Review Article

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Biplane Double-supported Screw Fixation of Femoral Neck Fractures: Surgical Technique and Surgical Notes

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Abstract

Osteosynthesis of femoral neck fractures is still associated with high complication rates. The novel method of biplane double-supported screw fixation offers better osteosynthesis stability by buttressing two of three medially diverging cannulated screws on the inferior neck cortex. Biomechanically, the most effective component of this fixation is the third, inferior obtuse screw, supported along considerable distance on both the inferior and posterior cortices of the femoral neck following its spiral anterior curve. Thus, biplane double-supported screw fixation achieves greater inferoposterior cortical support of the implants, allowing immediate full weight bearing for patients older than 55 years. Although the method has been recently communicated, some important surgical aspects still remain to be discussed. This report aims at describing a detailed and modified surgical technique and providing criteria and recommendations for its successful application according to the clinical experience over more than 9 years.

Level of Evidence: Level V, expert evidence

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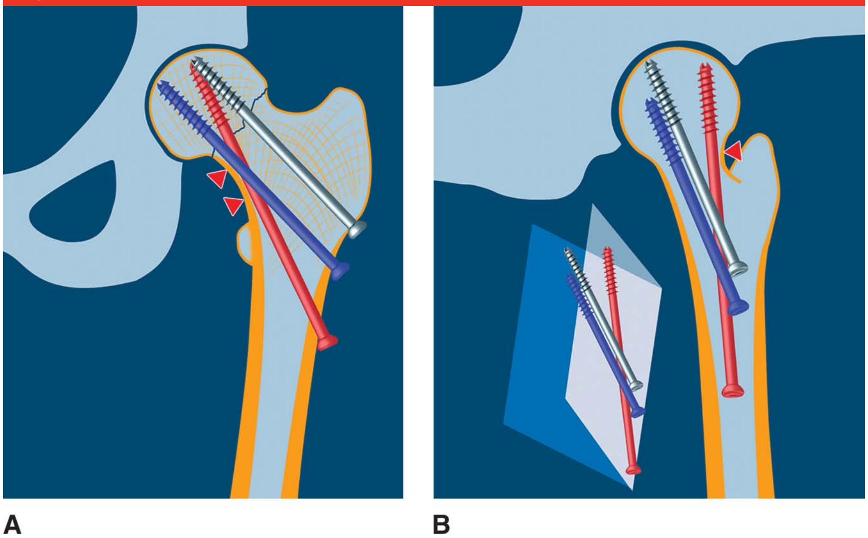
Internal fixation of femoral neck fractures has been debated for several decades. Although parallel-oriented cannulated screws are frequently used, such a fixation is associated with poor outcomes in up to 46% of the clinical cases.[1-3] On the basis of recent clinical evidence and experimental results, the novel method of biplane double-supported screw fixation (BDSF) was introduced and deemed to improve substantially the stability of cannulated screws osteosynthesis by implementation of an innovative biomechanical concept.[4-7] It is associated with up to 44% higher axial fixation strength in vitro compared with conventional parallel screw fixation (CFIX) and a bone union rate of up to 96.6% in the clinical practice, being much higher compared with the latter.[4-7] The concept of biplane positioning facilitates positioning of three medially diverging cannulated screws in steeper angles to the diaphyseal axis. Two of the screws are with entry points within the thicker cortex of the proximal diaphysis to improve their beam function and lateral cortical support (Figure 1). Moreover, two screws are calcar buttressed with different inclination angles in the coronal plane, whereas one of them is additionally supported on the posterior femoral neck cortex. Thus, constant fixation strength is provided during various patient activities, and immediate full weight bearing is possible after surgery for patients older than 55 years.[5,6]

Figure 1



Schematic representation of the biplane double-supported screw fixation method. **A**, AP view. **B**, Lateral view. By applying the biplane positioning principle, the inferior screw (red) is placed in the posterior oblique plane, whereas the middle (blue) and superior (gray) screws are placed in the anterior oblique plane. The inferior and middle screws are calcar buttressed, and they are inserted with coronal inclinations of 150° to 165° and 130° to 135°, respectively. Each of these screws is placed using the following two supporting points (pivots) in the caudal fragment: the medial supporting point at the inferior femoral neck cortex and the lateral supporting point at screw entry into the lateral diaphyseal cortex. The inferior screw has an additional supporting point at the posterior femoral neck cortex. The three medial supporting points are indicated by triangles. The inferior screw projection crosses the projections of the other two screws.

Indications and Contraindications

Strong evidence supports the use of arthroplasty in most elderly patients with displaced femoral neck fractures.[1-3,8] BDSF is indicated for osteosynthesis of Garden stage I–IV fractures of the femoral neck (Table 1), which commonly meet the indications for internal fixation according to accepted clinical algorithms.[8,9] Screw fixation is relatively contraindicated for inferior comminution or Pauwels type III fractures laterally to the midcervical line, where fixed-angle implants should be used in patients younger than 60 to 65 years, whereas arthroplasty is considered in patients older than this age.[8,9]

Fracture Reduction

Anatomic reduction is essential to achieve stable osteosynthesis and enable head fragment revascularization. Closed reduction is performed with the patient in the supine position on a fracture table. The unaffected limb is abducted to provide space for a C-arm and keep the pelvis centrally positioned relative to the perineal post. Traction is applied to the affected limb until slight longitudinal hypercorrection of the fracture. The limb is then internally rotated until repositioning is achieved, with confirmation in AP, lateral, and 45° fluoroscopic views. If necessary, abduction or adduction is additionally performed to restore the caput-collum-diaphyseal (CCD) angle. Reduction in lateral view can be facilitated with application of manual pressure in the sagittal plane before the fragment interdigitation via internal rotation. Some fractures can be reduced in neutral or external rotation.

If the repositioning on the fracture table fails, reduction using the Leadbetter method[10] should be attempted. In rare cases of femoral head dislocation in abduction, resulting in lateralization of the fracture surface, the following reduction technique is recommended. It involves traction, abduction, and external rotation, followed by release of the traction, internal rotation, and adduction, and it is termed as the TAERIA technique. If closed reduction fails, open reduction should be performed in patients younger than 65 years applying the Watson-Jones approach[11] or the modified Smith-Petersen approach,[12] or arthroplasty is planned in patients older than this age.

Assessment of the Reduction

Internal fixation should not be performed before satisfactory fracture reduction is obtained. In AP and 45° views, an anatomic or a slight valgus position of the femoral head is acceptable, with restored continuity of the inferior cortex. However, only a minimal deviation from the anatomic position is acceptable in lateral view, and remanipulation is required for a malalignment exceeding 10°. Repositioning can simply be achieved through correction of traction, internal rotation, and/or abduction/adduction in most of the cases.

In rare cases, axial rotational dislocation of the capital fragment occurs, which can be identified by the different width of the head and neck fracture surfaces because of the elliptical femoral neck cross section and/or mismatching of the contours of the fracture surfaces. In most cases, such rotational dislocation is successfully reduced using the Leadbetter method,[10] where traction in flexion disengages the

Table 1

Indications, Possible Indications, and Contraindications for the Use of Biplane Double-supported Screw Fixation in Management of Fractures of the Femoral Neck

Indications	Possible Indications	Contraindications/IF Is Generally Inappropriate
All nondisplaced fractures (Garden I and II)	Higher functioning/higher-demand patients (aged > 65 yr), who are unfit for arthroplasty	Late diagnosis of displaced fractures (patients aged >55 ± 5 yr)
Displaced fractures (Garden III and IV) in "young" patients (aged <65 yr)	Moderate- to low-functioning patients, who are unfit for arthroplasty	Fixation failure (patients aged > 55 ± 5 yr)
	Nonambulatory/bed dependent/—very-low-function/very-low-demand patients, who are unfit for arthroplasty	Small femoral head fragment (patients aged >65 yr)[a]
		Preexisting pathologies affecting the hip joint (eg, pathologic fractures, Paget disease, metabolic bone disease, rheumatoid arthritis, notable hip osteoarthritis, osteonecrosis)

IF = internal fixation
[a]Less than 12 to 15 mm distance between the center of the femoral head and the fracture line, that is, small bone size.

fragments and the fragment of the femoral head returns to its anatomic position within the acetabulum because of tension of the foveal ligament. C-arm imaging suffices for visualization of the medial trabecular group and fracture irregularities during reduction.

Surgical Technique

The surgical steps can be seen in the Video, Supplemental Digital Content 1 (http://links.lww.com/JAAOS/A279).

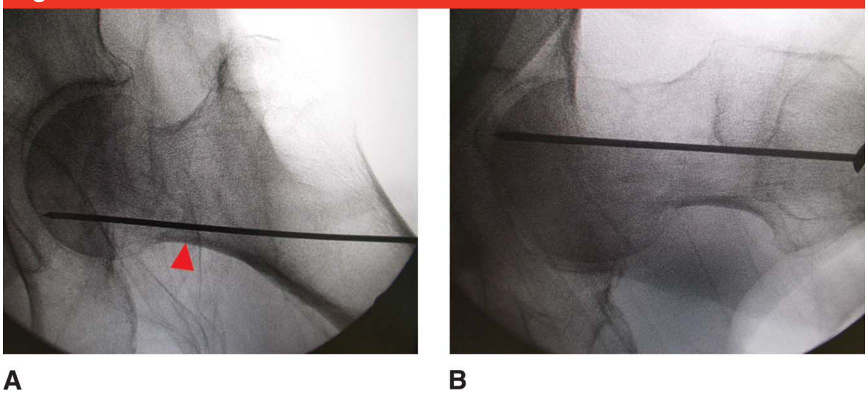
Implants

Three 7.3-mm, self-tapping, partially threaded (32 mm) cannulated screws, preferably with 2.8-mm cannulation, are used for internal fixation.

Approach

A straight lateral incision is made, starting at the level of the lower greater trochanter end, with a distal length of 6 to 10 cm. Following a direct lateral transmuscular approach, the periosteum of the lateral diaphysis is stripped along 5 to 7 cm caudally to the greater trochanter.

Figure 2

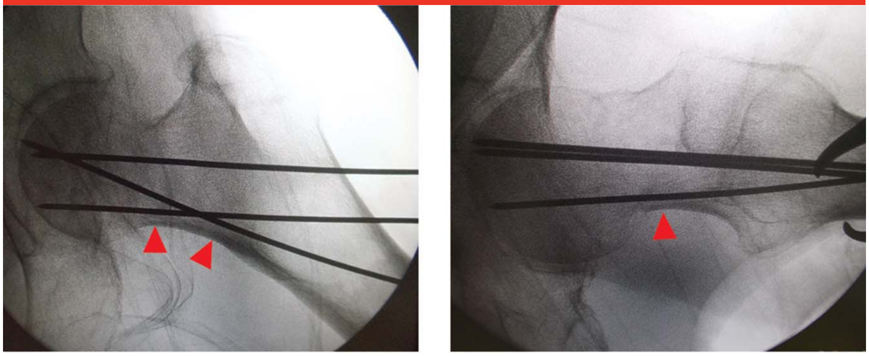


Placement of the middle guidewire. **A**, AP view (fluoroscopy). **B**, Lateral view (fluoroscopy). The calcar supporting point is denoted by a red triangle.

Placement and Positioning of Guidewires

The middle guidewire is inserted first, with an entry point in the posterior third of the stripped lateral cortex 3 to 4 cm caudally to the lower border of the greater trochanter, depending on the CCD angle and femur size. This wire is inclined anterocranially 130° to 135° to the diaphyseal axis so that after touching the inferior (caudal) neck cortex, it enters the inferoanterior aspect of the femoral head at the border between its caudal one-fourth (1/4) and cranial three-fourth (3/4) in AP view, as well as the border between its anterior 1/4 and posterior 3/4 in lateral view (Figure 2).

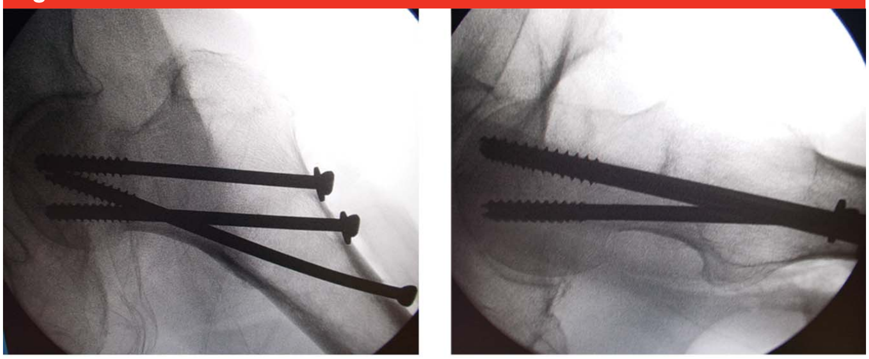
Figure 3



A B

Positions of the three guidewires. **A**, AP view (fluoroscopy). **B**, Lateral view (fluoroscopy). The medial supporting points on the cortex are denoted by red triangles.

Figure 4



A B

Positions of the three cannulated screws. **A**, AP view (fluoroscopy). **B**, Lateral view (fluoroscopy).

Second, the guidewire for the superior (cranial) screw is inserted with an entry point in the posterior third of the lateral cortex at a distance of 1.5 to 2.0 cm cranially to the middle guidewire and parallel to it. A parallel guide can be used. The guidewire is directed to the superoanterior part of the femoral head, entering the border between its anterior 1/4 and posterior 3/4 in lateral view, as well as the border between its caudal 3/4 and cranial 1/4 for a small femur or its caudal two-third (2/3) and cranial one-third (1/3) for a large femur in AP view (Figure 3).

Third, the guidewire for the inferior (caudal) screw is inserted with an entry point at the median line of the stripped lateral diaphyseal cortex and 4 to 7 cm caudally to the lower border of the greater trochanter or 2 to 4 cm caudally from the middle guidewire, depending on the CCD angle and the femur size (Figure 3). This guidewire is inclined posterocranially 150° to 165° to the diaphyseal axis and directed to the posterior third of the femoral head so that it tangentially touches the inferior cortex of the femoral neck in AP view and its posterior cortex in lateral view. Orientation in the bone is facilitated by palpation with the wire tip. In cases with a standard femoral anatomy, this wire ideally penetrates the femoral head at the border between its posterior 1/4 and anterior 3/4. In the AP view, the tip of the wire is positioned subchondrally at the border between the caudal 3/4 and cranial 1/4 of the dome of the femoral head articular surface.

The lateral distance between the shaft of each guidewire and the respective articular surface of the femoral head equator should not be less than one fifth (1/5) or more than one third (1/3) of the diameter of the femoral head. Intraoperatively, all described distances and proportions can be easily achieved according to the anatomy of a standard proximal femur. However, careful selection of the entry point locations is crucial for proper implant orientation. During insertion, the wire tips are guided in the appropriate directions manually, with assistance from a cannulated instrument.

Screw Insertions

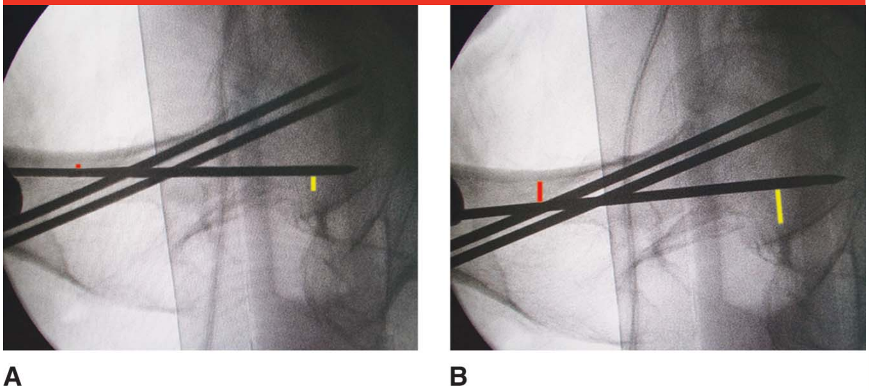
The screw lengths are measured, and drilling is performed using a 5.0-mm cannulated reamer along the middle and superior guidewires, followed by overdrilling of the middle screw hole in the lateral cortex with a 7.3-mm cannulated reamer. The middle and the superior screws are then inserted to achieve interfragmentary compression due to their orthogonal orientation to the fracture line (Figure 4).

The traction applied to the foot is then released, and the fracture is impacted by gently hammering on a plastic impactor placed on the diaphyseal cortex, caudal to the heads of the screws. After each impaction, any loosening of the two screws is addressed by gentle additional tightening. It is important to perform impaction before placing the inferior (caudal) screw.

Drilling is then performed along the inferior guidewire using a 5-mm cannulated reamer, followed by 7.3-mm overdrilling of its hole in the lateral cortex. Finally, the inferior screw is inserted (Figure 4).

All three screws are inserted less than 5 mm subchondrally. None of them should be placed in the central zone of the femoral neck in lateral view. Fluoroscopic exposure time during the surgery is 0.25 ± 0.05 minutes, and the mean surgical time is 39 ± 9 minutes.[4,6] The fascia lata, subcutaneous tissue, and skin are closed in the usual manner.

Figure 5



Entry point of the inferior screw should be at the median line of the stripped lateral diaphyseal cortex. A case of increased anteversion shown on lateral view radiographs. **A**, The entry point of the inferior guidewire is placed in the anterior one third of the lateral cortex, and proper positioning of the wire is prevented by the anterior cortex of the femoral neck. The wire tip could enter too posteriorly into the femoral head if the wire touches the posterior cortex of the neck. **B**, Changing the entry point more laterally allows the wire to be positioned properly, touch the posterior cortex of the neck, and enter into the head of the femur between its posterior 1/4 and anterior 3/4 parts. Note the different distances (indicated by red lines) between the inferior guidewire and the anterior cortex of the neck on both radiographs.

Postoperative Care

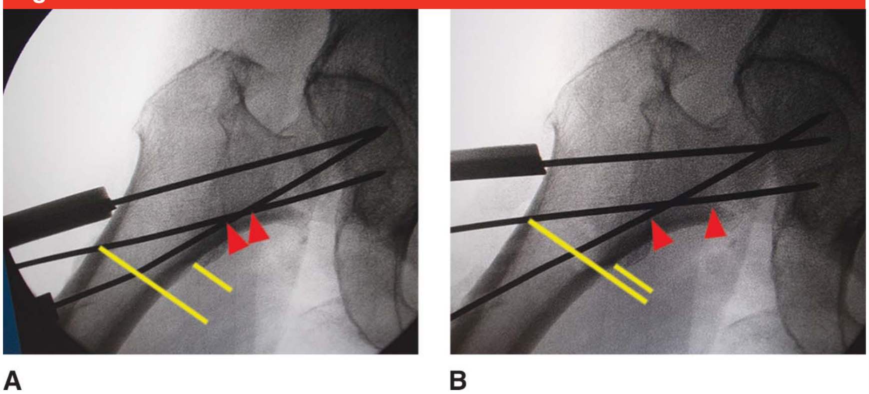
For patients older than 55 years, mobilization with full weight bearing is recommended immediately after surgery without any limitations in range of motion. For patients younger than 55 years, partial weight bearing (30 kg) is recommended during the first 8 weeks after surgery because their higher bone density does not allow to increase the frictional stability at the fracture site by intraoperative impaction.

Surgical Notes

Entry Point of the Inferior Screw

The inferior screw may sometimes be oriented too posterior in the femoral head in cases with increased femoral anteversion if its entry point is in the anterior 1/3 of the lateral cortex (Figure 5). Accordingly, the entry point of this screw should be relocated on the median line of the lateral diaphyseal cortex.

Figure 6



A, Extreme inclination of the middle guidewire in the AP view results in positioning of the calcar supporting point lateral to the midcervical line, which could interfere with the inferior guidewire. **B**, After reinsertion at an inclination angle of 130° to 135°, the supporting point of the middle guidewire is shifted onto the midcervical line and at the top of the inferior cortex arch, allowing the inferior screw to be inserted. The medial supporting points are indicated with triangles.

Distance Between the Two Calcar Supporting Points

In cases with a standard CCD angle, if the middle and superior guidewires are inserted more obliquely than 135° to the diaphyseal axis, the calcar supporting point of the middle screw will be located more lateral and closer to the calcar supporting point of the inferior screw in AP view. This scenario could lead to physical contact between the screws, resulting in either their malposition in the bone or breakage of the drill bit during drilling. Therefore, in such cases, the middle and superior guidewires should be reinserted in an angle of approximately 130° to the diaphyseal axis (Figure 6), resulting in a more medially located supporting point of the middle guidewire on the top of the inferior femoral neck cortex arch. A standard distance of 10 to 20 mm between the calcar supporting points of the middle and the inferior screws will allow for their free corridors through the femoral neck.

Guidewires

Old and blunted guidewires should not be used. They should have a sharp trocar tip and a diameter bigger than 2.0 mm (optimally 2.8 mm). New and thick guidewires can successfully penetrate the bone in an angle of up to 165°, even with a dense diaphyseal cortex. Moreover, thick and rigid wires rarely change their initial direction; therefore, difficulties in their positioning are rather infrequent.

Insertion of the Inferior Cannulated Screw at an Angle of 165° in the Thick Diaphyseal Cortex

Entry in the diaphyseal cortex with such high inclination to the bone axis requires a proper technique with an open approach involving stripping of the periosteum. In most cases, insertion of the inferior wire is not difficult, and drilling through the cortex requires approximately 15 ± 5 seconds (Video, Supplemental Digital Content 1, http://links.lww.com/JAAOS/A279). However, in a dense diaphyseal cortex, it may be difficult to insert the guidewire in proper inclination to touch both the inferior and posterior cortices of the femoral neck. In such a situation–only when the guidewire is placed with a correctly selected entry point–drilling of the lateral cortex only can be performed along the guidewire with a 5.0-mm cannulated reamer. Thus, the guidewire can be freed from the lateral cortex and can then be easily reinserted into the bone with a proper inclination. This approach is based on techniques previously published by LaVelle,[8] Garden,[13] Asnis,[14] and Fekete et al.[15] The reamed opening in the lateral cortex will be used later as entry opening for the inferior screw. After reinsertion of the guidewire in the proper position, the standard BDSF surgical technique is continued, with 5.0-mm drilling along the wire up to the subchondral bone, followed by 7.3-mm overdrilling of the opening in the lateral cortex and insertion of the inferior screw. This wire-releasing procedure is not applied routinely. Drilling the lateral cortex at a wrongly selected entry point will result in inappropriate placement of the screw because the drilled hole will dictate the position of the screw.[13] The entry point is deemed to have been correctly selected if the corresponding screw is inserted in correct position. The inferior guidewire can be easily directed through the drilled opening in the cortex, even without fluoroscopic guidance, by palpating the inner surface of the proximal femur using the wire tip. Initially, the medial diaphyseal cortex is palpated to detect the arch of the inferior femoral neck (ie, calcar), and the guidewire is passed over it. Keeping the guidewire touched to the calcar, it is directed posteriorly to palpate the posterior cortex of the femoral neck. Then, maintaining contact with the posterior cortex, the guidewire is drilled into the femoral head using a power tool. During obligatory fluoroscopic control (AP, 45°, and lateral views), the inferior wire is usually present in a perfect position.

Thermal Necrosis

Additional procedures for cooling of the bone during drilling in a dense diaphyseal cortex may be considered. Bone parts with possible generated thermal necrosis around the guidewire are removed later during the subsequent 5.0-mm drilling.

The Inferior Screw Acts as a Console Beam and Not as a Lag Screw

Considering the directions of forces and moments transferred through the hip joint, the steeper inferior BDSF screw acts mainly as a console beam when counteracting the more destructive AP bending moments (eg, when rising up from a chair), whereas its axial bearing capacity is manifested under rather vertical loads (eg, in the standing position). Therefore, this screw is not intended to act as a lag screw. Moreover, because of the steeper inclination, excessive tightening of the inferior screw after the contact of its head with the lateral cortex will tend to displace the lateral screw end cranially, causing additional pressure at the cranial rim of the opening. The pressure caused via such overtightening can be released by unscrewing at 1/2 turn without any risk of decreased fixation stability.

No Screw in the Central Femoral Neck Zone in Lateral View

The placement of the three cannulated screws requires consideration of the principle of biplane positioning, whereby none of the screws should be placed in the central zone of the femoral neck in lateral view. A centrally placed screw will be an obstacle for positioning of the other screws.

The Inferior Screw Should Always be Placed Posteriorly, the Middle and the Superior Screws Always Anteriorly

The steeper inferior BDSF screw should always be located in the posterior part of the femoral neck. If an attempt is made to place this screw anteriorly in an angle of 150° to 165°, the normal anteversion of the femoral neck will not allow its placement more anteriorly than in the middle aspect of the neck in lateral view. This phenomenon will impede the insertion of the other two BDSF screws. On the other hand, if the middle and the superior screws are positioned in the posterior part of the femoral neck, the stability of the bone-implant construct to AP bending moments will be considerably reduced because of the smaller inclination angle of these screws (130° to135°) compared with the inferior screw (150° to 165°).[16]

Table 2

Pearls and Pitfalls

Pearls	Pitfalls
Immediate full weight bearing (age >55 yr)	Requires experienced surgeons
Increased bone union rate	Importance of the location of screws entry
Effective for posteriorly comminuted fractures	Importance of the implant angle to the diaphyseal axis
Better cortical support and fixation strength	Importance of the biplane orientation of the implants
Increased varus resistance	Importance of the cortical screw support
Increased AP bending and torsion stability	Prolonged inferior wire drilling through the cortex
Two calcar-buttressed screws	No clinical disadvantages of BDSF versus conventional parallel screw fixation
Safe application below the lesser trochanter level	
Less extensive compared with THR/BH	
Relies on strong cortical support and not on the patient's cooperation desire	

THR/BH = total hip arthroplasty/bipolar hemiarthroplasty

Outcomes

With parallel cannulated screw fixation, optimal strength is achieved when the inferior screw is buttressed on the inferior femoral neck cortex and the posterior screw is supported on its posterior cortex.[17-19] As determined by the femoral anatomy, both supporting points at the inferior and posterior cortices are located at the midcervical line, whereas the entry points of the screws are at the fragile cortex of the greater trochanter region, thus lacking appropriate lateral beam support. Consequently, the implants principally act as first-class levers (with medial support only) and hardly as console beams; therefore, such a fixation is associated with a complication rate of up to 46%[1,2] and immediate full weight bearing is usually not allowed.[8]

Regarding fixation strength, the most effective aspect of the BDSF method is related to the location of its inferior screw, placed in an obtuse angle and supported along considerable distance on both inferior and posterior cortices of the femoral neck, following its spiral anterior curve. Thus, the inferior-posterior cortical support of the fixation construct is better with BDSF compared with the conventional parallel cannulated screw technique. Furthermore, the medial cortical supporting points of the two calcar-buttressed screws are located 10 to 20 mm apart, which distributes the weight-bearing load over more than 50% of the femoral neck cortex length between the basicervical and midcervical lines, compared with the concentrated weight-bearing stress at a single point after conventional parallel screws techniques. Furthermore, BDSF can be effective for most posteriorly comminuted fractures, where support over a large distance via a steeper inferior screw successfully bridges the posterior bone defect (Table 2).

The two calcar-buttressed screws, securely placed in the caudal fragment with five supporting points and different inclination, provide constant fixation strength during various weight-bearing activities and increase construct stability to counteract axial, torsional, and bending loads and moments.[5] In contrast, conventional parallel cannulated screws provide maximum stability under axial loading; however, they indicate a remarkable decrease in stability under changing direction of loading.[5] The steeper BDSF screw orientation contributes to increased resistance to varus collapse and allows for easier screw sliding, thus avoiding cutout and maintaining strong fixation strength. The nonparallel orientation of the screws does not prevent their sliding in the femoral neck, which can be considered a hollow cylinder from biomechanical point of view.[7]

In recently published biomechanical work, comparing BDSF with CFIX, instrumented femoral pairs were tested in 16° and 7° lateral inclination. The study reported axial fixation strength approximately 44% higher for BDSF versus CFIX in 7° inclination (initial axial stiffness instrumented, BDSF 0.93 ± 0.10 kN/mm versus CFIX 0.53 ± 0.06 kN/mm). In addition, BDSF demonstrated 15% higher secondary axial stiffness, 20% bigger failure load, and comparable fixation strength in 16° inclination.[5]

Biomechanical insufficiency of CFIX was observed with the more vertical load orientation of 7° inclination, where its stiffness markedly decreases by as much as 38% (0.85 kN/mm at 16° inclination versus 0.53 kN/mm at 7°). In contrast, BDSF stability remained similar in both inclinations. Interestingly, the axial BDSF stiffness in 7° inclination was even higher than that in 16° inclination. The similar BDSF stability in both inclinations was mainly based on the specific function of the inferior BDSF screw. Under more vertical loads, the CFIX construct stability decreases because of the increasing transverse component of the load with higher shearing forces acting on the screws placed parallel to the femoral neck axis. Mechanically, the middle BDSF and inferior CFIX screw are fairly equivalent and demonstrate similar positions and functions. However, in contrast to CFIX, BDSF has two calcar-buttressed screws oriented in different inclinations. If the load is more vertically oriented, the middle BDSF screw seems to reduce its bearing capacity (as observed for CFIX screws), but the obtuse inferior BDSF screw is with an optimal orientation for axial weight bearing. Its bearing capacity is added to that of the middle BDSF screw, which helps maintain constant stability across a wide range of inclinations during gait activities, in contrast to CFIX. This is an essential advantage of BDSF because resultant forces change their directions during diverse patient activities—a situation where the three parallel CFIX screws are far less functional.

The laboratory results have been confirmed clinically in two recent studies involving a total of 248 patients with displaced femoral neck fractures.[6,7] These clinical studies have revealed better fixation stability with BDSF, resulting in a lower incidence of nonunion (3.4%[6] and 5%[7]) and a higher rate of fracture union (96.6%[6] and 95%[7]) compared with literature data for CFIX.

Some studies recommend placing of parallel cannulated screws without entering the lateral cortex below the lesser trochanter to prevent subtrochanteric fracture complications.[9,14] A short distance of less than 7 mm between the three parallel cannulated screws with 130° inclination may cause an increase in stress at this area, especially when the distance is further decreased via a steeper insertion angle. In contrast to CFIX, BDSF results in a reduced rate of subtrochanteric fractures due to a much bigger distance between the BDSF screw heads (20 to 40 mm), allowing spreading of the tensile forces over a larger area on the lateral cortex and preventing the concentration of stress on a small surface as with CFIX.[6,7] Furthermore, a steeper screw angle that leads to a larger distance between the lateral supporting point (screw entry at the diaphyseal cortex) and the most medial supporting point (on the midcervical line) would further reduce the tension load at the lateral cortex by up to 42% compared with the load with CFIX (ie, beam theory).[4] The rate of subtrochanteric fractures after side fall incidents is approximately 0.3% among the elderly, and the rate of such fractures after conventional internal fixation is 2.4%.[20,21] During the past 10 years, approximately 500 cases have been treated with BDSF in our institution, and we have reported the outcomes for the first 5 years.[6] In our clinical practice, two subtrochanteric fractures (0.4%) occurred after a fall, and no iatrogenic fractures were observed. After drilling a hole into the cortex—either in the trochanteric or subtrochanteric region—a potential increase in stress is noted. Therefore, more caudal screw placement does potentially increase stress in the subtrochanteric region. However, in our opinion, the risk of subtrochanteric fractures is lower with BDSF versus CFIX for the reasons mentioned above.

BDSF provides strong cortical support and increased angles of screw insertion, and thus, it substantially enhances the strength of femoral neck fracture fixation. Moreover, it is logical and easy to learn by an experienced surgeon with few applications. Considering the fact that a fracture of the femoral neck is a devastating injury with a high complication rate even in young patients,[22] where joint-preserving surgery is the treatment of choice, BDSF is a reasonable treatment alternative to other fixation methods.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 2 and 8 are level I studies. Reference 1 is a level II study. References 6, 7, 20-22 are level III studies. References 4, 5, 9-19 are level V: expert evidence or cadaver studies.

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