Review Article

# Treatment of Valgus-Impacted and Nondisplaced Femoral Neck Fragility Fractures in the Elderly

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## ABSTRACT

As the life expectancy of the worldwide population increases, the number of hip fractures in the elderly cohort is expected to grow. It is important for surgeons to critically analyze available treatment options for these injuries, with the goal of optimizing outcomes and minimizing complications. Femoral neck fractures make up approximately half of all hip fractures. Nonoperative treatment of valgus-impacted and nondisplaced (Garden I and II) femoral neck fractures has high rates of secondary displacement, osteonecrosis, and nonunion; only patients with notable risk for perioperative complications are treated nonoperatively. Surgical intervention is the standard of care, with options including internal fixation (IF) with multiple cancellous screws or a sliding hip screw, hemiarthroplasty, or total hip arthroplasty. Patients with a posterior tilt of greater than 20° have a high rate of revision surgery when treated with IF and may benefit from primary arthroplasty. Furthermore, primary arthroplasty has demonstrated lower revision surgery rates and equivalent postoperative mortality when compared with IF. Surgeons should be aware of the functional outcomes, complications, revision surgery rates, and mortality rates associated with each treatment modality to make a patient-specific decision regarding their care.

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The treatment of valgus-impacted and nondisplaced femoral neck fractures (Garden I and II) typically involves surgery with internal fixation (IF) using multiple cancellous screws (MCSs) or a sliding hip screw (SHS), hemiarthroplasty (HA), or total hip arthroplasty (THA). Current literature comparing these treatment modalities for Garden I or II femoral neck fractures has shown differences in functional outcomes, rates of revision surgery, and complications. Determining the optimal treatment requires specific considerations regarding patients' medical history, preoperative functional status, and fracture pattern.

## Epidemiology

The worldwide number of hip fractures is estimated to increase to 6.3 million by the year 2050.[1] Hip fractures predominantly affect elderly patients, with a reported incidence in the United States of 414/100,000 and 957/100,000 in men and in women, respectively.[2] The 1-year mortality rate after hip fractures ranges between 15% and 36%, posing a notable burden to the healthcare system.[3] Femoral neck fractures comprise 50% of all hip fractures.[4] Nondisplaced and valgus-impacted femoral neck fractures represent a unique subset of these fractures that require special considerations in patient care. As the number of hip fractures grows worldwide, providers must understand ways to optimize treatment to improve clinical outcomes and mortality rates.

## Relevant Anatomy

When treating nondisplaced and valgus-impacted femoral neck fractures, specific anatomic factors exist that should be considered. The superior portion of the femoral neck is under tension forces, whereas the inferior portion is under compression forces. Inferiorly, the femoral neck is supported by the calcar femorale, a region of dense vertically oriented bone considered to be the major weight-bearing portion of the femur. When treating femoral neck fractures with IF, it is important to achieve adequate fixation in this region of the femoral neck.

In adulthood, the primary blood supply to the femoral head and neck arises from the deep branch of the medial femoral circumflex artery. Femoral neck fractures can compromise this vascular supply, leading to the development of osteonecrosis of the femoral head or nonunion after surgical fixation. The degree of fracture displacement and angulation is predictive of the likelihood of osteonecrosis, nonunion, or implant failure.[5] Complications such as these are why surgeons attempt to restore the native anatomy in younger patients with femoral neck fractures through open reduction and IF, although opting for in situ IF or arthroplasty in elderly patients.

## Classification

Femoral neck fractures are classified using either the Pauwels or Garden classification systems. The Pauwels classification uses AP radiographs of the hip to determine the vertical orientation of the fracture line—<30° (type I), 30 to 70° (type II), and >70° (type III). This system is generally reserved for classifying femoral neck fractures in younger patients because of its prognostic utility for subsequent nonunion and femoral head osteonecrosis. The Garden classification is preferred for elderly patients because of its reproducibility and guidance in clinical management.[6] Based on AP radiographs of the hip, four types of femoral neck fractures are identified: incomplete valgus-impacted (type I), complete nondisplaced (type II), complete partially displaced (type III), and complete fully displaced (type IV). Fracture treatment is based on the classification, with patient age and degree of displacement largely dictating surgical management. Displaced femoral neck fractures (Garden types III and IV) have higher incidences of osteonecrosis and nonunion.[7] In the United States, arthroplasty is the preferred treatment, although IF is still used worldwide.[8] In general, THA is recommended for younger, more active patients, whereas HA is recommended for less active or elderly patients. For nondisplaced and valgus-impacted fractures (Garden I and II), IF with MCS or a SHS is most common. Garden I fractures may be treated nonoperatively as well.[9] The Garden classification has served to help guide surgical treatment of femoral neck fractures, although the optimal treatment algorithm for Garden I or II fractures continues to be investigated.

## Nonoperative Treatment

Nonoperative treatment of Garden I and II femoral neck fractures has been reported, demonstrating satisfactory outcomes in specific patient populations. A primary concern, however, is secondary displacement (SD) of the fracture and nonunion and osteonecrosis.

Earlier literature describes the natural course of nonoperative management of femoral neck fractures. In 1991, Raaymakers and Marti[9] followed 170 patients with valgus-impacted femoral neck fractures treated nonoperatively with early weight-bearing; 86% of patients were found to have united fractures. The remaining 14% developed SD, most which were older than the age of 70 years and in poor general health. Shuqiang et al[10] treated 115 elderly patients with Garden I fractures nonoperatively; of them, 41% required revision surgery for SD. Additional studies done by Buord et al[11] and Cees et al[12] had similar findings, reporting 33% and 46% SD rates, respectively. Taha et al[13] found that patients with Garden II fractures

## Figure 1

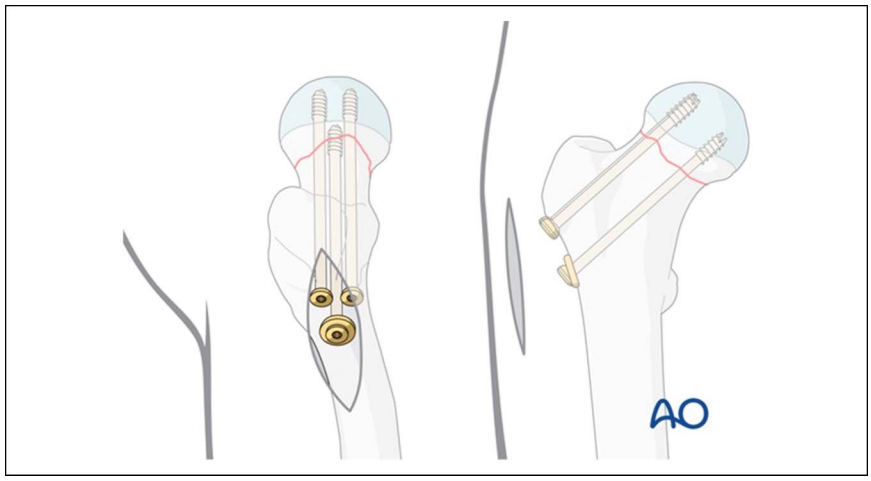



Figure demonstrating the optimal screw configuration placed in the antero-superior, postero-superior and postero-inferior aspects of the femoral neck. Copyright by AO Foundation, Switzerland. Source: AO Surgery Reference, www.aosurgery.org.

or osteoporosis have a 3.6 times greater risk of SD at 3 months when compared with Garden I with no osteoporosis, demonstrating SD rates of 88% and 24%, respectively. SD is a risk of nonoperative treatment, with osteoporosis and Garden II fractures at higher risk.

Osteonecrosis and nonunion are two more complications that may result when treating femoral neck fractures nonoperatively. A systematic review was conducted by Xu et al[14] that included 29 studies and 5,071 patients with nondisplaced femoral neck fractures treated conservatively or surgically with MCS, Knowles pins, SHS, or intramedullary implants. In their pooled analysis, surgical management notably improved rates of union, decreased rates of SD and nonunion, and decreased rates of bed rest–related complications. Given the inferior outcomes to surgical treatment, nonoperative management of Garden I or II femoral neck fractures is generally reserved only for patients with a high risk of perioperative complications and mortality.

## Internal Fixation

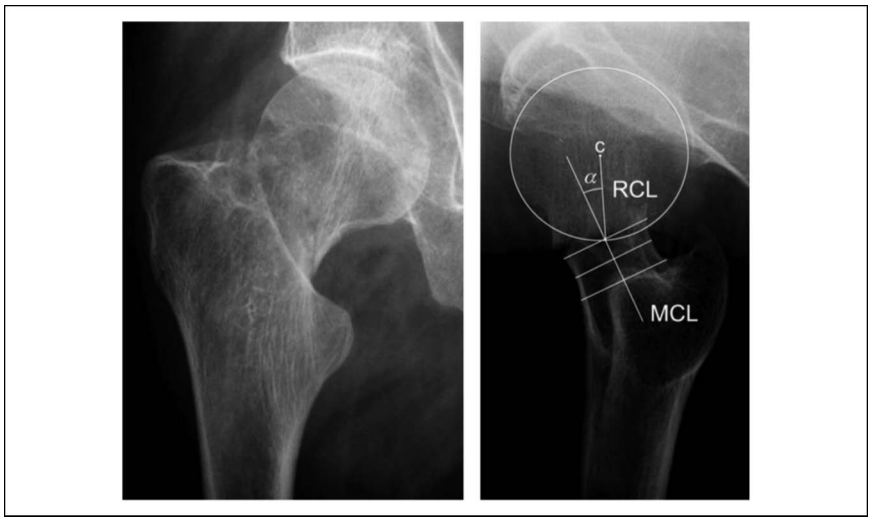
IF options for femoral neck fractures include MCS or SHS. Both techniques are designed to achieve in situ fracture fixation and create compression across the fracture site to promote healing and prevent displacement.

A percutaneous approach is used when treating with MCS, offering the advantage of shorter surgical time and minimal blood loss. Screw configuration plays an important role in achieving adequate fracture fixation. Three cannulated screws are positioned in a parallel inverted triangle configuration. Screws are placed in the antero-superior, postero-superior, and postero-inferior aspects of the femoral neck. The postero-inferior screw is meant to achieve purchase within the calcar of the femur and serve as a buttress to prevent femoral neck shortening.[15] The postero-inferior screw should be placed at or above the level of the lesser trochanter to minimize the risk of subtrochanteric fractures[16] (Figure 1).

Sliding hip screws are fixed angle devices that facilitate compression across the fracture site to promote healing. Use of a SHS is generally reserved for more vertically oriented (Pauwels III) or basicervical fracture patterns.[17] The disadvantage of using SHS is the increased surgical time and blood loss associated with a more extensive dissection.

Currently, debate exists over which technique provides optimal outcomes. Gjertsen et al[18] reported on 4,468 patients aged 60 years or greater with nondisplaced fractures treated with MCS; they reported an 89% 1-year implant survival. Most reoperations were conversion to bipolar HA or THA. A recent systematic analysis of 11 level 3 studies by Oñativia et al[19] reported a revision surgery rate of 8% to 19% for patients treated with MCS, with most being conversion to arthroplasty. Lee et al[20] retrospectively compared outcomes of conventional and minimally invasive SHS and MCS in 90 patients older than the age of 60 years who sustained nondisplaced femoral neck fractures. They were unable to demonstrate notable differences in hip scores, surgical time, hospital stays, or overall success between these methods. Watson et al[21] prospectively followed 62 patients with femoral neck fractures

## Figure 2




AP (**A**) and lateral (**B**) radiographs of a Garden type II femoral neck fracture demonstrating posterior tilt (α) measured as the angle between the mid-column line (MCL) and the radius column line (RCL), drawn from the center of the caput circle (**C**) to the point at which the caput circle and MCL cross. Palm H, et al: A new measurement for posterior tilt predicts reoperation in undisplaced femoral neck fractures: 113 consecutive patients treated by IF and followed for 1 year. *Acta Orthop* 2009;80:303-317.

randomly assigned treatment with either SHS or MCS. No notable difference in revision surgery rates was demonstrated between the SHS group and MCS group.

More recently, an international, multicenter, randomized controlled trial known as the FAITH trial was conducted to determine the difference in revision surgery rates of 1,108 patients undergoing IF for femoral neck fractures with either MCS or SHS.[22] Although this study included both displaced and nondisplaced femoral neck fractures, the results of the FAITH trial found no notable difference in revision surgery within 24 months between the two types of surgical fixation—20% in the SHS group and 22% in the MCS group. Furthermore, no notable difference was found regarding healing rate, implant failure, health-related quality of life, or mortality between the treatment groups. The current data on MCS and SHS for treatment of femoral neck fractures demonstrate high revision surgery rates, with equivalent clinical outcomes between methods of fixation.

## Complications of Internal Fixation

The complications associated with IF for Garden I and II femoral neck fractures include SD, osteonecrosis, nonunion, and subtrochanteric fracture, all requiring revision surgery. Many studies exist investigating whether preoperative posterior tilt of femoral neck fractures is predictive of revision surgery (Figure 2). In a series of 113 patients, Palm et al[23] reported that preoperative posterior tilt greater than 20° was associated with revision surgery within 1 year. This was challenged by Lapidus et al[24] who found no correlation in a cohort of 382 patients followed for 5 years. However, a follow-up study by Dolatowski et al[25] on a series of 322 patients found similar results to Palm; preoperative tilt of greater than 20° increased rates of fixation failure. A more recent study published by Okike et al[26] did a secondary analysis from the FAITH trial to determine the association between preoperative posterior tilt and revision surgery rates after IF for Garden I or II femoral neck fractures. Their results demonstrated notably increased risk of undergoing salvage arthroplasty in patients with preoperative posterior tilt greater than 20° and recommended consideration of primary arthroplasty in this group of elderly patients.

Patient factors predicting failure of IF also include albumin and bone mineral density. Bajada et al[27] analyzed failure rates, albumin levels, and lymphocyte count in 111 nondisplaced fractures treated with MCS. Patients with failure had lower albumin and lymphocyte counts. This finding was also reported in a similar study done by Riaz et al[28] on 251 patients treated with MCS. Although posterior tilt was not the primary outcome of these studies, both also reported a higher percentage of fixation failure in patients with a posterior tilt greater than 20°. Although poor bone quality is commonly cited as a reason for failure, a study by Viberg et al[29] did not find any association with fixation failure and low bone mineral density (T-score below 2.5 standard deviation from the reference) in a series of 140 patients treated with MCS who had DEXA scans postoperatively.

Osteonecrosis is another complication that can lead to failure of treatment with IF, requiring subsequent salvage arthroplasty. Bray[30] discuss the results of clinical trials demonstrating higher rates of osteonecrosis using SHS when compared with MCS. These findings were corroborated by the FAITH trial, which demonstrated notably higher rates of osteonecrosis in patients treated with SHS (9%) compared with MCS (5%).[22] It is important again to note that this study included both nondisplaced and displaced femoral neck fractures treated with IF. A subgroup analysis of Garden I and II fractures was not done to compare rates of osteonecrosis between methods of fixation because this was not the primary outcome of the study.

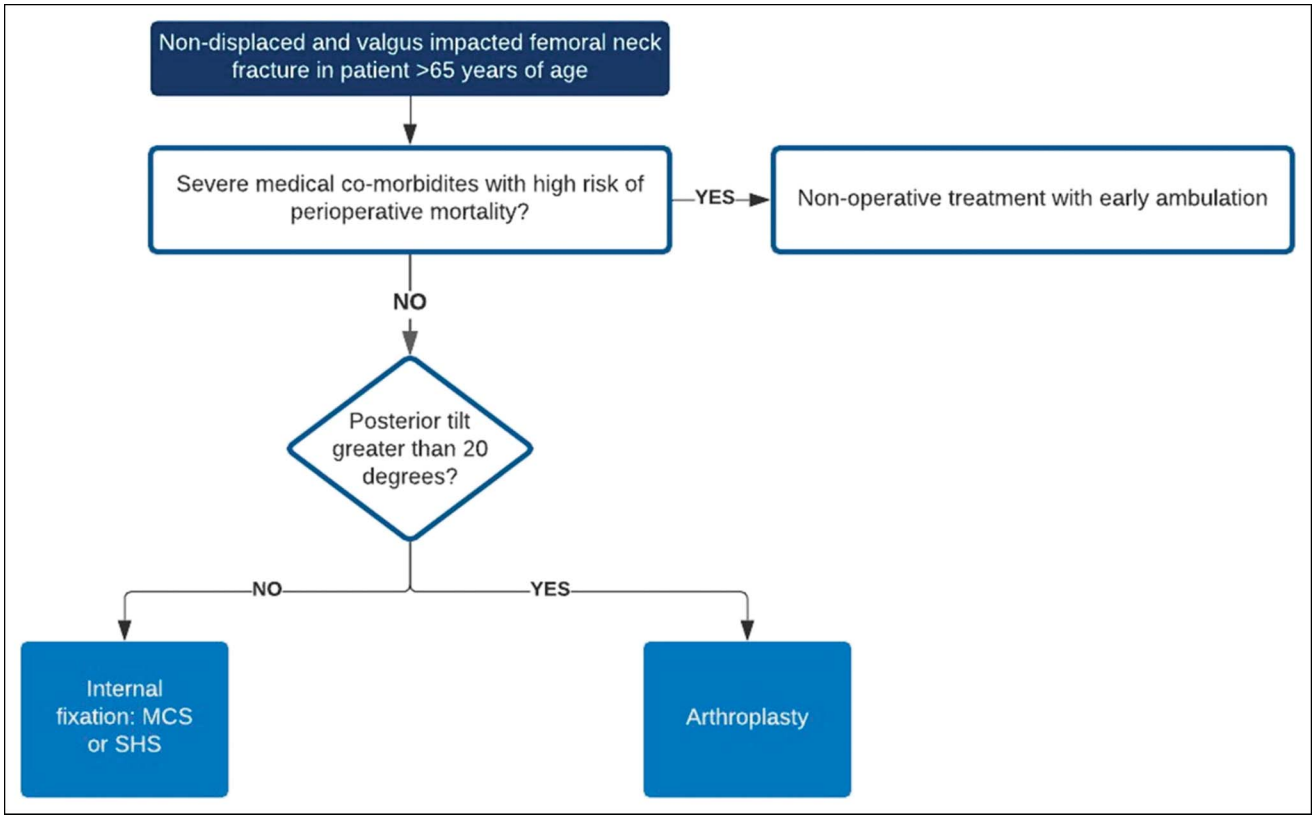
Surgical fixation of Garden I or II fractures in patients with posterior tilt greater than 20° and poor nutritional status is associated with high revision surgery rates; primary arthroplasty in these patients may mitigate these adverse outcomes; however, this must be further investigated.

## Internal Fixation Versus Primary Arthroplasty

The decision to treat Garden I or II femoral neck fractures with IF versus primary arthroplasty has been debated over recent years. Sikand et al[31] retrospectively analyzed 160 patients with a mean age of 78 years who sustained nondisplaced intracapsular fractures treated with MCS or HA. They found notable improvement in 1-month and 1-year mortality rates after MCS versus HA, but their revision surgery rates were higher with MCS. In a study done by Parker et al,[32] similar findings were reported. Those patients treated with MCS had a notably lower 1-year mortality rate than those treated with HA and decreased dependence on walking aides; however, the rates of revision surgery were higher for MCS compared with HA.

Lu et al[33] conducted a prospective study involving 78 patients older than the age of 80 years who sustained nondisplaced femoral neck fractures treated with either IF or HA. Compared with IF, patients treated with HA

## Figure 3




Flowchart demonstrating the proposed treatment algorithm for valgus-impacted or nondisplaced femoral neck fractures. MCS = multiple cancellous screw, SHS = sliding hip screw.

showed notably lower revision surgery rates and higher hip function scores with no difference in overall survival. Recently, Dolatowski et al[34] conducted a multicenter randomized controlled trial comparing IF versus HA for nondisplaced femoral neck fractures. They report no notable difference in hip function between the two groups; however, patients treated with HA were more mobile than the IF group when comparing the timed "Up & Go" test at 24 months. In addition, 20% (22/110) of patients in the IF group required major revision surgery, as opposed to 5% of patients (5/108) who underwent HA (relative risk reduction 3.3; 95% confidence interval, 0.7-10.0, $P < 0.01$). Two-year mortality was higher in the IF group (36%) compared with the HA group (26%), but this was not statistically notable.

The three previously discussed studies[31,33,34] were included in a meta-analysis conducted by Ma et al[35] of studies analyzing patients older than 65 years with nondisplaced femoral neck fractures treated with either IF or HA. They reported on revision surgery rates, mortality rates at 1 month and 1 year, Harris Hip Score at 1 and 2 years post-op, and length of hospital stay and duration of surgery. They found that HA was associated with a lower revision surgery rate than IF (odds ratio 4.5; 95% confidence interval, 2.0-9.9). No difference was noted in postoperative mortality rates or Harris Hip Score at 1 year, but patients treated with IF had shorter lengths of stay and surgical time.

Primary arthroplasty with either THA or HA for the treatment of displaced femoral neck fractures has been investigated in two recent randomized controlled trials known as the HOPE and HEALTH trials.[36,37] In both studies, no notable differences were found regarding revision surgery rates, hip function, or quality of life after a 2-year follow-up period. The revision surgery rates in the HOPE and HEALTH trials were 2.5% and 8%, respectively, both well below the reported revision surgery rates when treating femoral neck fractures with IF.

The role of primary arthroplasty in treating Garden I or II femoral neck fractures must be further investigated. Based on the current literature, primary arthroplasty has been shown to minimize revision surgery rates without notably increasing mortality rates. Given the associated complications of IF requiring revision surgery, future studies are required to identify patients who may benefit from treatment with primary arthroplasty. Surgeons should consider primary arthroplasty in patients who are at high risk for failure of IF.

## Arthroplasty as a Salvage Procedure

Given the high failure rates of IF for intracapsular femoral neck fractures, it is important to understand the outcomes of hip arthroplasty as a salvage procedure. Ozturkmen et al[38] demonstrated superior mean clinical hip scores for pain, mobility, and walking in their primary THA patients compared with salvage THA. The primary THA group had 79.4% of patients independently ambulating with a cane versus 55.9% in the salvage THA group (Fisher exact and chi-squared tests, $P < 0.05$). Blomfeldt et al[39] supported these findings as well, reporting lower clinical scores in patients who underwent salvage THA. Mahmoud et al[40] conducted a systematic review of level IV evidence analyzing the postoperative outcomes of salvage THA. In the salvage THA group, a notable increase was noted in overall complications, deep infection, early dislocation, and periprosthetic fracture. Overall, functional outcomes and complications reported in these studies favor primary THA over salvage THA, highlighting the need to preoperatively identify patients who would benefit from treatment with primary arthroplasty.

## Treatment Algorithm

Based on the presented evidence and previous guidelines, the authors propose the following treatment algorithm for Garden I and II femoral neck fractures (Figure 3). No consensus exists on which type of arthroplasty (HA versus THA) is recommended as primary treatment. This decision should be based on patient specific factors including age, preinjury functional status, history of inflammatory arthritis, and presence of osteoarthritis.[41]

## Summary

Nondisplaced and valgus-impacted femoral neck fractures can be challenging injuries to treat. Nonoperative management may be appropriate care in patients with high risk of perioperative mortality, although outcomes are superior with surgical treatment. IF options include MCS and SHS, with equivalent clinical outcomes. Recent literature has shown posterior tilt greater than 20° to be predictive of early failure of IF. When MCS are used, apex distal screw configuration with the postero-inferior screw positioned within the calcar and above the lesser trochanter is recommended. Primary arthroplasty is associated with decreased revision surgery rates and equivalent mortality rates, when compared with IF. Poor outcomes are demonstrated in salvage arthroplasty after

failed IF, highlighting the importance of the initial treatment selection. Patients' medical condition, preoperative functional status, and fracture pattern should be carefully considered when deciding to treat Garden I or II femoral neck fractures with IF versus primary arthroplasty.

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