonoperative treatment is usually only considered for patients who are unfit for surgery. Stabilization with screws is based on three cancellous screws[21]. The goal of surgery should be to allow the patient to weight bear as tolerated after

the procedure. The surgeon must choose internal fixation construct to allow weight bearing. The femoral neck system consists of: 1) plate with locking screws, 2) bolt, 3) antirotation screw. Owing to type of system, this fixation has higher resistance to varus collapse compared to fixation with three screws.[22] However, this method of treatment has higher risk of surgical complications, including subtrochanteric fracture through screw hole. [18, 23] Displaced subcapital femoral neck fractures in young patients should be preserved and fixed internally, although in elderly patients with osteoporosis and/or pre-existing hip arthritis, arthroplasty is more commonly chosen. In elderly patients, these fractures have a high risk of failed fixation, non-union and avascular necrosis. As it goes to internal fixation, the femoral neck system should be preferred over multiple smaller screws if intrinsic stability is questionable. The advantages of hemiarthroplasty and total hip arthroplasty are no risk of secondary displacement and avascular necrosis, immediate weight bearing as tolerated with walking aids, good chance of long-term function. However, these treatment methods are related to risk of dislocation and complications of arthroplasty. [24] Transcervical femoral neck fractures (simple or multifragmentory), transcervical shear and basicervical fractures of femoral neck have similar treatment, in which we aim for immediate weight bearing as tolerated with walking aids. In young patients we seek to preserve the femoral head and fixed internally. Otherwise, in elderly patients with osteoporosis and/or preexisting hip arthritis, arthroplasty is better option. [25]

Femoral head fractures

Split and depression fractures of the femoral head usually occurs in young patients by high-energy trauma. [26] The optimal treatment strategy is not clear, only anatomical reduction gives good long-term results. Fractures of femoral head are associated with dislocation of the hip. An unreduced dislocation threatens the blood supply to the head, and it may also be accompanied by pressure on a major nerve. Therefore, the treatment must be focused on restoration of the articular surface. Depending on whether the fragments are part of a weight-bearing surface, should be mandatory, anatomically reduced or primary resected, particularly if they block an anatomical reduction of the hip. After determined by a CT scan, osteochondral fragments are removed through a capsulotomy or arthroscopically. For those, which take a significant part in weight-bearing surface, may be stabilized with absorbable screws, recessed small cancellous lag screws, or headless compression screws. If it is possible, two screws should be used in each fragment in order to maintain rotational stability. The disadvantage of this treatment is associated with risk of heterotopic ossification.[18, 27]

Combined injuries

Femoral neck and greater trochanter fracture should be treated with hemiarthroplasty with reconstruction of greater trochanter. The treatment is mainly the same as for hemiarthroplasty

of isolated femoral neck fractures.[18] Additionally, the trochanter needs to be reconstructed and stabilized to support the prothesis and allow for proper functioning of the hip abductors. The reduction may be achieved with tension band wiring or hook plating. [18] Femoral neck and head fractures with hip dislocation are combined injuries associated with disrupted the blood supply to femoral head. The outcome in most cases will not be satisfying due to high risk of avascular necrosis.[28] Therefore, the treatment of choice for most adults is total hip arthroplasty. [18] Femoral head fractures with posterior wall fracture of the acetabulum are much more likely to be unstable than either injury alone. The main goal of treatment is to preserve blood supply to femoral head by open reduction and internal fixation. However, in case of avascular necrosis or posttraumatic arthritis, total hip arthroplasty may be used as a salvage procedure. [16,20]

Augmentation

In many types of proximal femoral fractures are used lag screws. In cases of poor bone quality, which indeed is in osteoporosis. There is mechanical difficulty with proper and stable implant insertion. According to mechanical studies augmentation method enhances the implant anchorage and offers a potential solution to the problem of implant cut-out in osteoporotic metaphyseal bone.[29]. Furthermore, the biomechanical studies show that cement augmentation of proximal femoral nail antirotation increase the implant stability in osteoporotic pertrochanteric fractures. [30] There was no evidence of cement-associated complications in augmented proximal femoral nail antirotation and good fracture healing was shown.[31] The standardized augmentation of the proximal femoral nail antirotation is a safe method to treat pertrochanteric femoral fractures. It leads to good functional results and is not associated with cartilage or bone necrosis. [32]

SUMMARY

Proximal femoral fractures will gain increasing importance in the future due to the epidemiological development. Osteoporosis is often a limiting factor in the achievement of implant stability and often challenges orthopaedic trauma surgeons. New nailing systems offer the possibility of augmentation of the femoral neck component with cement. Recent studies found advantages of cement augmentation in biomechanical and clinical trials. The results of studies show that cement augmentation of the proximal femoral nail antirotation increases the implant stability in osteoporotic proximal femoral fractures. In addition, cement augmentation is safe method of treatment with good fracture healing.

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