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Application of a medial buttress plate may prevent many treatment failures seen after fixation of vertical femoral neck fractures in young adults

Hassan Mir [a], Cory Collinge [b,*]

[a] Department of Orthopedic Surgery and Rehabilitation, Vanderbilt University School of Medicine, Nashville, TN, United States
[b] Harris Methodist Fort Worth Hospital, Staff Physician John Peter Smith Orthopedic Surgery Residency, Fort Worth, TX, United States

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ABSTRACT

Femoral neck fractures in young adults with normal bone are mostly vertically oriented and may have variable amounts of comminution, which result from shearing forces during high-energy trauma. These factors play a role in the high rate of complications after this injury, including nonunion, malunion, failure of fixation, and avascular necrosis. These problems often occur together and inter-relate, for example, nonunion or malunion frequently result from fixation failure and varus collapse of the femoral head after reconstruction. The orthopaedic surgeon's goals of obtaining and maintaining anatomic reduction until bony union have been addressed by a number of surgical approaches and fixation constructs, however, complications are still common and no consensus exists on how these problematic fractures may be best treated. For optimal treatment of vertical femoral neck fractures, anatomic reduction must be achieved and fixation must be able to resist the high shear forces across the fracture with hip motion, weight-bearing, and muscle tone. Buttress plate fixation is a common method for stabilizing fractures that require resistance to shear forces and stands as one of the basic principles of fracture care. This technique has not been widely applied to this injury pattern. We propose that the concepts of modern fracture care should be applied together for vertical femoral neck fractures in young adults. Specifically, we propose that anatomic reduction and fixation of vertically oriented femoral neck fractures with the addition of a medial buttress plate to resist shearing forces will improve on the historically high rate of complications after these difficult injuries.

Introduction/background

The treatment of displaced femoral neck fractures in healthy young adults remains an unsolved challenge in orthopaedic surgery. These injuries typically result from high energy mechanisms causing a vertically-oriented shearing injury through the femoral neck [1–25]. Pauwels classified these fractures according to the verticality of the fracture, recognizing the problems nature of the injury pattern: type I – less than 30° Pauwels' angle, type II – angle 30–50°, and type III – angle greater than 50°. These factors contribute to the difficulty of obtaining adequate construct stability to resist vertical shear forces around the hip, and the risk of complications increase as the fracture's angle of inclination increases despite a number of fixation strategies. Complications associated with femoral neck fractures in young patients are frequent (20–60%), and include avascular necrosis (AVN), malunion and nonunion [4,5,10,11,16,26–30]. Previous authors have related these poor outcomes to initial fracture displacement, quality of reduction, and the method of fixation.

Open approaches are sometimes used to obtain an anatomic reduction, in an effort to restore stability as best possible. Several modified fixation constructs have been proposed for treating this injury pattern, in an effort to maintain fracture alignment through the healing process in order to try and improve on the historically high failure rates. Despite these changes in surgical approach and fixation methods, concerning rates of treatment failure still persist.

Our medical hypothesis is that vertical femoral neck fractures in young adults are currently inadequately treated with important resulting morbidity and poor outcomes. Orthopedic surgeons, who are taught and practice basic fracture repair principles, have largely failed to apply the principle of buttress support to improve treatment and patient outcomes for patients with this injury. We present a logical, principles-based approach to improve the frac-

* Corresponding author at: 800 5th Avenue, Suite 500, Fort Worth, TX 76104, United States. Tel.: +1 817 878 5300; fax: +1 817 878 5307.
E-mail addresses: hmirwvu@aol.com (H. Mir), ccollinge@msn.com (C. Collinge).

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ture mechanics of repair using open reduction and internal fixation including a medial buttress plate.

Current clinical trends

A number of strategies and methods are currently recommended for femoral neck fractures in young adults. A cornerstone of treatment is anatomic reduction of the fracture, whether using open or closed (indirect) means. Anatomical reduction of the fracture, aside from restoring the normal anatomy, should allow for maximal stability of the fixation construct. Open approaches during repair of a femoral neck fracture provides a numbers of potential advantages. Open may provide the best opportunity for achieving anatomical reduction, as the fracture can be inspected and manipulated under direct visualization. For example, many of these fractures have an apical fracture spike that, if anatomically reduced, may dramatically increase the stability of the repair construct. Open approach to the hip also allows the surgeon to apply supplemental fixation into the neck area that may be desirable in some cases. Finally, open approach provides decompression of the intra-capsular hematoma, which likely increases the risk for AVN in cases where the pressure from that hematoma prevents adequate blood flow to the femoral head [13,31–47].

There are two commonly used surgical approaches to the femoral neck, a direct anterior approach as described by Smith-Petersen (or Heuter) and an anterolateral approach as described by Watson-Jones. The Smith-Petersen approach allows for excellent direct visualization of the femoral neck, and the typical vertical fracture line which typically exits in the antero-inferior region of the femoral neck to the level of the lesser trochanter [48,49]. It can be reduced with a combination of manipulation of the femur and the use of modified fracture reduction clamps and provisional K-wires. The disadvantage of this approach is that traditional implants must still be applied through a lateral incision, thus a second approach is necessary for fixation. Through the Watson-Jones approach, the entire operation can be performed through the anterolateral window, although access for reduction and instrumentation of the neck is limited, especially in large patients.

Several fracture fixation constructs have been recommended for vertical femoral neck fractures, although, none of these constructs have been found to optimally resist the shearing forces across the hip with this fracture pattern [26,28,50–66]. As discussed, failed fixation with resultant malunion or nonunion has been a common problem. Three (or four) cannulated lag screws placed in parallel along the axis of the femoral neck have been frequently described. These screws, however, while optimally applied perpendicular to typical femoral neck fractures (e.g. Pauwels' type I) are applied obliquely in relation to more vertically-oriented factures (e.g. Pauwels' II and III) thus failure due to shearing forces are possible. Also, the mechanical advantage of placing a screw along the shaft-neck's inferior cortex (or "calcar") as in repairing a typical neck fractures is lost, as this part of the fracture is attached to the head fragment in the vertical fracture pattern. This intact cortical bone prevents the screw from collapsing inferiorly, allowing failure into varus. For these reasons, failure from shearing is not only not-resisted, but perhaps induced further with tightening of these lag screws. Historical failure rates using parallel screws range from 10% to 30% and have been shown to have the worst performance compared to other methods in mechanical testing using a vertical fracture model.

Other authors have recommended a non-parallel screw configuration, where two of the three screws are placed in typical orientation [59], but the third screw is modified to be placed more horizontally into the head or neck, more perpendicular to the vertical fracture line. This may allow a true lag effect compressing the major fragments across the vertical fracture the fracture to gain stability and possibly control shearing better than an all parallel, oblique screw construct. While never proven in a comparative clinical series, applying screws in the latter, non-parallel configuration has performed significantly better in several mechanical testing studies using a vertical neck fracture model.

The sliding hip screw (SHS) also has a successful record for typical hip fractures. It is a fixed angled device so that it may provide increased resistance to varus collapse compared to parallel screws, while also allowing compression along the axis of the femoral neck. For most femoral neck fractures this is approximately perpendicular to femoral neck fracture line, which induces shearing forces with axial compression for more vertical fractures. As such, the SHS used alone may facilitate shortening and it also lacks rotational control. This implant showed improved mechanical testing strength similar to the non-parallel screw construct previously described and better than three parallel screws in a vertical fracture model [51]. Some clinicians have added a long parallel screw superior to the SHS lag screw for anti-rotation and intramedullary buttress effect which seem to have improved failure rates, but have still failed with varus collapse in 10% of cases [10]. The dynamic compression screw (DCS) is similar in design to the SHS, only with a 95° angle. This device appears to have had limited use for femoral neck fractures, but theoretically allows for dynamic compression in the desired axis for fixation of vertical fractures. This device, like the SHS has minimal rotational control when used alone.

Finally, less frequently used implants have been proposed as improving on older methods. Proximal femoral locking plates are relatively new implants where the use of non-locking screws for fracture compression at 95°, can be followed by locking screws for fixed angle support in the 120–125° range [50]. Initially thought to be a good solution for these problematic fractures; however, clinical series have shown high implant failure rates (70%) for these implants [67]. Reconstruction nails are intramedullary femoral nails dual points of cephalomedullary fixation proposed for femoral neck fractures to allow for rotational control of the head and may provide an endoskeleton to resist varus collapse. Problems with catastrophic migration of the cephalomedullary screws (Z-effect) and violation of the abductors have dampened enthusiasm, and the use of reconstruction nails in clinical series involving patients with femoral neck fractures have shown noteworthy failure rates ranging from 10% to 20% [68].

It appears that an innate problem all of these constructs share is that they do not directly provide an optimal medial buttress support along the femoral neck to help obtain and maintain reduction of the apical fracture spike. Controlling this component of the injury is regarded as a key to successfully treating other oblique fractures that experience ongoing shearing forces.

Our medical hypothesis

Orthopaedic surgeons frequently apply the concept of buttress (or "anti-glide) plate fixation to other fractures that require resistance to shear forces. Buttress plates are applied over the apex of fractures and act by resisting shear forces and converting them into compressive forces. The mini Smith-Petersen anterior approach provides excellent visualization of the femoral neck fracture as it is anatomically reduced along the antero-inferior aspect of the femoral neck. The apical fracture spike for most of these injuries are oriented along the femoral neck axis or anterior to that, where with gentle external rotation of the hip, instrumentation of the neck for plating is not difficult. Thus, the addition of a medial buttress plate over the fracture apex can usually be easily performed through this exposure (Fig. 1). The limb should be draped free to aid in manipulation of the shaft component while stout K-wires