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Unique stability of femoral neck fractures treated with the novel biplane double-supported screw fixation method: A biomechanical cadaver study

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ABSTRACT

Osteosynthesis of femoral neck fractures is related to 20–46% complication rate. Filipov's novel method for biplane double-supported screw fixation (BDSF), using three cannulated screws, has demonstrated excellent clinical results since 2007. Its two calcar-buttressed screws are oriented in different coronal inclinations with steeper angles to the diaphyseal axis and intended to provide constant fixation strength under different loading situations.

The aim of this study was to biomechanically evaluate BDSF fixation strength and compare it with the conventional fixation (CFIX) using three parallel cannulated screws.

Methods: Eight fresh-frozen and six embalmed human femoral pairs with simulated AO/OTA31–B2.2 fracture were fixed applying either CFIX or BDSF. Quasistatic tests were performed in anteroposterior (AP) bending, followed by axial quasistatic, cyclic and destructive quasistatic tests run in 10° flexion with 7° or 16° varus specimen inclination.

Results: Initial axial stiffness was significantly higher for BDSF in comparison with CFIX at 7° inclination ($p = 0.02$) and not significantly different between BDSF and CFIX at 16° inclination. Compared with the intact state, it decreased significantly at 7° inclination only for CFIX ($p = 0.01$), but not for BDSF. Interfragmentary displacement during cyclic testing was significantly smaller for BDSF than CFIX at 7° inclination ($p \leq 0.04$) and not significantly different between BDSF and CFIX at 16° inclination. Failure load did not differ significantly between BDSF and CFIX at both inclinations.

Conclusions: Femoral neck fracture stability can be substantially increased applying BDSF due to better cortical screw support and screw orientation. Having two calcar-buttressed screws oriented in different inclinations, BDSF can enhance constant stability during various patient activities. The more unstable the situation, the better BDSF stability is in comparison to CFIX.

Introduction

The rate of femoral neck fractures, one of the most common traumatic injuries in the elderly, increases constantly among the aging population [1,2]. Treatment complications originate from insufficient reduction, unstable fixation, and poor-quality osteoporotic bone [3,4]. Cannulated screws are often used; however, this osteosynthesis is associated with poor results in 21–46% of the clinical cases [5,6]. Screw configuration has been investigated in several biomechanical studies [7–14]. Currently, there is rather a divergence of views and concepts. The majority of authors recommend placement of the distal screw so that it is supported by the distal femoral neck cortex [4,8–10,14–20], which is traditionally called the "calcar", although this is not the true anatomic calcar [21]. Central screw placement on the lateral view is advised in some papers [19], while other authors suggest peripheral placement [8,10,18]. Secured posterior cortical screw support is also recommended [9,18,22]. It is widely accepted that the screws should be placed parallel to each other [4,8,9,17–19,22]. However, the dictum of parallel placement has not been proven [20] and some authors prefer divergent placement on the lateral view [14,20,23]. The inverted triangle configuration is usually favoured because it provides higher stability [7,8], and screw insertion at

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higher angles relative to the diaphyseal axis seems to achieve better fixation strength [12].

The current conventional method for femoral neck fracture fixation uses three parallel cannulated screws, but this does not always provide appropriate fixation strength (Fig. 1). This is especially true if osteoporosis is present, and poor results might subsequently develop. The initial interfragmentary compression of these constructs is frequently insufficient and therefore unable to ensure stability in osteoporotic bone. Moreover, the constructs could be occasionally instable with regard to varus stresses, anteroposterior bending and torsion because of the screws inserted pretty close to each other with entry points localised in the rather thin section of the cortex near to the greater trochanter, lacking appropriate lateral cortical support (Fig. 1).

When cannulated screws are used to fix a femoral neck fracture with osteoporosis, intraoperative interfragmentary compression alone may not ensure adequate stability during the healing process because it could soon be lost on fracture impaction. Construct stability can be considerably increased if cannulated screws with better cortical support in the distal fragment are used, acting more effectively as console beams with overhanging ends.

Filipov's novel method for biplane double-supported screw fixation (BDSF) can increase fixation stability, demonstrates a high degree of reproducibility during its standardized surgical procedure, and has been clinically applied since 2007 [24]. The innovative concept of biplane screw positioning makes it feasible to place three cannulated screws at steeper angles to the diaphyseal axis in order to improve their beam function and cortical support. The three screws are laid in two vertical oblique planes that medially diverge towards the femoral head on lateral view (Fig. 2). The distal screw is placed in the dorsal oblique plane with additional support by the posterior femoral neck cortex. The middle and proximal screws are oriented in the ventral oblique plane.

The entry points of the screws, which are placed with steeper angles relative to the diaphyseal axis, are located much more distally within the thicker cortex of the proximal diaphysis. BDSF uses two calcar-buttressed screws: the distal and the middle ones with different coronal inclinations of 150–165° and 130–140°, respectively. Each of these screws is placed with the following two supporting points (pivots) in the distal fragment: the *medial* supporting point on the distal femoral neck cortex, and the *lateral* supporting point at the screw-entry point into the lateral diaphyseal cortex. The distal screw has an additional third supporting point on the posterior femoral neck cortex. The two calcar-buttressed screws are oriented in different coronal inclinations in order to maintain constant stability during various physical activities. Their medial supporting points are located 10–20 mm apart, thereby distributing the axial load over a larger cortical area. The enhanced cortical support and increased angle improve the beam function of the calcar-buttressed screws when standing, whereas the proximal screw stabilises the upper neck under tensile stress. In addition, the distal screw, with its three supporting points, provides improved beam resistance to AP bending forces (e.g., rising from a chair), while the two anterior screws hold the side under tension.

The aim of this study is to evaluate biomechanically the fixation strength provided with the novel BDSF method in comparison to the conventional fixation (CFIX) for treatment of femoral neck fractures with three parallel cannulated screws.

Hypothesis. From biomechanical point of view, BDSF provides superior stability compared to CFIX.

Materials and methods

Specimens and study groups

Eight fresh-frozen (20 °C; 3 female and 5 male donors; mean age 72.4 years; range 42–76 years) and six embalmed pairs (2 female and 4 male donors; mean age 64.2 years; range 60–71 years) of human cadaveric femora were used in this study. Conventional AP and mediolateral (ML) radiographs were taken to confirm the absence of preexisting pathology in all specimens. Bone mineral density (BMD) was defined using dual-energy X-ray absorptiometry (DEXA) measurements (Lunar Prodigy Primo; GE Lunar, Madison, WI, USA) of the femoral neck and greater trochanter regions.

Each fresh-frozen (FRZ) pair was split and assigned to two study groups, CFIX-FRZ and BDSF-FRZ, to be instrumented applying CFIX

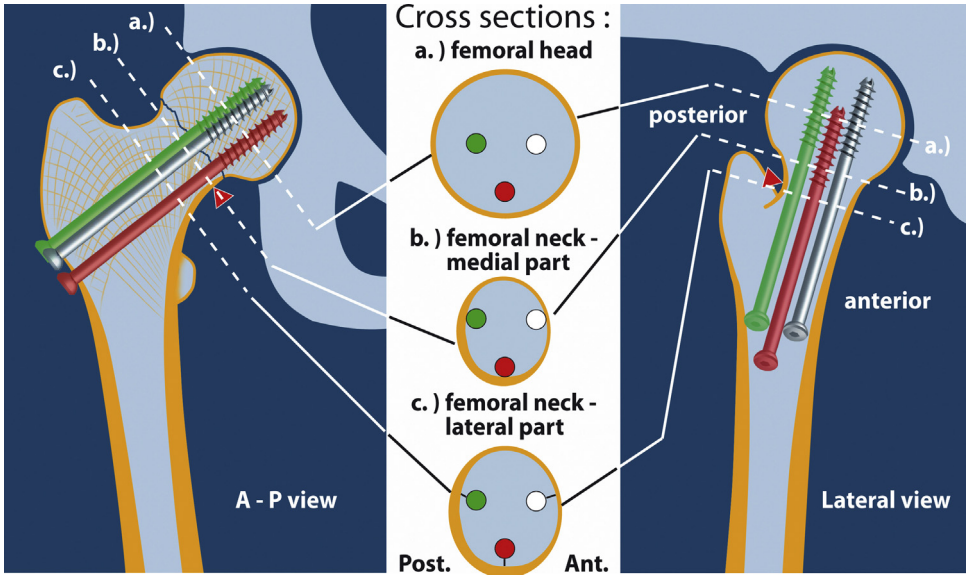

Fig. 1. Schematic of the conventional method with three parallel cannulated screws. Only one distal calcar-buttressed screw is used. Its contact point on the calcar is at the level of the medial part of the femoral neck (cross section b). The parallel screw orientation allows placement angles of 120–130° maximally. The screws are too close to each other.