Treatment Update for Intertrochanteric Fractures

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ABSTRACT

Intertrochanteric fractures represent 50% of all proximal femur fractures and their incidence is increasing due to the greater life expectancy of the population. Reduction and fixation with a proximal femoral nail is the treatment of choice. However, the failure of osteosynthesis generates an increase in morbidity and mortality, especially elderly patients. Numerous studies indicate that main factors of failure are related to errors in fracture reduction and incorrect implant placement. These errors can occur at different steps of the surgical technique: preoperative planning, patient positioning, visualization and reduction of the fracture; location of the entry point and positioning of the cephalic element (screw or plate). Therefore, based on the existing literature and the experience of more than 1000 intertrochanteric fractures treated with proximal femoral nails from April 2002 to May 2020, we set to describe possible errors during the surgical technique and provide a systematic guide to avoid them. **Conclusion:** Despite implant design improvements in recent years, the main factors that determine the final result of the fixation of intertrochanteric fractures are the quality of reduction and the correct positioning of the implant. Awareness of the different errors that may occur at each step of the surgical technique is essential to avoid them.

Key words: Intertrochanteric fracture; proximal femur nail; hip fracture.
Level of Evidence: V

Actualización del tratamiento de las fracturas intertrocantéricas

RESUMEN

Las fracturas intertrocantéricas representan el 50% de todas las fracturas del fémur proximal y su incidencia aumenta debido a la mayor expectativa de vida de la población. La reducción y fijación con un clavo de fémur proximal es el tratamiento de elección. Sin embargo, la falla de la osteosíntesis genera un aumento en la morbilidad y mortalidad, especialmente en el grupo de pacientes más añosos. Numerosos estudios señalan que los principales factores predictivos de falla están relacionados con errores de reducción de la fractura o con una incorrecta colocación del implante. Estos errores pueden ocurrir en distintas etapas de la técnica quirúrgica, como la planificación preoperatoria, la ubicación del paciente, la visualización y la reducción de la fractura, la ubicación del punto de ingreso y la colocación del clavo, y el posicionamiento del elemento (tornillo o lámina) cefálico. Por lo tanto, sobre la base de la bibliografía disponible y las más de 1000 fracturas intertrocantéricas tratadas con clavos de fémur proximal desde abril de 2002 hasta mayo de 2020, nos proponemos describir los posibles errores durante la técnica quirúrgica y ofrecer una guía sistematizada para evitarlos. **Conclusión:** A pesar del gran avance y desarrollo de implantes en los últimos años, los principales factores determinantes del resultado final de la fijación de las fracturas intertrocantéricas siguen siendo la calidad de la reducción y el correcto posicionamiento del implante. Conocer los diferentes errores que se pueden producir durante cada uno de los pasos de la técnica quirúrgica resulta indispensable para poder evitarlos.

Palabras clave: Fracturas intertrocantéricas; clavo de fémur proximal, fractura de cadera.
Nivel de Evidencia: V

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INTRODUCTION

Intertrochanteric fractures represent 50% of proximal femur fractures and their incidence is increasing due to the greater life expectancy of the population.[1] Reduction and fixation with a proximal femoral nail is the treatment of choice; however, the failure of osteosynthesis generates an increase in morbidity and mortality, especially in elderly patients.[2] Numerous studies indicate that the main predictive factors for failure are related to fracture reduction errors or incorrect implant placement.[3] These errors can occur at different stages of the surgical technique, such as preoperative planning, patient placement, fracture visualization and reduction, entry point location, nail placement, and cephalic element positioning (screw or plate).

Therefore, based on the available literature and our personal experience, we propose to update the concepts of the treatment of intertrochanteric fractures with intramedullary nails, as well as to describe possible errors during the surgical technique and to offer a systematic guide to avoid them.[4]

1. PREOPERATIVE PLANNING

The key aspects that should be anticipated during preoperative planning are: the cervico-diaphyseal angle of the femur, the diameter of the femoral canal and the presence of any deformity that may prevent implant placement. For this, it is essential to have an radiograph of both hips so as to evaluate the healthy contralateral proximal femur, as well as a complete radiograph of the affected femur. Occasionally, a traction radiograph of the proximal femur may facilitate the interpretation of the fracture pattern.[5]

In most cases, an implant with an angle of 130º will be adequate. Although in elderly patients, due to the loss of cortical thickness, the femoral canal is usually larger than that of young patients; occasionally, it may be necessary to ream the canal to insert the nail without subjecting the femur to forces that could generate an iatrogenic fracture.

2. POSITIONING OF THE PATIENT

Positioning the patient supine on a traction table is the most commonly used position. Although it requires extra time and is not free of perineal complications, it offers the advantages of facilitating a complete visualization of the proximal femur (especially in the profile) and the reduction and maintaining it throughout the procedure. The key points are: the correct fixation of the foot to the boot stirrup that guarantees an effective traction; careful padding of the perineal post to avoid injury to the pudendal nerve, vulva or scrotum[6] and, lastly, management of the contralateral lower limb. Regarding this last point, if the patient presents normal mobility of the contralateral hip, we prefer to abduct the limb to facilitate the visualization of the proximal femur in profile (Figure 1A). If the mobility of the contralateral hip is limited, we always adopt the "scissors" position, in both cases, exerting traction on the limb to counteract the traction generated on the affected leg and thus avoid the pelvic tilt (Figure 1B).

Another alternative is to position the patient supine on a common radiolucent table (Figure 1C). The main advantage is to keep the limb free, allowing mobility in all planes during the procedure; however, it requires manual traction by an extra assistant and makes viewing with the C-arm more difficult.

Figure 1. **A.** Supine decubitus position on the traction table with the contralateral limb abducted and tractioned. **B.** Supine decubitus position on the traction table with the contralateral limb in hip and knee extension (“scissors”). **C.** Dorsal decubitus position on a common table. An enhancement is placed under the affected limb to facilitate lateral vision with the C-arm.

3. VISUALIZATION OF THE PROXIMAL FEMUR

Correct visualization and optimal fracture reduction are closely related. The probability of poor reduction or improper implant placement is high if visualization is not correct.[7] The structures that must be clearly identified in both the frontal and profile views are: the femoral head and joint space, the femoral neck, both trochanters, and the proximal two-thirds of the femur. The true lateral view should consider the anteversion of the femoral neck. For this, the image intensifier beam should be located between 0 ° and 20 ° with respect to the horizontal plane until a straight line is drawn from the center of the head, parallel to the femoral neck and the femoral shaft (Figure 2).[7] Once the desired images are achieved, it is useful to make some marks on the floor to indicate the place where the C-arm should be repositioned after placing the fields (Figure 3).

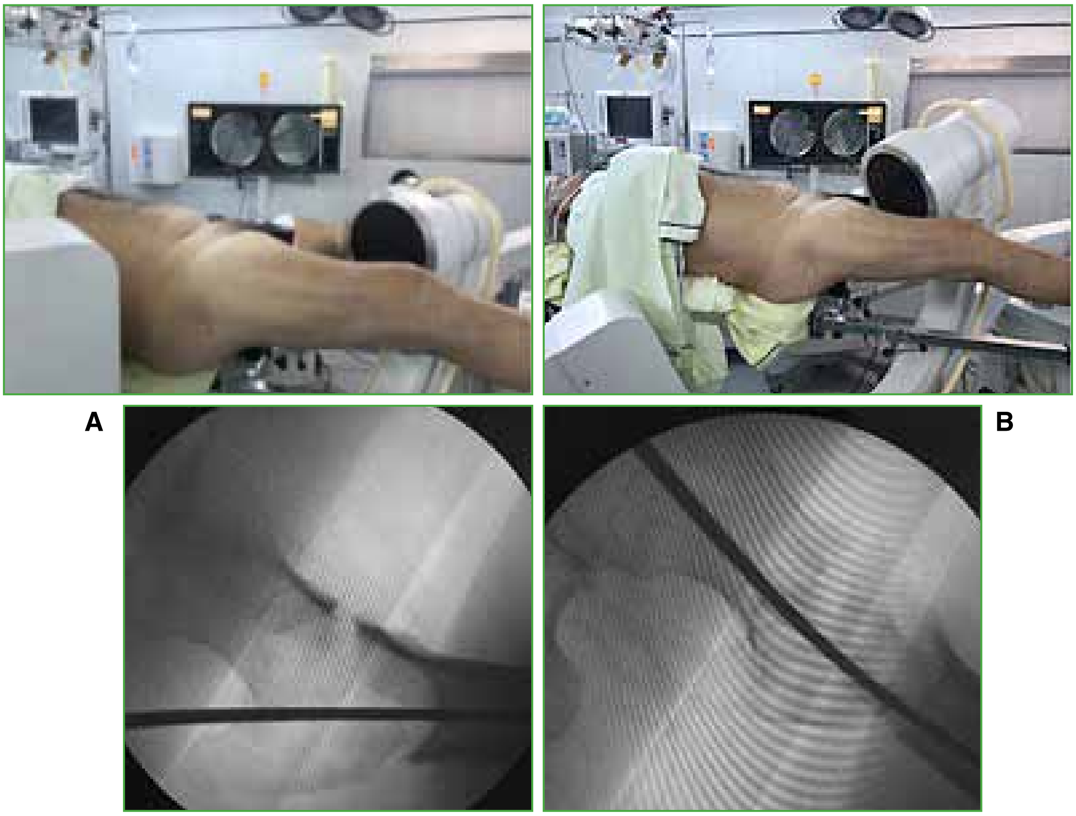

Figure 2. **A.** Lateral image of the proximal femur (C-arm at 180º) **B.** Lateral image contemplating the anteversion of the femoral neck (C-arm at 160º).

Figure 3. References on the floor to reposition the C-arm.

4. FRACTURE REDUCTION

In recent years, implants have undergone design improvements, but none are a substitute for a proper reduction technique. It is worth noting that, while many articles emphasize the importance of the quality of the reduction as the main predictor of failure, few actually describe the reduction technique. In 2020, Yoon et al. reported that, in more than 50% of the 322 intertrochanteric fractures analyzed, closed reduction was insufficient and required percutaneous reduction efforts to achieve optimal reduction.[8]

a. Coronal plane reduction

While it is true that the internal rotation traction maneuver generally results in adequate reduction; on some occasions, especially in unstable patterns, it may be insufficient. Ottolenghi et al. warned about some intertrochanteric fractures, which they classified as "extradigital", because they maintained the insertion of the external rotator muscles, which require external rotation of the diaphyseal fragment for their reduction.[9] If, after traction on the axis and the internal or external rotation maneuver, the desired cervico-diaphyseal angle is not achieved, a slight abduction of the limb can help. It should be anticipated that the position of the abducted leg may make it difficult to locate the nail entry point correctly. For this reason, in these situations it is advisable to temporarily fixate the fracture with pins so that the leg can then be repositioned, avoiding loss of reduction.

In the anteroposterior projection, the continuity of the calcar should also be evaluated, since, on occasions, despite having recovered the cervico-diaphyseal angle, a translation of the cortices may persist. In this case, the use of a collinear clamp or a bone hook on the medial cortex of the neck or the distal fragment may reduce displacement.

b. Sagittal plane reduction

In certain fracture patterns, the proximal fragment tends to flex and the shaft to fall. The first maneuver to reduce this displacement in the sagittal plane is usually the placement of a support on the posterior aspect of the thigh (fist of the hand, hammer, crutch, etc.). However, this is often insufficient. For these situations, some percutaneous reduction maneuvers have been described. In 2011, Chun et al. described a technique that consists of the percutaneous insertion of a 4.2 mm Steinmann pin in the anteromedial cortex of the neck and, by the exertion of a posterior force, reducing the flexion of the proximal fragment (Figure 4).[10] Yoon et al. introduced, through a small anterolateral approach proximal to the lesser trochanter in the thigh, a long hemostatic clamp and, by generating upward traction, the defect of flexion and rotation of the proximal fragment was corrected.[11]

In 2007, Carr described a displacement pattern in comminuted intertrochanteric fractures, in which the diaphyseal fragment shortened and externally rotated, and the proximal fragment was displaced in varus and impacted within the distal fragment, generating an overlap of the anterior cortices. He proposed, then, to insert a Steinmann pin between the two fragments to lift the proximal fragment and disimpact it from the distal fragment (Figure 5).[12]

5. LOCATION OF ENTRY POINT

Defining an ideal entry point may be impossible, since it depends on the anatomical variations of the greater trochanter and the variations in the angle of the different types of nails. In a cadaveric study using different nail designs, Osrtum et al. defined the tip of the greater trochanter 2 to 3 mm medial to it as the "universal" entry point in the coronal plane. They also mentioned that the lateral entry point should be avoided, because it inevitably generates a varus displacement of the proximal fragment.[13]

The profile entry point has been less studied; however, an incorrect entry in this plane can cause an iatrogenic fracture of the proximal femur; thus, an entry point 5 mm posterior to the tip of the trochanter is recommended.

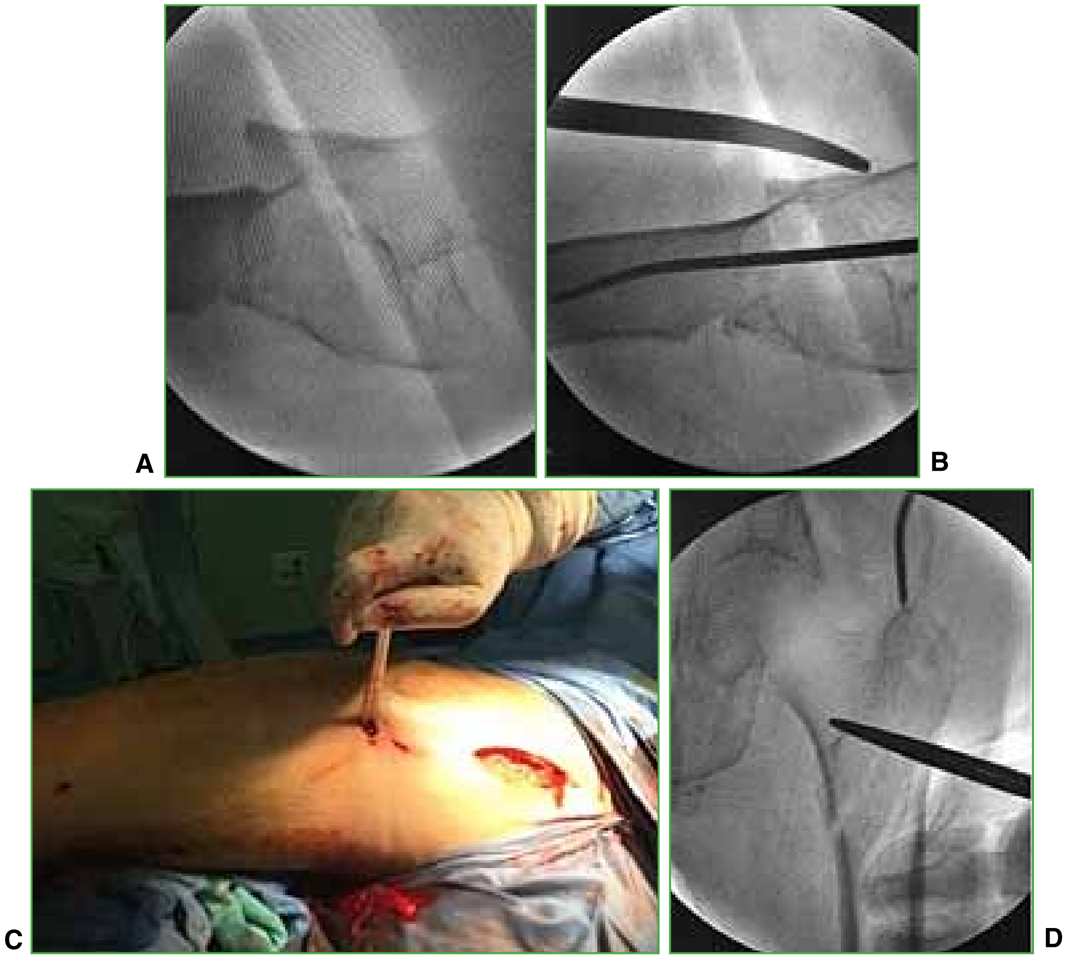

Figure 4. **A.** Flexion displacement of the proximal fragment. **B and C.** Reduction of displacement with scissors through a percutaneous approach. **D.** Fluoroscopic image of the reduction achieved in the front.

Once the ideal entry point is defined, all the factors that may interfere with its correct positioning must be recognized. In this sense, the situations that can cause a lateralization of the entry point are: the comminution of the fracture that extends towards the tip of the trochanter, the incorrect placement of the patient on the traction table or surgery table, the incorrect preparation of the the fields that interfere with the approach or errors in the approach. Another time when the entry point may be inadvertently lateralized is during reaming. Reaming should not be started until close contact of the reamer with the bone to avoid eccentric reaming and thus cause a lateral displacement of the entry canal.[13]

6. NAIL PLACEMENT

Once the entry canal has been reamed, we proceed to insert the nail. It is usually possible to insert it manually, with gentle rotational movements. Only once the nail is aligned with the femoral canal can gentle hammer blows be applied—if necessary—to achieve the desired position. If, despite this, its descent does not progress, it is advisable to remove the nail and ream the canal to avoid an iatrogenic fracture of the femur.

After inserting the nail in the desired position—especially if the entry point was lateral to the tip of the greater trochanter—a secondary varus displacement of the proximal fragment and lateralization of the diaphysis ("wedge

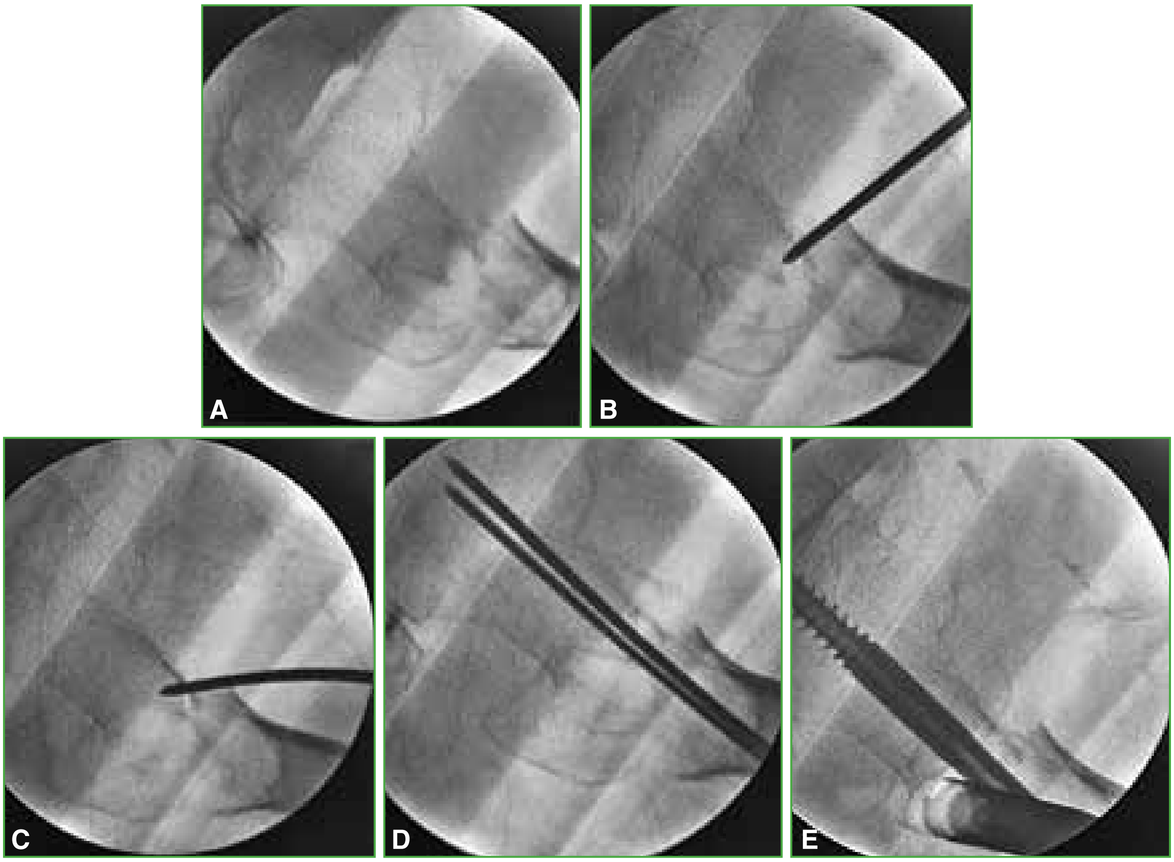

Figure 5. A. Lateral fluoroscopic image showing the posterior fall of the proximal fragment and the overlapping of the cortices, which makes closed reduction impossible. **B and C.** Inserting a 3mm pin into the site and reducing displacement. **D.** Transient stabilization with two anterior pins, ensuring that they do not interfere with the introduction of the nail. **E.** Definitive fixation with the cephalic screw.

effect") can be generated.[14] It is important to detect this situation before placing the cervicocephalic guide pin. The solution is usually to apply more traction to the axis or, in some circumstances, to apply a slight abduction on the limb. If, despite this, the desired reduction is not achieved, the conflict is probably caused by a lateral entry point. In that case, it is advisable to reposition the entry point. The first thing we do, after extracting the nail, is to check that the soft tissues are not interfering with the access. If this happens, we extend the approach proximally to allow an entry more aligned with the femoral canal. If, despite this, the comminution of the trochanter or the previously generated canal causes the pin to move laterally, re-reaming the entrance canal exerting force medially to remove the superolateral cortex of the head-neck fragment will grant more space to the proximal end of the nail, thus preventing the nail from causing varus displacement.[15]

Although rare, a valgus displacement of the fracture may occur after inserting the nail, this is the "reverse wedge effect".[16] This type of secondary displacement is described mainly in basicervical fractures. In this situation, it is possible to insert a bone hook or collinear clamp and, in this way, generate lateral traction from the medial cortex of the femoral neck.[16]

7. CEPHALIC ELEMENT POSITIONING

In terms of the position of the screw or plate in the femoral head, there is considerable consensus that the ideal position in the profile is the center.[6] However, in the frontal image, like us, there are those who defend the central location[6] and those who defend the lower location.[17] In practice, a screw in an inferior position with good clinical results was often associated with a tip-apex index> 25 mm; therefore, it was necessary to describe a new predictive failure index that favors this inferior screw / plate position. The "Cal TAD" index, described by Kuzyk et al. in 2012, differs from the tip-apex index, described by Baumgaertner,[6] only in the frontal image. It uses a line parallel to the femoral neck and adjacent to the calcar, rather than running down the center of the neck.[17]

In any situation, the concept of the tip-apex index is to position the cephalic element in the area of the best bone to guarantee the best possible fixation and reduce the chances of cut-out.

Once the desired position in the head is established, the insertion of the plate or screw may cause rotational displacement of the fracture. This is more likely in basicervical or comminuted fractures. One way to avoid this displacement is to temporarily fixate the reduction achieved initially with 3.2 mm pins outside the nail guide system. However, if the fracture was not initially stabilized and rotation occurs, it is indicated to remove the screw and reinsert it after stabilization, monitoring with the image intensifier. If a rotational defect is observed when the desired position is reached with the tip of the screw, the screw should be removed as much as necessary to correct the deformity observed in the image intensifier.

Another possibility is that, due to the traction necessary to achieve the reduction or due to the introduction of the screw or plate, a distraction of the fracture site is generated. If this occurs, after inserting the plate or screw, the traction on the limb should be released and, by means of the compression system, the reduction of the fracture should be completed.

8. SHORT NAIL VS. LONG NAIL

Since the vast majority of intertrochanteric fractures occur in elderly patients with osteoporosis, it is reasonable to think that a longer implant will protect the femur from a second fracture. In contrast, Curtis et al. reported a higher incidence of fractures around the implant in the metaphyseal region than in the diaphyseal region.[18] However, the results of a 2019 meta-analysis show that the risk of secondary fracture, osteosynthesis failure, nonunion or infection was similar between long and short nails. Only a longer surgical time to place the long nails was significant due to the need to ream and drill distally, freehand.[19] Our practice of using short nails, as a routine, is not only due to the shorter surgical time, but also to the fact that, if a distal fracture occurs, the exchange of a short nail for a longer one would be simpler than the treatment of a supracondylar fracture with a distal femural plate over the nail.

9. PLATE VS. SCREWS

Adequate fixation of the implant to the femoral head is a determining factor for the success of osteosynthesis. Some authors argue that it is the rotational forces that cause a loss of screw fixation, the subsequent varus collapse of the femoral head and finally the "cut-out".[20] In biomechanical studies, it has been shown that plates are more resistant to rotational forces, due to their geometry and their radially compacting entry into the bone.[21] Clinical studies have supported the laboratory results. In a 2015 meta-analysis, Shuang Li et al. showed that the risk of cut-out is significantly lower in the plate group than in the screw group.[22] On the other hand, in 2019, Ibrahim et al. did not find statistically significant differences in the failure rate between the plate group and the screw group. However, they mention a difference in the failure pattern between both groups: axial migration and intra-articular penetration were more frequent with the plate.[23]

10. DISTAL LOCKING

Load transfer in the proximal femur after osteosynthesis with a proximal femoral nail will depend on the fracture pattern and the quality of reduction. In unstable fractures, all loads will be transmitted to the distal femur by the nail lock until union or rupture. Whereas, in stable fractures, if the reduction is adequate, the intimate cortical contact will transmit the loads directly to the distal femur. For this reason, some authors have questioned the usefulness of distal locking in stable intertrochanteric fractures.[24] In 2019, Yan et al. conducted a meta-analysis on the need to perform the distal locking of the nail in stable fractures and found that the surgical time and the exposure time to fluoroscopy were shorter, and that there was less bleeding and thigh pain in the postoperative period in the group of nails without distal locking. At the same time, the functional results of both groups were similar.At the same time, the functional results of both groups were similar.[25] As the additional irradiation time is minimal with the use of the guides, our routine practice is to perform the distal locking. With nails that offer the possibility of two distal locks, we always choose the most proximal to reduce the stress concentration on the nail tip.

CONCLUSIONS

Despite the great progress and development of implants in recent years, the main determinants of the final outcome of the fixation of intertrochanteric fractures continue to be the quality of the reduction and the correct positioning of the implant. Awareness of the different errors that can be made during each of the steps of the surgical technique is essential to avoid them.

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