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HIP FRACTURES IN ADULTS

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REVIEW ARTICLE

Stability and Principles of Osteosynthesis in Intertrochanteric Femur Fractures

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Abstract

Intertrochanteric femur fractures remain an important global health concern with rising numbers with an aging population. Determining the stability of the fracture is essential to choosing the appropriate implant for fixation of these fractures. To achieve a successful outcome, surgeons must consider the fracture pattern and choose a technique to obtain the reduction and an implant that will maintain reduction until bony union. This review examines how to determine the stability of intertrochanteric fractures and choose the optimal implant. In addition, we suggest technical tips for reduction and implant placement to reduce the risk of implant failure.

KEYWORDS

Hip Fractures; Femoral Fractures; Fracture Fixation, Intramedullary; Fracture Fixation, Internal; Bone Nails; Bone Screws; Fracture Dislocation; Biomechanical Phenomena

Introduction

Hip fractures remain a major global public health concern and are projected to double in number globally by 2050 as the population ages, particularly in developing countries.[1,2] Intertrochanteric fractures specifically account for a yearly economic burden of 2.63 billion to the United States health system, which represents 44% of the total economic burden of all hip fractures.[3] In anticipation of the aging population and resultant burden to the healthcare system, optimization of perioperative care, operative management, and post-fracture treatment and secondary prevention is crucial.

In contrast to femoral neck fractures, intertrochanteric fractures are extracapsular hip fractures composed of well-vascularized cancellous bone and therefore, have excellent healing potential and low risk for non-union and avascular necrosis.[1] Further, the fracture frequently involves the calcar and/or the greater tuberosity. For these reasons, internal fixation is preferred for the vast majority of intertrochanteric fractures across age groups.

DIAGNOSIS

Plain radiographs, including an anteroposterior (AP) pelvis and full-length femur films, are sufficient for diagnosis and treatment in nearly all cases. (Figure 1) Traction views may be a useful adjunct in cases of shortening to better delineate and classify the fracture for planning treatment. Advanced imaging, such as computed tomography (CT) or magnetic resonance imaging (MRI), may be considered if x-rays are

Figure 1 X-ray pelvis with both hips AP view showing right intertrochanteric fracture

negative but remains high suspicion for hip fracture based on history, or in the presence of an isolated greater tuberosity fracture.[4–6]

Timing to operating room

Delays to the operating room have been shown to affect mortality.[7] Surgical treatment allows for early mobilization, which is critical in reducing mortality after hip fracture. In one study, patients who did not ambulate within the first three days of surgery had significantly increased 30-day and 1-year mortality compared to those who did. This significant association persisted at 30 days even after accounting for age and comorbidities.[8] In another study, delay in ambulation resulted in increased 6-month mortality and reduced function at two months.[9]

Determining stability of intertrochanteric fracture

Stability of the fracture dictates the choice of surgical treatment and broadly refers to the degree to which the fracture will share load during weight bearing. In stable fracture, the load of weight bearing actually compresses the fracture and improves fracture healing. Conversely, unstable fractures are more susceptible to collapse under load-bearing conditions without the appropriate fixation.

The concept of stability was first introduced by Evans[10] in 1949, in which intertrochanteric fractures were subdivided into two major types. (Figure 2) Type 1 fractures, which were parallel to the trochanters, were composed of two stable patterns: 1) nondisplaced, or 2) displaced but with an intact inner cortical buttress after reduction. The following two unstable patterns were described as: 1) displaced but with an inner cortical buttress that remains in discontinuity after reduction, or 2) comminution, both resulting in cox vara deformity. Type 2 fractures were composed of reverse obliquity patterns that were inherently unstable due to an incompetent lateral cortex. These fractures are prone to medialization of the femoral shaft. Therefore, stability classification was determined based on the integrity of the calcar femorale and the lateral cortex.[11]

Jensen[12] later modified the Evans classification system based on the number of fragments: (1) stable patterns, which include two-part fragments (nondisplaced versus displaced), and (2) unstable patterns, which include three-fragment fractures with disruption of the posterolateral or medial cortex, and four-fragment fractures.[12] It was concluded that this system provides the most reliable prediction of reduction instability and secondary fracture dislocation.

The AO/OTA classification system categorizes fractures into three groups, each with its respective subgroups: A1) simple fractures along the intertrochanteric line, A2) comminuted fractures with a posteromedial cortex fragment but intact lateral cortex, A3) reverse obliquity, transverse, and fractures with subtrochanteric extension. (Figure 3) 31-A1.1-3 and 31-A2.1 are considered stable patterns, whereas multi-fragmentary patterns with more than one intermediate fragment in the A2 group and all A3 patterns are considered unstable.[13] The AO classification system has been shown to have almost perfect agreement among experienced surgeons.[14] The newest version has significantly better inter-observer agreement than the original, as well as better agreement in distinguishing stable from unstable fracture patterns.[15]

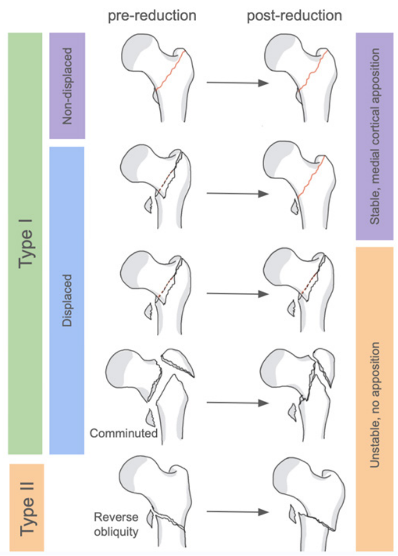

Figure 2 Evan's Classification

Treatment options

Historically, the treatment of intertrochanteric fractures commonly included conservative management with continuous traction, requiring prolonged immobilization. However, average mortality rates were as high as 38% due to secondary medical complications associated with immobilization, such as pneumonia, delirium, and decubitus ulcers. Conversely, surgical management with a contemporary nail-plate construct allowed for early mobilization, greater comfort, and improved resource utilization, resulting in decrease in mortality to 18%.[10] As a result, the benefits of surgical management as the mainstay treatment became increasingly apparent.[10,11,16]

In current practice, virtually all intertrochanteric fractures are treated surgically, unless an extenuating condition, such as resource limitation or medical instability, precludes operative management. The question now is whether one implant is better than another for select fracture patterns, which remains a controversial and active area of research. Modern classification systems build on the initial concepts of stability; however, they are more granular in their ability to guide and influence prognosis and the appropriate choice of implant.

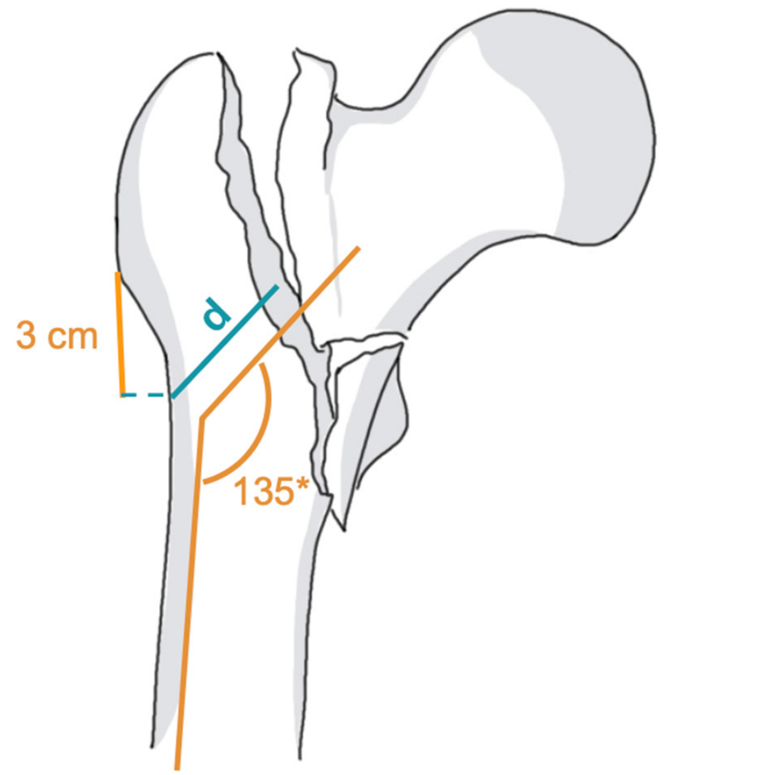

Figure 4 Measurement for lateral wall thickness. Thickness (d) less than 20.5mm predicts lateral wall failure and poor outcomes with a sliding hip screw without trochanteric stabilizing plate

Fixation methods for intertrochanteric fractures include extramedullary and intramedullary devices. Sliding hip screw and plate constructs (SHS) are generally used to treat stable fractures (A1).

Intramedullary nails (IMN) are typically used to treat unstable fractures (A3). IMNs include short and long cephalomedullary nails,[17,18] as well as constructs adapted for low-resource settings, such as the SIGN nail.[19]

The choice of implant for A2 fractures remains equivocal and controversial, and depends on the severity of posteromedial comminution. While some studies have shown SHSs are acceptable for select A2 fractures (31-A2.1), others have advocated for IMN usage in all A2 fractures.[20] A trochanteric stabilizing plate (TSP) may be used with SHS for A2 fractures with a thin lateral wall cortex to mitigate the risk of postoperative lateral wall fracture and reoperation, and decrease sliding screw distance.[21]

Integrity of the lateral wall cortex is a significant risk factor for reoperation.[22] A disrupted lateral wall makes an intertrochanteric fracture a reverse oblique equivalent.[23] A lateral wall thickness (Figure 4) of less than 20.5 mm has been associated with

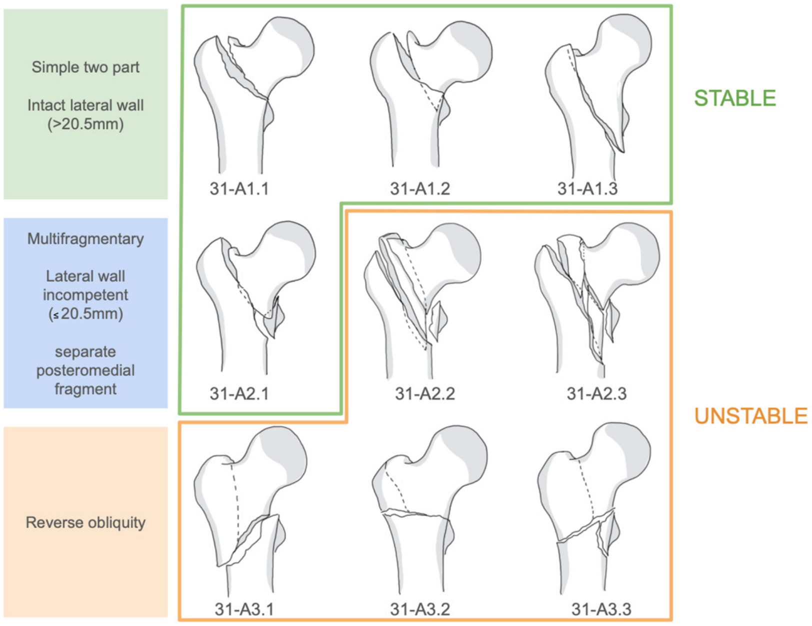

Figure 3 AO/OTA Classification

increased risk of intraoperative lateral wall fracture, and SHS is not sufficient in these circumstances without the added trochanteric stabilizing plate.[24]
Historically, pooled studies have shown equivalent rates of functional outcomes, mortality, and medical complications between extramedullary and intramedullary methods; however, IMN use has been associated with increased risk of perioperative fracture.[25] In a recent systematic review across 76 RCTs and over 10,000 patients, IMNs were associated with decreased risk of non-union and infection; however, increased risk of perioperative fracture, which was not reduced with newer designs on subanalysis.[26] Nonetheless, IMNs are advantageous for unstable fractures, mechanically serving as a buttress against femoral medialization, particularly when the integrity of the lateral wall cortex is compromised.[27] IMNs have been shown to tolerate more load-bearing with increasing instability and varus malreduction, compared to extramedullary fixation.[28,29]
Furthermore, a meta-analysis of 17 RCTs showed IMN use for unstable 31-A2.2-A3 fractures resulted in a lower incidence of implant failure and reoperation, as well as better postoperative hip mobility recovery compared to extramedullary fixation.[30] Two more recent RCTs of patients with A1 and A2 fractures found similar functional outcomes between both methods of fixation;[31,32] however, a sub-analysis of patients with high preinjury functional status and A2 (3 or 4-part fractures) revealed worse functional scores and increased shortening in patients treated with SHS compared to IMN.[31] Another RCT of unstable fractures found a return to preoperative functional state at 1 year (EQ-5D scores) that was not achieved in the extramedullary device group.[33] While rates of general adverse surgical events between treatment methods were similar, IMN fixation has additionally been associated with reduced postoperative length of stay comparatively.[34]

Important fixation principles

In 1980, Kaufer[35] identified five variables that determine the mechanical stability of the fixation used for intertrochanteric fractures: two patient factors of:
(1) bone quality and
(2) fracture geometry
and three surgeon-controlled factors of :
(3) reduction,
(4) implant choice, and
(5) implant placement.
The major modes of fixation failure are cut-out and excessive shortening or collapse. Cutout occurs when the lag screw in the SHS or IMN perforates the femoral head subchondral bone and enters the acetabulum, which commonly leads to rapid progression of hip arthritis. Cutout most commonly occurs through the anterior superior femoral head with associated varus displacement of the neck-head segment.[36] The failure occurs at the bone-implant interface at the tip of the lag screw. Poor bone quality and posteromedial comminution combined with poor reduction and implant placement are the major predictors of this mode of failure. In the majority of cases the salvage solution is total hip arthroplasty due to the damage to the hip cartilage.
Shortening occurs when there is excessive collapse through the fracture after fixation accompanied by relative medialization of the femoral shaft. The major factor in this mode of failure is an incompetent lateral wall that is not addressed by the choice of implant. Because the lateral wall is incompetent, there is nothing to prevent continued collapse of the fracture along the lag screw. An IMN can effectively replace the lateral wall in these cases, or if unavailable, a SHS augmented by the TSP can be used. In severe cases, shortening may lead to catastrophic implant failure and nonunion requiring reoperation. Less severe cases may still lead to malunion with associated pain due to altered hip biomechanics from a shortened leg length and abduction lever arm.[37]

Reduction

The quality of the reduction has been identified as one of the most important modifiable variables to a good outcome for fixation in intertrochanteric femur fractures.[20,35,38–40] Both the SHS and the IMN are designed for controlled collapse by allowing the lag screw to slide through the side plate or nail, respectively. This creates compression at the fracture site during weight bearing allowing the fracture to share the load and lessen stress on the bone-implant interface at the tip of the lag screw.
An anatomic reduction optimizes the amount of cortical bone contact and increases fracture load sharing. In addition, varus alignment can worsen biomechanics leading to increased load on the implant.[20,39] Jiamton et al.[38] found that reduction of varus more than 10 degrees was one of the major factors leading to further varus displacement and cutout. In another study, poor fracture reduction led to a 5.2-fold increase in the odds of cutout.[40] In Yoon et al's[41] study, 40% of the cases without an acceptable reduction required a revision surgery.
Implants have been shown to bear more load with a varus malreduction[20,28] and loss of medial cortical buttress.[29] For unstable fractures in particular, the anterior cortex often fails in tension with compression failure and comminution to the posteromedial cortex.[39] This combination leads to the characteristic shortening and external rotation of the distal shaft segment with varus deformity and posterior translation of the head neck segment into the area of comminution.[39] Given these known areas of comminution, often the remaining area of cortical stable bone is the anterior and medial aspect of the fracture. Carr et al.[39] recommend using the reduction of the anterior and medial cortex to get the most stable reduction. Similarly, the Ikuta classification of reduction is based on the reduction of the anterior femoral neck, recommending the achievement of subtype A or subtype N.[42,43]

Technical tips for obtaining & maintaining good reduction

Table choice can be the first way to help one obtain a good reduction. Both the fracture table as well as a flat radiolucent table can be used. (Figure 5 and 6)The reduction can be obtained and held using the traction boot on the fracture table or using skeletal traction on a radiolucent table. It is first recommended to attempt a closed reduction. External rotation, followed by traction and then internal rotation is the often successful. Abduction or adduction of the leg can help change the neck shaft angle.[39] If closed reduction is unable to provide an anatomic reduction, a percutaneous or open reduction can be performed. Some reduction aides include using a bone hook from a small lateral approach or percutaneous incision to lateralize the shaft or head/neck segment.[39,41] To correct translation or angular deformity in the sagittal plane, a ball-spike or AO elevator can be used through a small anterior incision with downward force or a crutch, homan or cobb elevator can be used posteriorly to provide an upward pressure.[39,41] If an open approach is required, a Watson-Jones approach through the interval between the gluteus medius and TFL is gives excellent access for both reduction and implant placement. A point-to-point clamp or a collinear clamp are useful options to aid in reduction with an open approach.[41]

If using fluoroscopy, the most accurate location to assess reduction is the anterior cortex on the lateral view and the medial cortex on the AP view.[39,41] Yoon et al.[41] laid out 3 criteria to judge a reduction intraoperatively:

Continuity of the anterior and medial cortical lines in both AP and lateral views

Restoration of the neck-shaft angle with a horizontal line from the greater trochanter tip passing through the center of the femoral head

Restoration of the anteversion with extension of the anterior cortical line drawn from the shaft passing through the center of the femoral head.

To maintain the reduction throughout the procedure, wires can be used provisionally to hold the reduction. One must be mindful of placing these wires either anterior or posterior to the predicted pathway of the implant chosen, which can be particularly challenging with an IMN.

Each implant has specific pitfalls leading to loss of reduction during implant insertion. For the SHS, malrotation may occur during the screw insertion due to the large size of the lag screw. This is classically a larger problem on left-sided intertrochanteric fractures where the clockwise turn of the lag screw exacerbates the typical apex anterior deformity. In contrast, in right sided fractures the rotation tends to compress the anterior cortex and improve stability of the construct. Malrotation during lag screw insertion can be prevented by tapping for the screw and using additional anti-rotational k-wires.[39]

For the IMN, loss of reduction most commonly occurs during the insertion of the nail. This phenomenon, known as the "wedge effect" as first described by O'Malley[44], occurs when the entry hole is inadequate or in the incorrect location. The most common pitfalls are the entry reamer enters the fracture site rather than creating a hole. (Figure 7) When the nail is inserted, rather than entering the entry hole it displaces the fracture, which causes varus malalignment and lateralization of the shaft segment from the head/

Figure 5 Positioning on a fracture table. The reduction is performed unsterile prior to prep. The table with fracture boot maintains the leg position and reduction during implant placement.

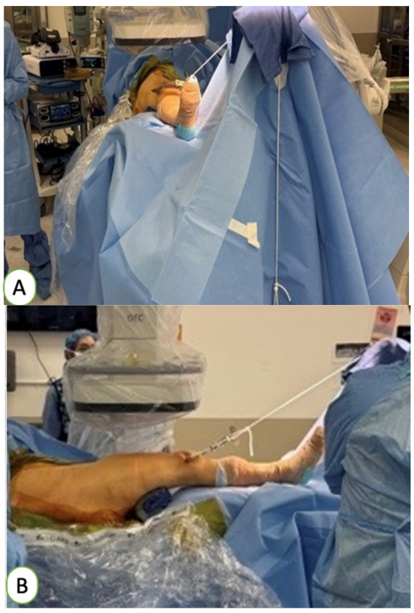

Figure 6 A/B The patient can be positioned on a standard radiolucent table with traction hanging over the end of the bed. In this technique, the reduction is performed after the limb is prepped and draped.

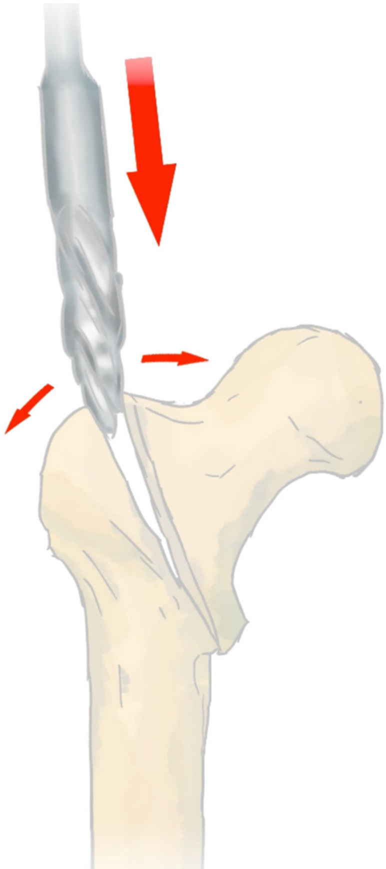

Figure 7 The “wedge effect” commonly occurs due to the reamer entering the fracture rather than cutting an entry hole. When this occurs, the nail will cause the same displacement as it enters the fracture.

neck segment.[44,45] Even if the reamer does make a hole, the tendency is for the reamer to fall laterally into the bone of the greater trochanter, which is less dense than the superior femoral neck. As the nail is inserted the proximal body pushes against the intact femoral neck, which again results in a medial and varus displacement of the proximal segment.[45] Some of the suggestions by Butler et al.[45] to prevent “wedge-effect” include passing reamers carefully to prevent lateralization, the use of a reduction clamp to hold the fracture reduced, medialization of the start point, and to use a cannulated drill or trephinated reamer to get the starting hole. If a wedge effect occurs, the nail can be removed, and additional reaming over a long-ball tip guidewire to medialize the start site is often effective.

Another important aspect to consider is the starting point for a nail can have a major effect on maintaining the reduction. For trochanteric intramedullary nailing, too lateral of a starting point can lead to varus malreduction and possible subsequent fixation failure.[46] Ostrum et al.'s[47] cadaveric study showed that a lateral start point lead to varus alignment for a variety of nails with an average range of 4 to 8* of varus.

This study also found that a neutral start point lead to an average range of 0 to 2* of varus and a more medial start point lead to an average of 3.2 to 8.8* of valgus. The authors recommended the tip of the trochanter or even medial to the tip as the ideal start site and entry hole after reaming for nails. It may also be important to look at a patient's native greater trochanter and proximal femur anatomy as the ideal entry point may differ between patients.[48]

Implant choice

The second modifiable variable identified by Kaufer[35] was implant choice. As described above, differentiating between stable and unstable intertrochanteric femur fractures is crucial for choosing between an SHS and an IMN construct. In short, most authors recommend that an intramedullary device is used for fractures that involve large posteromedial fragments, involvement of the lateral cortex such as reverse obliquity fractures or those with subtrochanteric extension, and fractures with multiple fragments of the lateral wall of the greater trochanter.[49] There are also specific decisions to be made regarding the different implants options that may impact stability.

SHS implant options

SHS plate length

Historically, the 4-hole SHS was the most commonly used implant, however more surgeons are advocating for the use of the 2-hole plate due to decreased operative time, surgical dissection, blood loss and postoperative pain.[49] Soni et al's[50] systemic review of 15 different articles found that biomechanical studies show the 4-hole SHS has better load to failure, cyclical loading, and lower stress seen at the distal hole, however there is clinically no difference in healing time, failure or infection rates, radiation exposure, analgesic consumption, or hospital stay. This study did find that there was lower blood loss and shorter operating times for the 2-hole plate.[50] For OTA 31-A1, the 2-hole plate is recommended.[49]

SHS blade plate angle

For intertrochanteric femur fractures, there is some evidence comparing the 130^0 SHS to the 135^0 SHS. Studies have compared the two devices and their impact on achieving the desired tip-to-apex distance (TAD) of < 25mm, a known factor in preventing cutout and implant failure. TAD, as first described by Baumgaertner et al.,[36] is calculated as the sum of the distance between the tip of the lag screw and the apex of the femoral head on both the AP and lateral radiograph. The specifics of TAD will be discussed more in depth in a separate section. These studies showed that the 130^0 SHS often was able to achieve a significantly lower TAD compared to the 135^0, resulting in fewer cutout implant failures.[51,52] The authors of these studies suggest that the 130^0 plate more closely matches the "normal" proximal femur anatomy and allows for a more optimal trajectory of the screw to achieve the desired TAD.[51] The 135^0 device often requires the lag screw to be placed more inferiorly in the femoral neck to be centralized in the femoral head.[52] The more obtuse angle may also mean that the fracture line is not as perpendicular to the lag screw, leading to less reliable fracture compression.[52]

Lateral trochanteric stabilizing plate

In cases where the lateral wall is incompetent or at risk of fracture due to a thickness <20.5mm, the use of a trochanteric stabilizing plate (TSP) is recommended to prevent excessive collapse. The use of a lateral trochanteric stabilizing plate is able to limit the amount of lateral displacement and is comparable clinically and biomechanically to the use of an IMN.[37,53] Of note, the TSP requires using a minimum 4-hole side plate, which requires a larger incision and dissection compared to a 2-hole side plate.

IMN implant options

Short versus long IMN

One of the major downsides of a short IMN ending in the diaphysis is a higher rate fracture at the tip of the nail compared to a long IMN. Historically, the short IMN was more rigid due to being made with stainless steel and caused more of a stress riser at the tip due to the shape and location of the interlocking screw near the tip of the implant. Modern implants are made with more flexible titanium and have a tapered end with the interlocking screw further from the tip.[18] With these modifications, more recent studies show no difference in periprosthetic fracture comparing short and long nails.[18,54,55] Short nails have been shown to have lower rates of blood loss and transfusion along with lower costs and shorter operative time. Studies have also found no difference in reoperation rates, infection, fracture healing, avascular necrosis, or hardware failure for intertrochanteric fractures with up to 3cm of subtrochanteric extension.[18,54,55] Special circumstances that may favor a long nail include patients with pathological fractures or those with subtrochanteric extension greater than 3cm. Pathologic fractures due to tumor often will form additional lesions in the bone and hence it is advised to protect as much of the bone as possible.[55]
One unique complication of the long nail to consider is anterior cortical abutment and perforation. Horwitz et al.'s[55] review offers multiple recommendations to prevent this complication including ordering full-length femur films pre-operatively for all patients to assess femoral bow, avoid eccentric reaming and a posterior starting point, use shorter and smaller nails on patients with more bowed femurs. Additionally, they recommend accepting only a central or slightly posterior position of the guidewire when placed into the distal femur.[55] To reduce the risk of anterior perforation, modern long nails are designed with greater radius of curvature, typically 1-1.5 meters, compared to early designs with up to 3m bow.

Helical blade versus Lag screw

Some studies suggest that the advantage of the helical blade is that it has a larger bone-implant interface in comparison to the lag screw and greater resistance to torsional and translational displacement. However, given this biomechanical advantage, the clinical studies suggest there is no difference in cutout, complications, postoperative function, or fracture reduction.[20,56] The unique complication that can occur with the helical blade is "cut-through" where there is central perforation and migration of the helical blade through the femoral head[20,57,58] With "cut-through", there is no varus displacement or rotation of the femoral head in relationship to the femoral shaft. The recommendation given to prevent this complication is to avoid pre-drilling into the femoral head and to have at least 10mm of distance from the tip to the femoral head joint surface. [20,57]

Two versus one lag screw

There have been no major clinical differences noted with two versus one screw, however dual-lag screws can have the complication of "Z-effect" or "reverse Z-effect" where there is differential sliding between the screws. In the classic "Z-effect", there is more collapse of the inferior screw leading to varus alignment. In severe cases this can lead to perforation of the femoral head by the superior screw.[59–61] This effect is noted in the postoperative period with weight bearing and the etiology is still unknown.[60]

Implant placement

Implant placement is a critical variable that surgeons can control. Below are some of the factors that can during implant insertion to optimize outcomes:

Tip-Apex Distance (TAD)

Tip-apex distance (TAD), first described by Baumgaertner[36] in 1995, is one of the most important aspects of implant placement that can prevent cutout and implant failure. TAD is the standardized sum of the distance from the tip of the implant to the femoral head apex in both the AP and lateral imaging. (Figure 8) Baumgaertner found a direct relationship between an increased TAD and cut-out, using a TAD of less than 25 as their cut-off to prevent cutout.[36] Multiple studies have found that the TAD is still one of the most important factors dictating risk of cutout.[38,40,62–64] Caruso et al.[62] found a different cutoff of TAD > 30.7mm with a 4.51 times greater risk of cutout above that threshold. Kuzyk

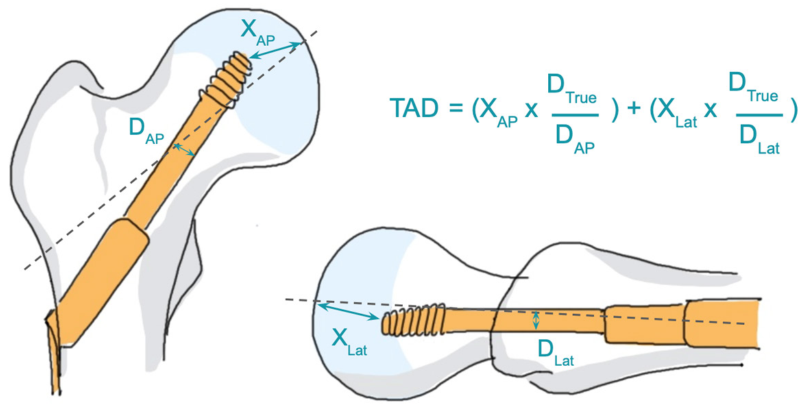

Figure 8 Tip-apex distance is calculated by measuring the distance from the tip of the implant and the center of the femoral head on AP and lateral views.

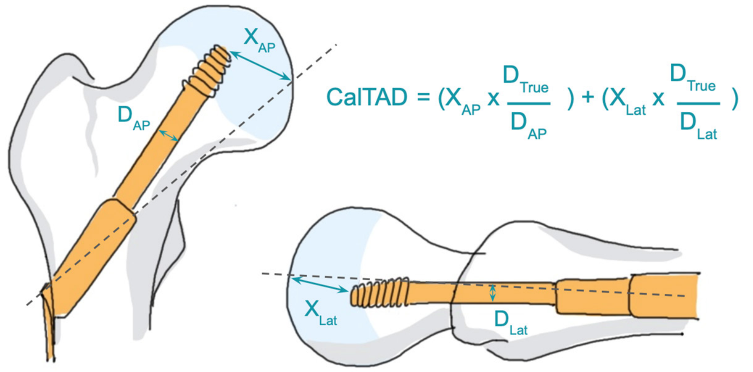

Figure 9 Calcar Tip-apex Distance (CalTAD) is calculated by measuring from a line along the calcar and favors more inferior screw placement compared to the standard TAD.

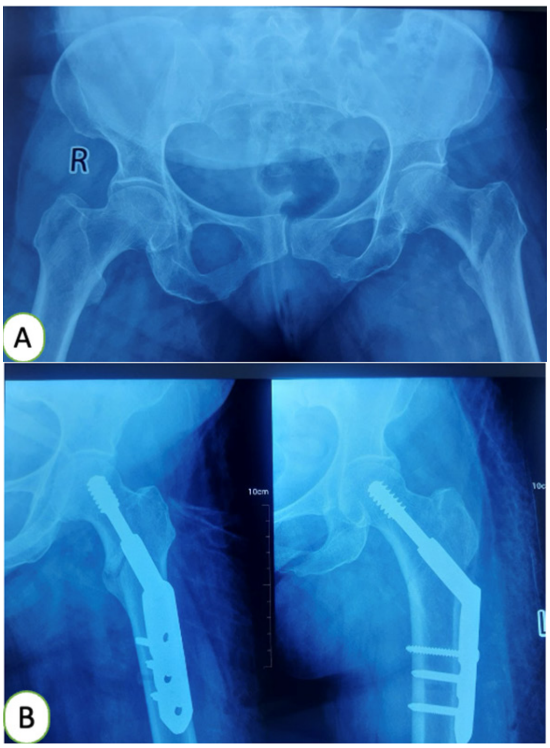

Figure 10 A/B Patient with stable left intertrochanteric fracture treated with 3-hole 135º DHS

et al.[65] introduced a calcar-referenced TAD (CalTAD) which only differed in the AP measurement by using a calcar reference line instead of the head apex line. (Figure 9) Caruso et al.[62] found that the CalTAD was highly predictive for cutout using the cutoff of 37.3mm with a 4.85 greater risk of cutout above that threshold. Kashigar et al's[64] and Caruso et al's[62] study both found TAD and CalTAD to be highly predictive of implant cutout for IMN.

Lag screw location in the femoral head

Another important aspect of implant position is the ideal location of the screw in the head. The Cleveland system divides the femoral head into 9 zones with three zones going anterior to posterior and another three zones when moving superior to inferior.[62,66] Generally, the screw should be centered on the sagittal plane and either centered or inferior on the AP view. Baumgaertner's original paper[36] found that cutout was highest in the peripheral zones of posteroinferior and anterosuperior. Similarly, Caruso et al.[62] found that any superior lag screw tip positioning had the highest risk with an odds ratio of 8.58 for cutout compared to a center-center screw. De Brujin et al.[40] recommended the optimal positioning is central on sagittal imaging and more inferior on AP imaging, however center-center or anteroinferior placement of the screw are also reasonable with minimal TAD. Kuzyk et al.[65] likewise recommended central-inferior placement since they found that an inferior position showed the highest axial and torsional stiffness. Kane et al.'s[67] biomechanics study similarly found that a center-inferior position with a TAD > 25 was similar in stability to a center-center placement with an optimal TAD < 25mm. (Figure 10 and 11)

Conclusion

Intertrochanteric femur fractures are an increasingly common injury with significant morbidity and mortality when not treated in a

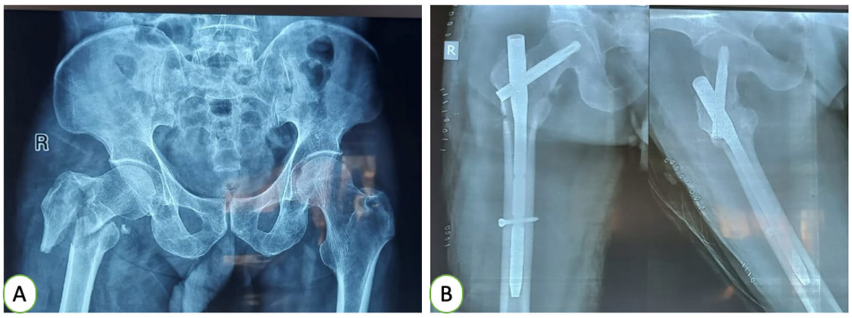

Figure 11 A/B Patient with unstable right intertrochanteric fracture treated with short PFNA

timely manner or with appropriate fixation. There are three modifiable factors to give patients an optimal outcome and prevent complications. These surgeon-controlled variables include obtaining and maintaining an anatomic reduction, choosing the appropriate implant for fixation, and ensuring adequate implant placement minimizing tip-apex distance (TAD).

Conflict of Interest

None

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