J Orthop Spine Trauma. 2023 March; 9(1): 14-9. DOI: 10.18502/jost.v9i1.12564

Review Article

Surgical Approaches for Femoral Neck Fractures: A Review Article

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Received: 13 June 2022; **Revised:** 21 August 2022; **Accepted:** 18 September 2022

Abstract

Displaced femoral neck fractures in the young are difficult to treat. The complexity of the fractures for closed or open reduction requires careful surgical planning and experience. Acceptable reduction criteria in this fracture is crucial and should be followed strictly in order to get the favorable outcomes. Various reduction techniques have been described ranging from closed reduction by traction table or closed reduction with minimal direct manipulation with instruments to direct open reduction. This manuscript describes the mini open reduction, Watson-Jones and Smith-Petersen approaches, and some modifications in terms of indications, advantages, and disadvantages of each approach for the decision-making in these complex fractures.

Keywords: Femoral Neck; Fractures; Internal Fracture Fixation; Open Reduction; Surgical Procedures

Citation: Apivatthakakul T. **Surgical Approaches for Femoral Neck Fractures: A Review Article.** *J Orthop Spine Trauma* 2023; 9(1): 14-9.

Background

Displaced femoral neck fractures remain challenging, particularly in young adults. The goal of surgical treatment is an anatomical reduction and stable internal fixation. The quality of the reduction is a crucial factor in predicting clinical and radiological outcomes. For minimally displaced or partially displaced fractures, closed manipulation is the first option with favorable outcomes (1-3).

Since most femoral neck fractures are intracapsular fractures, the soft tissue and hip capsule around the fracture contain the fracture within the joint which usually facilitates the reduction of the fracture fragments. Totally displaced fractures have a high incidence of disruption of the soft tissue and/or the joint capsule which can result in an unsuccessful closed reduction. Comminuted femoral neck fractures, especially medial calcar fractures, require anatomical reduction of the fracture fragments to prevent varus collapse of the fracture (1-4).

Knowledge of hip and pelvic anatomy and the surrounding vasculature as well as alternative reduction techniques and implant options is essential to accomplish the perfect reduction of a femoral neck fracture (4). Open reduction of a femoral neck fracture is a procedure which may not be familiar to many surgeons as the majority of surgeons perform the open reduction in fewer than 20% of their cases. Surgical approaches and optimal implants and treatment strategies for open reduction are still evolving and require additional large clinical trials (5). This study presented surgical approaches for femoral neck fractures.

Radiographic Evaluation

Most femoral neck fractures in young patients are caused by high-energy injury, unlike in the elderly. The fracture patterns or configurations are generally more complex in younger patients than in the elderly. For all femoral neck fractures, X-rays, both hip anteroposterior (AP) and cross-table lateral views are the routine radiographs. X-rays of both hips provide details for comparison with the normal hip which can be used as a template to judge the neck-shaft angle, neck length, and quality of reduction using the Garden alignment index (1, 6) (Figure 1).

The lateral cross-table X-ray is used to determine the anteversion or retroversion of the fracture and identify bony contact between the proximal and distal fragments and the degree of posterior comminution. Most lateral cross-table X-rays are usually inadequate due to their poor quality. In addition to the X-rays, a pre-operative computed tomography (CT) scan is mandatory in cases of a high-energy fracture to identify the angle of the fracture to the horizontal plane (Pauwels angle), degree of fracture comminution, and the location of the fracture. CT scans are helpful in determining the reduction technique, sequences of the reduction, implant options, and optimal surgical approaches required for the selected implant (6, 7).

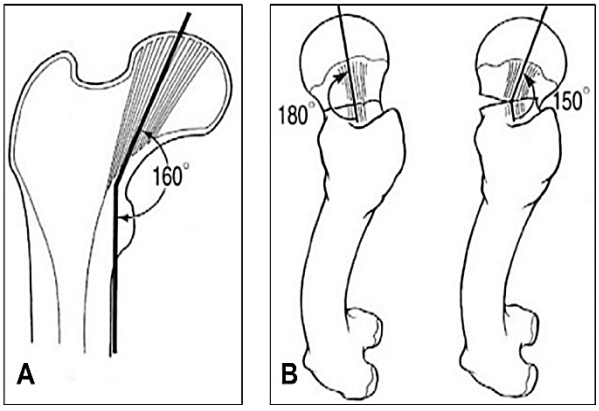

Figure 1. The Garden alignment index in anteroposterior (AP) view (A), lateral view (B)

Pre-Operative Planning

Pre-operative planning is very important for reducing the number of surgical steps, selecting appropriate tips and tricks, and predicting the difficulty of a reduction. The surgeon must have a plan for each of the steps and must also have a backup plan in the event that the first plan is not successful. The quality of the reduction is crucial to

determine whether the fracture reduction is acceptable or unacceptable. The Garden alignment index, which is based on the shape of the femoral neck cortices and the bony trabeculae on both AP and lateral X-rays, is the primary guide for determining the quality of a reduction. Normally, the angle between the principal compressive trabeculae of the neck and diaphysis is 160° in the AP view and the major trabeculae on the femoral neck axis extend at an angle of 180° in the lateral view (Figure 1) (6). However, using the Garden alignment index can be difficult since the trabeculae of the intraoperative fluoroscopic images are often not very clear. Lowell demonstrated that the cortices of an anatomically aligned femoral head and neck would project as shallow S- or reversed S shape on both AP and lateral views. Malalignment is demonstrated by a flattening of one curve into an I-shape and by a sharp apex on the opposite side as a V-shape (Figure 2) (8).

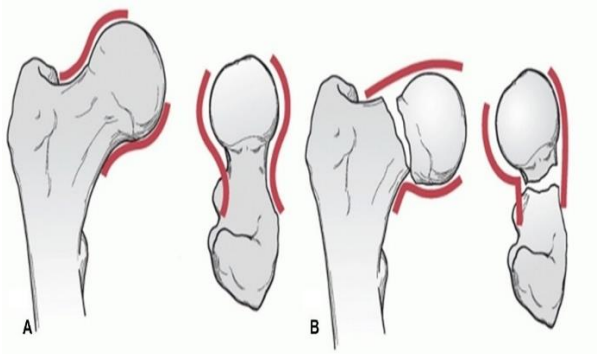

Figure 2. The Lowell S or reversed S shape of good reduction for alignment of the head and neck junction in anteroposterior (AP) and lateral view (A) and mal-reduction with flattening of the curve shown as an "I" or "V" shape (B)

The quality of alignments can be difficult to determine definitively and evaluations vary among surgeons. More experienced surgeons tend not to accept any abnormal angulation or translation and have a tendency in such cases to opt for open reduction. Less experienced surgeons are generally more reluctant to perform open reduction and tend to accept greater malalignment which can result in an increased incidence of fixation failures. Some fractures cannot be perfectly reduced by closed manipulation, but the use of appropriate minimally invasive percutaneous reduction tools, e.g., a ball spike pusher, bone hook, collinear reduction forceps, or leverage Steinmann pin can facilitate a perfect reduction. When none of these techniques are possible or when the reduction criteria are unacceptable, then the open reduction technique is inevitably the best reduction option.

Anesthesia and Patient Positioning

General anesthesia under endotracheal intubation is usually preferred as it results in complete muscle relaxation allowing easy manipulation of the fracture and the patient's position. Isolated regional anesthesia may cause high tissue or muscle tension, potentially resulting in mal-reduction (9). Most femoral neck fracture reductions and fixations are done in the supine position (10). The lateral position is not commonly used because of the difficulty with C-arm positioning to obtain a clear AP radiographic image and the risk of gravity causing fracture displacement. The supine position with a traction table helps in achieving and maintaining fracture reduction in cases where the reduction is accomplished by closed manipulation. Open reduction on the traction table has some limitations as well, e.g., free manipulation of the leg is difficult and there is no table space for surgical instruments. The authors prefer to use the supine position with a radiolucent flat top table and with the opposite hip in flexion and external rotation or the hemi-lithotomy position (Figure 3). If the leg rest on the opposite side is removable, the lateral cross-table X-ray will be easier. The AP and lateral X-rays make it easy to determine the quality of the reduction. The injured limb is draped freely for easy manipulation and reduction and the surgical field is similar to that in other types of hip operations. The only limitation is the need to maintain the reduction which is accomplished using surgical tactics of ready-to-go pin for temporary fixation after closed or open manipulation.

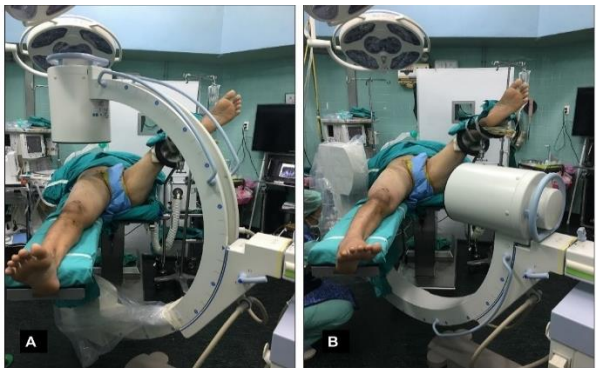

Figure 3. Patient positioned in the hemi-lithotomy position on a radiolucent table in anteroposterior (AP) (A), and lateral view (B)

Surgical Approaches

Minimally Invasive Percutaneous Approach: The aim of this approach is the direct manipulation of a fracture that requires minimal manipulation to accomplish perfect reduction through a small incision using some reduction tools (10, 11). Approach to the femoral neck is usually through a 2-3 cm anterolateral incision at the level of the femoral neck. After opening the thigh fascia, blunt dissection is done posteromedially to the anterior surface of the femoral neck over the hip capsule. Before insertion of the reduction tool, multiple 2.0 mm Steinmann pins (nicknamed "ready to go pins") are inserted from the lateral cortex into the femoral neck in the distal fragment, stopping just distal to the fracture which permits full-speed forward drilling of the pin when the reduction has been achieved. The reduction tool is inserted and used to directly manipulate the proximal femoral neck fragment; sometimes a joystick in the distal fragment is needed as a counterforce. A bone hook or a small tip Hohmann retractor from the anterolateral incision can usually help manipulate the medial calcar to close the medial gap, while a Schanz screw acts as a joystick, creating a counterforce pushing on the lateral cortex to close the gap. The Steinmann pin which is in proper alignment in AP and lateral views can be used as a guide for definitive fixation (Figure 4).

Anterior angulation of the fracture or the anterior gap is reduced by using a blunt raspatorium or cobb pressing on the anterior cortex of the proximal fragment. Then the "ready-to-go pins" are advanced forward through the femoral neck into the femoral head. The quality of the reduction is checked with C-arm images in both AP and lateral views (Figure 5) (10, 11).

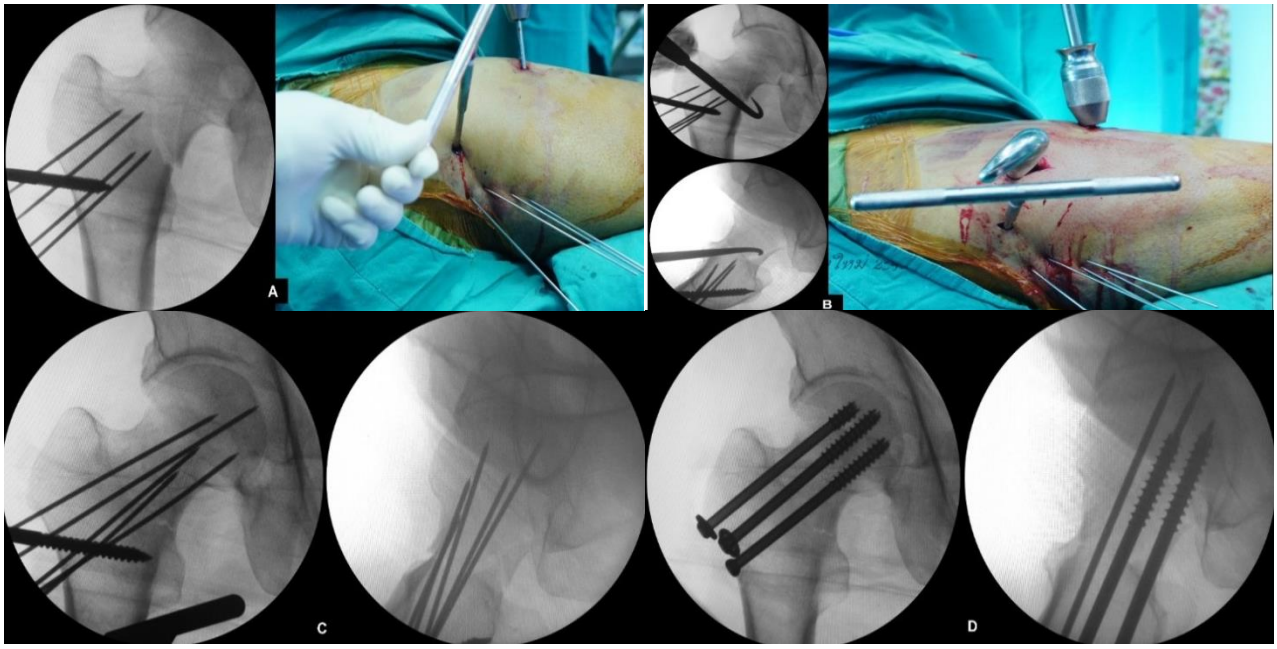

Figure 4. Intraoperative radiograph and image of a "ready to go pin" before reduction (A), reduction of the femoral neck using a bone hook with intraoperative anteroposterior (AP) and lateral radiographs (B), intraoperative AP and lateral radiographs showing temporary multiple pin fixation after closed reduction (C), AP and lateral radiographs showing cannulated screw fixation with reversed triangular configuration (D)

Open Reduction: The decision for open reduction of a femoral neck fracture in young adults varies according to the level of experience of the surgeon, with less experienced surgeons more frequently opting for closed reduction. Multiple attempts to close or manipulate a reduction may result in more soft tissue dissection and a potential insult to the blood supply of the femoral head. It is possible to perform closed reduction of the comminuted or totally displaced fracture, but the success rate is generally very low. If the reduction is not achieved, then the procedure for open reduction must be done. A more anatomical reduction reduces the risk of healing complications and leads to high union rates and a low incidence of implant failure (12, 13).

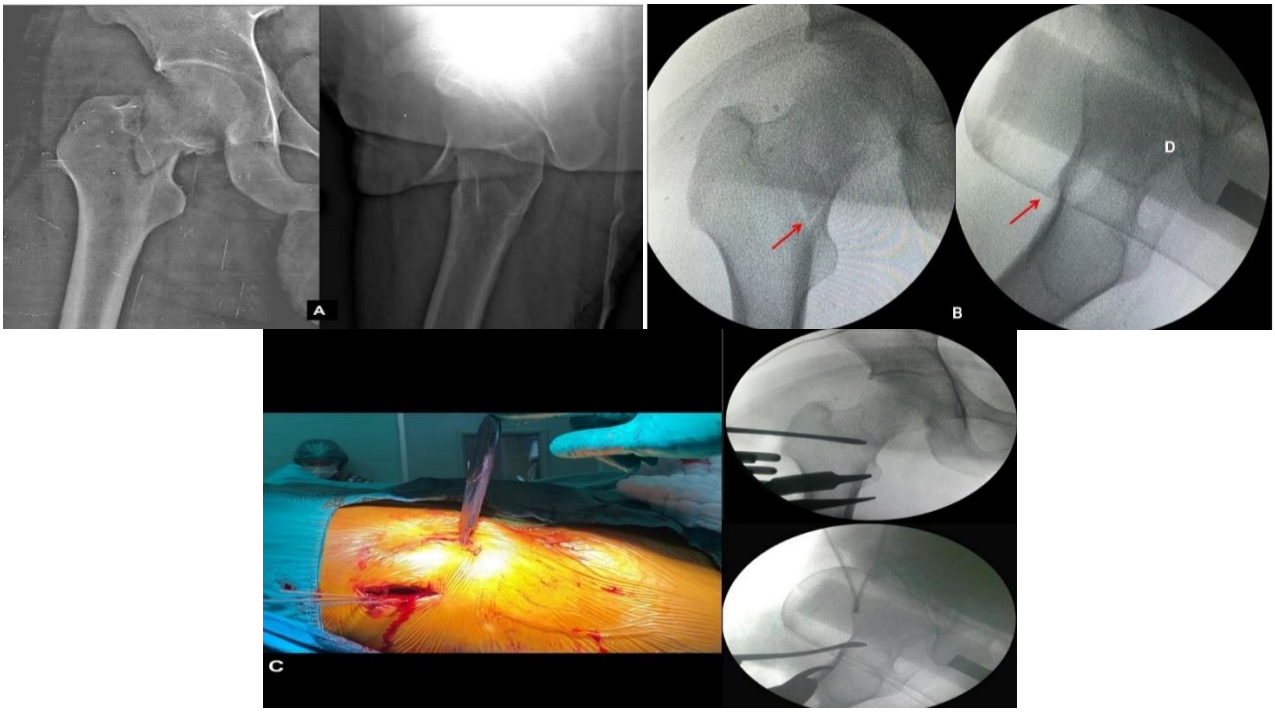

Figure 5. Anteroposterior (AP) and lateral radiographs showing a femoral neck fracture with anterior displacement (A), intraoperative AP and lateral radiographs showing anterior displacement of the femoral neck (arrow) (B), AP and lateral radiographs after fixation with sliding hip screw and anti-rotation screw (C), percutaneous reduction with blunt periosteal elevator with perfect reduction (D)

Two approaches for direct open reduction are the Watson-Jones anterolateral approach and the Smith-Petersen direct anterior approach. Each approach has different advantages and disadvantages. Lichstein et al. compared the area of the exposed femoral neck with the Watson-Jones and the modified Smith-Petersen approaches in terms of the ability to visualize and/or palpate important anatomical landmarks of the proximal femur using ten fresh-frozen human specimens. They concluded that the modified Smith-Petersen approach, with or without rectus femoris tenotomy, provided superior exposure of the femoral neck and articular surface, both by visualization and palpation of the important proximal femoral anatomic landmarks, compared to the Watson-Jones approach (14).

Singh et al. similarly reported that the modified Smith-Petersen approach in terms of optimal visualization and access to clinically relevant femoral neck anatomical landmarks was superior to the Hueter and Watson-Jones approach (15). However, Patterson et al. described a retrospective study of the quality of reduction based on AP and lateral radiographic outcomes in 32 patients with the modified Smith-Petersen versus 48 patients with the Watson-Jones approach. There was no difference in the quality of reduction in radiographic outcomes between these two approaches when performed by orthopedic trauma surgeons (16). Surgeons should select the approach according to the location of the fracture, fracture configuration, selected implant, and the individual surgeon's preferences.

Modified Smith-Petersen Approach: The incision with the standard Smith-Petersen approach starts from the anterior third of the ilium, passing the anterior superior iliac spine (ASIS) parallel to the palpable interval between the sartorius and the tensor fascia lata. That is the true intermuscular and inter-nervous plane of dissection which can be accomplished without cutting any muscle or tendon. The modified Smith-Petersen approach utilizes a 12 cm straight cut from the ASIS running downward distally. There are some variations of the modified Smith-Petersen approach. For example, Molnar and Routt described an approach and dissection to identify the lateral femoral cutaneous nerve (LFCN) in the superficial fascial layer (17). However, this dissection is not easy to do because of the subcutaneous location of the LFCN. Even if the nerve can be identified and tagged with a vascular loop, retraction of the nerve during surgery may endanger the nerve.

Blair et al. described it as a 12 cm incision in a lateral trajectory, in line with the lateral edge of the patella and centered over the tensor fascia lata muscle belly (18). This is almost the same as what Paillard (19) described as a minimal incision anterior approach for total hip replacement which starts from a point 2 cm lateral and 1 cm distal to the ASIS extending to the head of the fibula and presently is known as the direct anterior approach for hip replacement (Figure 6).

The incision over the tensor fascia lata is slightly lateral to the tensor fascia lata and the sartorius interval, opening the fascia over the tensor fascia lata and with deep dissection down to the subfascial plane using blunt finger dissection. The LFCN lies medially and superficially to the fascia, thus making the nerve less vulnerable (20).

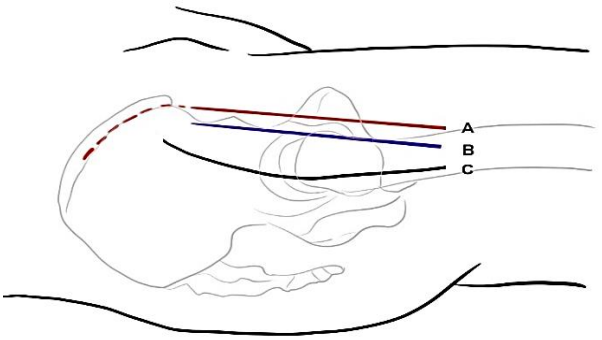

Figure 6. Incision using the original Smith-Petersen approach with the dotted line, modified Smith-Petersen approach with only the straight part below the anterior superior iliac spine (A), the modified Smith-Petersen approach with slightly lateral incision (direct anterior approach or DAA) (B), and the Watson-Jones approach (C)

Two retractors are used to displace the tensor fascia lata laterally and the sartorius medially. The innominate aponeurosis is located immediately on the deeper surface of the tensor fascia lata. Beneath this aponeurosis, the anterior circumflex vessels are identified. The ascending branches of the lateral femoral circumflex artery should be preserved. When the transverse branches are identified, they can be either tied off or coagulated. The reflected tendon of the rectus femoris is either incised or preserved. The tension of the rectus femoris may reduce anterior exposure. Flexion of the hip and the knee is usually enough to reduce the tension of the rectus femoris without tenotomy. The rectus femoris tendon is retracted medially, and the anterior capsule of the hip is exposed, followed by an oblique T-shaped capsulotomy. The upper limb of the oblique capsulotomy parallels and spares the anterior acetabular labrum. The caudal limb of the capsulotomy parallels the normal femoral neck orientation. The Hohmann retractor on the posterior aspect of the femoral neck should be placed carefully because it could potentially endanger the femoral head blood supply. After cleaning the fracture site, the fracture is manipulated under direct vision using the joystick, Schanz screw, Steinmann pin, or bone holding clamp (Figure 7).

The bone defects resulting from impaction can be supported with bone graft. The perfect reduction of the fragments is confirmed both visually and radiographically. However, an additional lateral approach for implant placement is needed for cannulated screws or a sliding hip screw (17). For fractures with medial cortex comminution or those with Pauwels type III that need a medial or anteromedial buttress plate, it is possible to achieve fixation with this approach by flexion and external rotation of the hip following preliminary fixation (21).

Watson-Jones: With the Watson-Jones approach, the patient lies in the supine position. An incision is made 2.5 cm posterior and distal to the ASIS and is carried down distally over the posterior third of the greater trochanter to the shaft of the femur for a total of 12 cm (Figure 6). The fascia lata is incised over the greater trochanter and a deep dissection is made between the plane of the tensor facia lata and the gluteus medius. This approach also involves either partial or complete detachment of the abductor mechanism. The fascia lata and the tensor fascia lata muscle are retracted anteriorly and the gluteus medius is retracted posteriorly, revealing the gluteus medius and branches of the superior gluteal artery which cross this interval.

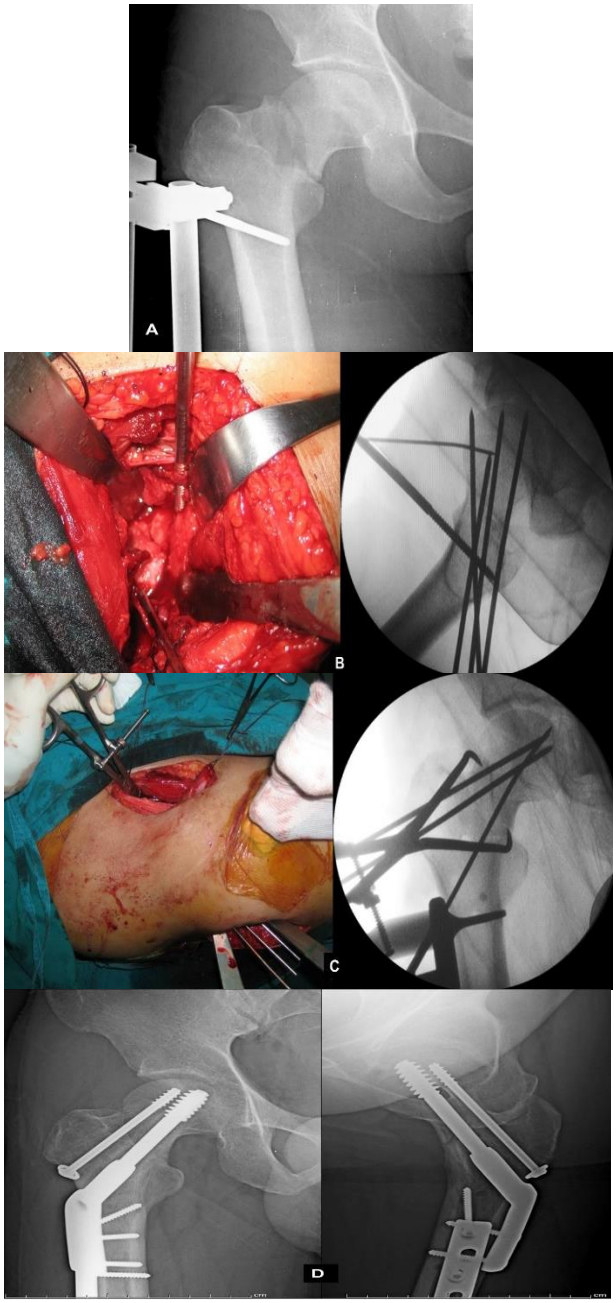

Figure 7. Radiograph of a vertical femoral neck fracture Pauwels type 3 (A), open reduction internal fixation by application of the joystick and Weber clamp using the modified Smith-Petersen approach (B), temporary pins fixation from a separate lateral incision (C), anteroposterior (AP) and lateral radiographs of the final fixation with sliding hip screw and anti-rotation screw (D)

These vessels should be carefully preserved and should be ligated when necessary. The fatty layer over the anterior hip capsule is uncovered, exposing the anterior hip capsule. The hip is slightly flexed to relax the rectus femoris. For wider exposure at the base of the femoral neck, detachment of the anterior third of the gluteus medius is recommended. A T-shaped capsulotomy is performed, as well as retraction of the hip capsule to expose the femoral neck. The Watson-Jones approach visualizes the femoral neck from the lateral side or anterolateral view and requires more force to retract the tensor fascial lata medially. Comminuted fractures involving the medial calcar are more difficult to expose, especially the application of a bone reduction clamp to compress the fracture in the mediolateral direction. However, this approach allows fracture reduction and implant placement such as cannulated screws or a sliding hip screw through a single incision. A medial buttress plate is extremely difficult if not possible with this approach (14, 22).

Surgical Approaches Related to Implants: Most of the implants widely available today are inserted from the lateral cortex of the proximal femur, including partially threaded or fully threaded cannulated screws, a sliding hip screw with an anti-rotation screw, or a fixed-angle locking plate. Each of these implants can be fixed via a single incision using the Watson-Jones approach. Recently, some surgeons have suggested that small or mini plates on the anterior-inferior of the calcar can be used for preliminary reduction to maintain the length and rotation of the fracture (17, 23). Application of a medial buttress plate at the calcar also decreases the angular displacement and shear displacement in a Pauwels type III fracture. It can also shorten healing time, reduce postoperative complications, and improve the postoperative Harris score (24). With the advantages of the medial buttress or anterior-inferior reduction plate, the only approach that is recommended is the modified Smith-Petersen approach in which it is more convenient to apply the implant in abduction and external rotation position (25).

Conclusion

Femoral neck fractures in young patients need perfect reduction which can be achieved by closed reduction, minimally invasive percutaneous reduction, or open reduction. The modified Smith-Petersen approach is an anterior approach that provides direct access to the fracture on the anterior and medial aspect of the femoral neck for reduction and medial implant fixation; however, it does require an additional lateral approach for implant placement. The Watson-Jones approach is an anterolateral approach which can access the oblique view of the femoral neck and can use the same incision for lateral implant placement. Understanding the details of each approach will help the surgeon determine which is optimal for each patient.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgements

The author wishes to thank Dr. Apipop Krisaneepaiboon for providing the case as well as G. Lamar Robert, PhD, for reviewing the paper. The author thanks the patient for permission to publish the images.

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