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The use of 'blocking' screws for the 'closed' reduction of difficult proximal and distal femoral fractures

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- Most meta-diaphyseal femoral fractures that are treated with intramedullary nailing can be reduced satisfactorily by skeletal traction without 'opening' the fracture site and therefore, complications such as nonunion, infection and wound healing problems are reduced.
- In cases where adequate fracture reduction cannot be achieved by skeletal traction, 'reduction aids' have been used during the operative procedure in order to avoid the exposure of the fracture site.
- The 'blocking' screw, as a reduction tool, was proposed initially for the 'difficult' metaphyseal fractures of the tibia. Subsequently, surgeons have tried to implement the 'blocking' screw technique in 'difficult' distal femoral fractures.
- This article presents the 'blocking' screw technique as an adjunctive process in the management of fractures of the proximal and distal femur which are found to be non-reducible by skeletal traction alone. The minimal invasiveness of the technique contributes greatly to the preservation of both the soft tissue integrity and the fracture haematoma and thus reduces the major complications that can occur by exposing the fracture site.

Keywords: blocking screw; difficult femoral fracture reduction; intramedullary nailing

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Introduction

Intramedullary nailing (IMN) has been established as the gold standard technique for the management of diaphyseal long bone fractures. Advantages of the technique include respect of the soft tissues, preservation of the fracture haematoma and biomechanical superiority. Inevitably, surgeons have tried to expand the indications for the IMN technique to metaphyseal fractures of the long bones, where, due to the anatomical characteristics in those regions, difficulties (mainly related to the unsuccessful 'closed' reduction of the fracture) were encountered. The problems were attributed to the broadness of the metaphyseal areas that cannot contain the nail firmly and additionally to the attachments of ligaments and tendons that act adversely and do not allow satisfactory fracture reduction by 'closed' means. Not very long ago, it has been reported that IMN, as a minimally invasive technique, should not be used for the management of metaphyseal tibial fractures.[1,2]

From the beginning of the 21st century, surgeons who did not want to abandon a surgical technique that offered so many biological and biomechanical advantages proposed technical adjuncts, supplementing the IMN technique, in an effort to obtain and maintain fracture reduction at the metaphyseal area without compromising the minimal invasiveness of the technique. Initially, these adjuncts were proposed for fractures located at the metaphyseal areas of the Tibia. These include the use of an additional small – usually unicortical – plate, the percutaneous use of a pointed reduction clamp, the modification of the nail design, the use of a distractor, the definition of a fracture pattern specific location for the entry portal of the nail or a 'mini open' reduction of the fracture.[3–7]

Alongside these proposals, Donald and Seligson initially, followed by Krettek et al and Ricci et al at a later stage, introduced the use of a 'free' percutaneous screw for guiding the intramedullary nail within the medullary canal and thus reducing a metaphyseal tibial fracture without approaching the fracture site.[8–10] This screw was initially named 'poller' but over the years the term 'blocking' prevailed. The basic idea was that a single screw engaging both cortices in one of the two fragment segments can act as a fulcrum and, with the nail acting as a lever, the surgeon could reverse the deformation at the fracture site and thus obtain a 'closed' reduction.

Over the last two decades the 'blocking' screw technique has been adopted and used by surgeons mainly for the management of fractures involving the proximal and distal metaphyseal areas of the tibia that could not be satisfactorily reduced by traction. The success of the reported outcomes contributed to the expansion of indications for

the use of 'blocking' screw in similarly 'difficult' fractures involving mainly the distal and infra-isthmal areas of the femur while the reports for the use of 'blocking' screws in the proximal femoral fractures have been scarce.[11–15]

General guidelines

- The 'blocking' screw must engage firmly both cortices of the bone.
- The 'blocking' screw must not be inserted too close to the fracture site in order to avoid further fracture comminution, either by its insertion or by the forces generated by the impingement of the screw with the nail during its insertion.
- It is the author's preference that the 'blocking' screw should be inserted after reaming and with the intramedullary guide wire in situ. However, in some cases, surgeons prefer to insert a 'blocking' screw before reaming. In these cases, extra care should be taken during reaming to avoid problems created by the contact of the reamer with the 'blocking' screw.
- Although there have been various definitions about the point of location of the 'blocking' screw, the author proposes that the 'blocking' screw must be perpendicular to the direction of the fracture displacement, in contact with the guide wire at its side that indicates the direction that the bony segment that carries the 'blocking' screw should move in order to meet the other bony segment (Fig. 1 (b), (e), Fig. 4 (f), (h) and Fig. 5 (c),(d)). This rule may not apply when the 'blocking' screw is inserted for diverting the nail rather than reducing the fracture (Fig. 2 (g), (h) and Fig. 3 (f), (g), (h)).
- It is believed that the 'blocking' screw must be inserted into the short bony segment. Although this rule may apply in most fractures, there are cases, such as segmental fractures or fractures with a comminuted short fragment, where the 'blocking' screw should be inserted into the long bony segment. The choice of the point of insertion should be defined as previously described.
- More than one 'blocking' screw can be used in cases of multi-directional displacement or partial correction of the displacement with one screw (Fig. 1).

Operative technique

'Blocking' screw(s) in retrograde nailing for infra-isthmal femoral fractures (Fig. 1)

The patient lies supine on a radiolucent operating table. Under general or spinal anaesthesia, the operation can be performed either with the injured leg free on a radiolucent triangle support that will keep the knee in 40–50° of flexion or with the use of skeletal traction from the proximal tibia just below the tibial tubercle. The author's preference is the latter option, as in such a setting the leg is stable, in the same position throughout the procedure, and the reduction of the fracture and alignment of the leg are better controlled without the need for an assistant to stabilize the limb. From this point the operation proceeds typically as has been well described for the retrograde nailing technique with an incision of 3–4 cm, usually just medial to the patellar tendon, opening the entry portal for the nail at the intersection of the intercondylar groove and the Blumensaat's line.[16]

Introduction and passage of the guide wire to the distal and through the fracture to the proximal femur follows and then reaming up to the appropriate width. The passage of the guide wire to the proximal femoral segment is usually not difficult but, in some cases, external manipulation or use of leavers such as Schanz pins may be necessary. If the reduction of the fracture is satisfactory, the intramedullary nail with the pre-determined appropriate length and width is introduced and locked distally and proximally and the operation comes to an end. However, if, following the introduction of the nail, the reduction is not satisfactory, the nail is withdrawn while the guide wire is left in situ. If the fracture is angulated anteriorly or posteriorly (sagittal plane), a 'blocking' screw will be inserted with a medio-lateral direction, thus perpendicular to the displacement, according to the previous guidelines. Similarly, if the fracture is angulated or displaced in varus or valgus (coronal plane), something that is usually happening in segmental fractures, the 'blocking' screw should be inserted with an antero-posterior direction. According to the general guidelines, in all cases, the 'blocking' screw should be in contact with the guide wire, at its side that indicates the direction that the bony segment that carries the 'blocking' screw must move in order to meet the other bony segment and reduce the fracture (Fig. 1). Although it appears more convenient for the 'blocking' screw to be inserted into the shorter distal bony segment, it can be introduced into the longer proximal segment as well, depending on the fracture pattern and morphology. Any strong screw can play the role of a 'blocking' screw; however, most surgeons prefer to use an interlocking screw from their nailing system. These screws are strong and made from the same material as the nail and thus the adverse effect of galvanic corrosion is avoided. Following the introduction of the 'blocking' screw, the nail is re-inserted with caution, as it may impinge on the 'blocking' screw, something that will require some manipulation either of the nail from its handle or at the fracture site externally in order to avoid over-stress of the 'blocking' screw, that may lead to an iatrogenic fracture. It is the author's

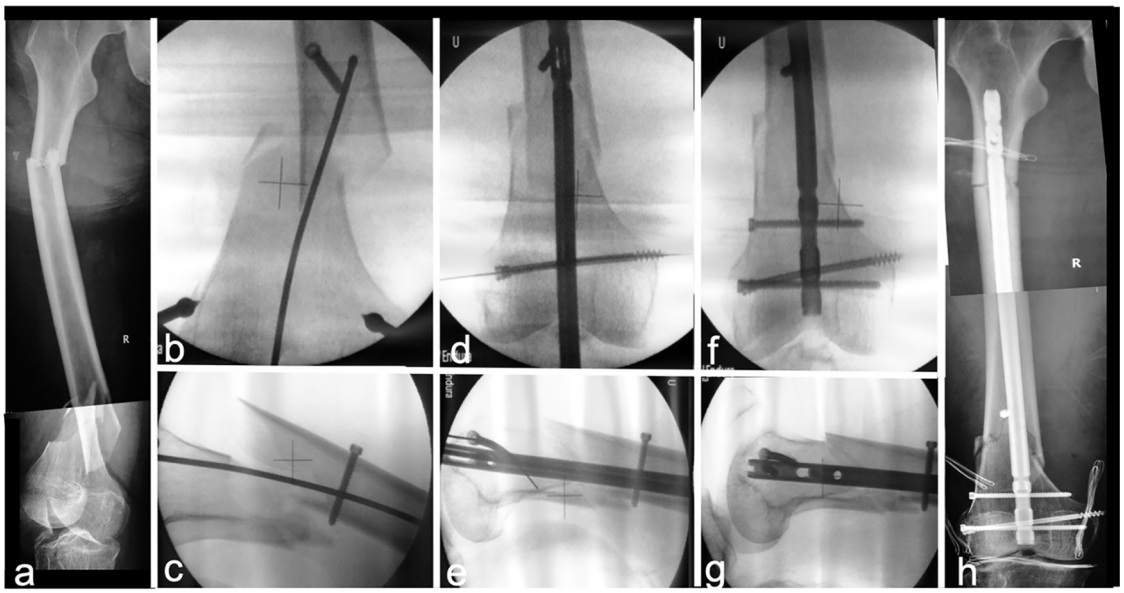

Fig. 1 (a) Segmental 'closed' fracture of the right femur in a 33-year-old male. (b) (c) Intraoperative fluoroscopic images showing the displacement in both antero-posterior (AP) and lateral views and the insertion of an AP 'blocking' screw, perpendicular to the displacement on the coronal plane, in the proximal fragment, at the lateral side of the guide wire, as the bony segment where the 'blocking' screw has been inserted must move laterally. (d) (e) A second 'blocking' screw has been inserted at the distal segment, in a medio-lateral direction in order to contribute towards the reduction of the distal fracture on the sagittal plane. (f) (g) Final intraoperative views depicting the good overall 'closed' reduction at the distal fracture site. The proximal fracture site was reduced by the introduction of the nail. (h) AP postoperative X-ray.

recommendation that reaming should not be repeated after the insertion of the 'blocking' screw, thus avoiding unpredictable stress situations during the contact of the reamer with the 'blocking' screw which can occur even if there are efforts to avoid reaming when the reamer passes next to the 'blocking' screw. The nail is advanced towards its final position and after confirmation of the adequate reduction of the fracture, care should be taken to avoid interference of the 'blocking' screw with the interlocking screws of the nail. It is the author's preference not to remove the screw after the nail is locked, as the 'blocking' screw enhances the stability of the osteosynthesis and prevents later displacement of the fracture. The use of one or more 'blocking' screw(s) does not influence the postoperative management of patients. Mobilization of the knee, weight-bearing and return to activities are conducted similarly to nailing cases where there has been no need for introducing 'blocking' screw(s).

'Blocking' screw(s) in antegrade nailing for infra-isthmal femoral fractures (Fig. 2)

Cases of diaphyseal femoral fractures, treated by antegrade nailing, that cannot be reduced by the traction and nail and require the use of 'blocking' screw for obtaining a 'closed' reduction are usually segmental fractures that involve the proximal and middle femur or, less frequently, fractures in which, for various reasons, the nail cannot be directed towards the middle area of the distal metaphysis and tends to divert, usually, towards the medial femoral condyle. In these cases, the operation starts and proceeds as in any antegrade femoral nailing procedure. The surgeon should think about using a 'blocking' screw only if the fracture cannot be satisfactorily reduced after the passage of the nail through the diaphyseal fracture site. In this case, the nail is withdrawn until its distal end lies within the last 1–2 cm of the proximal bony fragment and, with the guide wire in place, within the entire femoral canal, a 'blocking' screw is introduced, perpendicular to the displacement, following the previous guidelines. In cases of infra-isthmal fractures, the 'blocking' screw is positioned at a narrow area of the femur, therefore care should be taken to allow enough space within the femoral canal for the passage of the nail. In some cases, the guide wire occupies the location where the 'blocking' screw should be inserted in order to allow adequate space for the nail. In such a case, the guide wire should be withdrawn as well (as the nail) just proximal to the fracture site and the 'blocking' screw should be inserted without the guide wire in situ (Fig. 3). Good experience with the 'blocking' screw technique is required in these cases for its successful introduction in order to obtain a 'closed' reduction with all accompanying benefits. Following the insertion of the

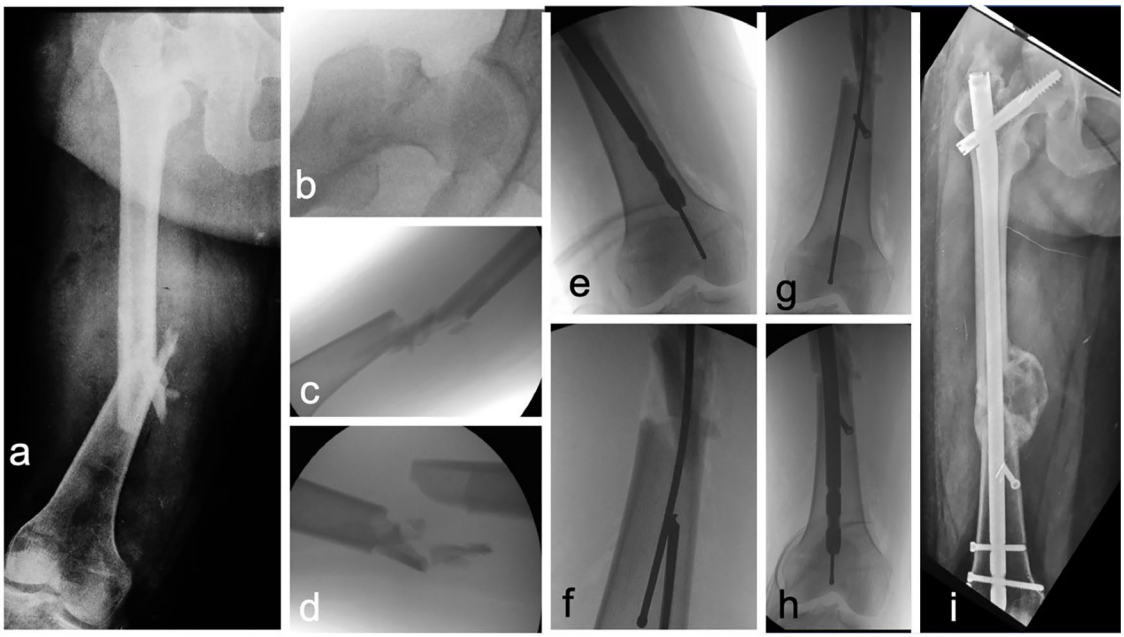

Fig. 2 (a) Segmental 'closed' fracture of the right femur in a 48-year-old female. (b) (c) (d) Intraoperative fluoroscopic images showing good reduction proximally and gross displacement in both antero-posterior (AP) and lateral views at the distal fracture site. (e) The guide wire diverts the nail towards the medial condyle. The nail followed the same direction even when the guide wire was withdrawn. (f) (g) The nail was withdrawn and a second curved guide wire was introduced just to indicate the best location for the insertion of the 'blocking' screw. (h) The 'blocking' screw diverted the nail at the correct direction and allowed flexibility in the final positioning of the nail, so an optimal position of the lag screw proximally could be obtained. (i) AP X-ray at four months showing healing of both fracture sites with sizable callus formation.

Fig. 3 (a) Antero-posterior (AP) view of a segmental 'closed' fracture of the right femur in a 52-year-old male. (b) (c) (d) Intraoperative fluoroscopic images showing the initial position of the proximal (AP) and distal (AP and lateral) fracture sites under skeletal traction. (e) AP view of the distal femur that shows the tendency for the nail to follow an eccentric trajectory. (f) As the guide wire crosses the pathway of the 'blocking' screw, it is withdrawn (but not removed from the distal segment) and the 'blocking' screw is inserted antero-posteriorly, at a position (g) (h) that will allow both the insertion of the nail and its direction towards the middle of the distal femur. (j) AP X-ray at three months when the patient was instructed to fully weight-bear.

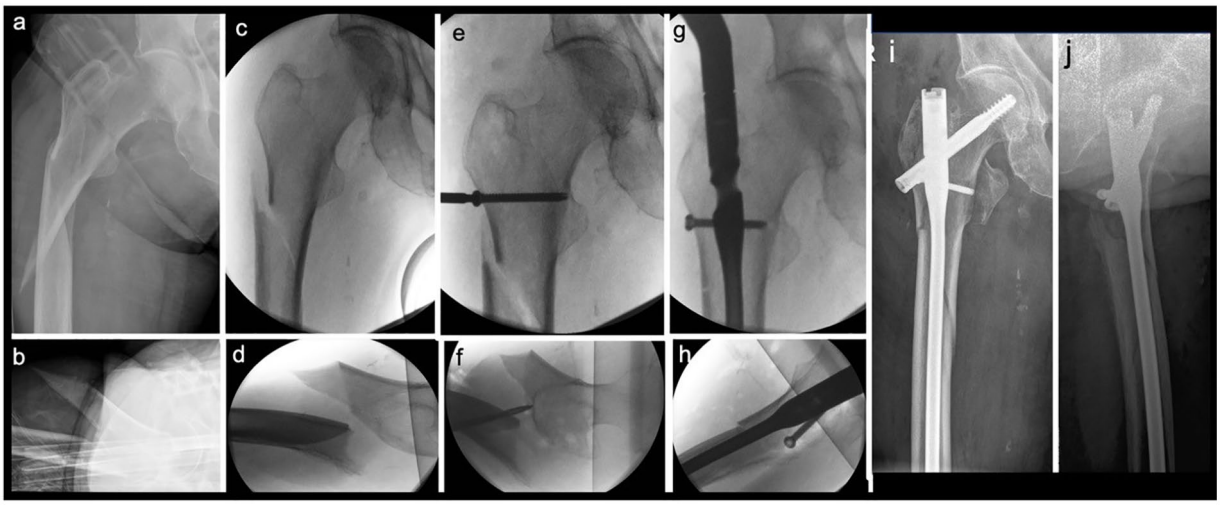

Fig. 4 (a) (b) Preoperative AP and lateral X-rays of a 78-year-old female that show an extensive, oblique sub-trochanteric fracture of the right femur with marked anterior displacement on the lateral view. (c) (d) Intraoperative fluoroscopic images showing the initial position of the fracture under skeletal traction. (e) (f) Positioning of the drill-bit on the lateral view and insertion of the 'blocking' screw at the trochanteric area. (g) (h) Following the reduction of the fracture with the reduction tool ('joy-stick'), the insertion of the guide wire and reaming, the insertion of the nail above the 'blocking' screw, reduces the fracture. (i) (j) Postoperative antero-posterior (AP) and lateral X-rays show excellent reduction of the fracture.

'blocking' screw the nail is advanced towards its final position and, after confirmation of the adequate reduction of the fracture, it is locked distally and proximally as routine for antegrade femoral nailing. The 'blocking' screw is not removed after the nail is locked, as described previously. The use of the 'blocking' screw in infra-isthmal femoral fractures does not influence the postoperative management of patients. Mobilization of the hip and knee joints, weight-bearing and return to activities are instructed similarly to nailing cases where there has been no need for the use of a 'blocking' screw.

'Blocking' screw(s) in antegrade nailing for proximal femoral fractures

Sub-trochanteric fractures constitute a group of fractures that tend to displace significantly and resist most methods of 'closed' reduction, as they are subject to the highest tensile and compressive stresses that the human body is exposed to.[17] Because of these stresses, the proximal short bony fragment abducts, flexes and rotates externally and comes to a position that requires careful consideration and planning for the entry portal of the nail in order to avoid additional problems related to the nail trajectory.

The operation starts as usual for a routine antegrade femoral nailing with the patient in a supine position on the traction table. The approach starts with an inferiorly inclined 3–4 cm skin incision, 2–3 cm proximal to the 'tip' of the greater trochanter. The entry portal for the nail is opened with the penetrating awl and the guide wire is introduced up to the level of the fracture. If, with some external manipulation and manoeuvres, the guide wire passes through the fracture site to the distal fragment, reaming follows and the nail is introduced as usual for antegrade nailing. If the reduction of the fracture appears satisfactory there is no need for a 'blocking' screw. However, it is not infrequent that despite a satisfactory reduction on the antero-posterior view, there is great displacement on the lateral view due to the deforming forces as described above. In many cases it may not be possible even for the guide wire to pass through the fracture site to the distal bony segment and the use of a 'blocking' screw may be the only way to avoid an 'open' reduction. In this case, it is advised that the guide wire should be introduced and advanced up to the fracture site and reaming should be performed up to that level. At this point, there are two possibilities:

a) *The proximal fragment is displaced mainly anteriorly (as seen on the lateral view)*. In this case, a 'blocking' screw can be inserted into the proximal fragment, at about the level of the lesser trochanter in a lateral to medial direction (Fig. 4). Care should be taken for the screw not to block the nail passage, but to leave enough space within the femoral canal in order to allow the passage of the nail between the screw and the anterior cortex. A cannulated tool described as 'joy-stick', which is contained in most intramedullary nailing sets of tools, can be introduced over the guide wire and is advanced and passes above the 'blocking' screw

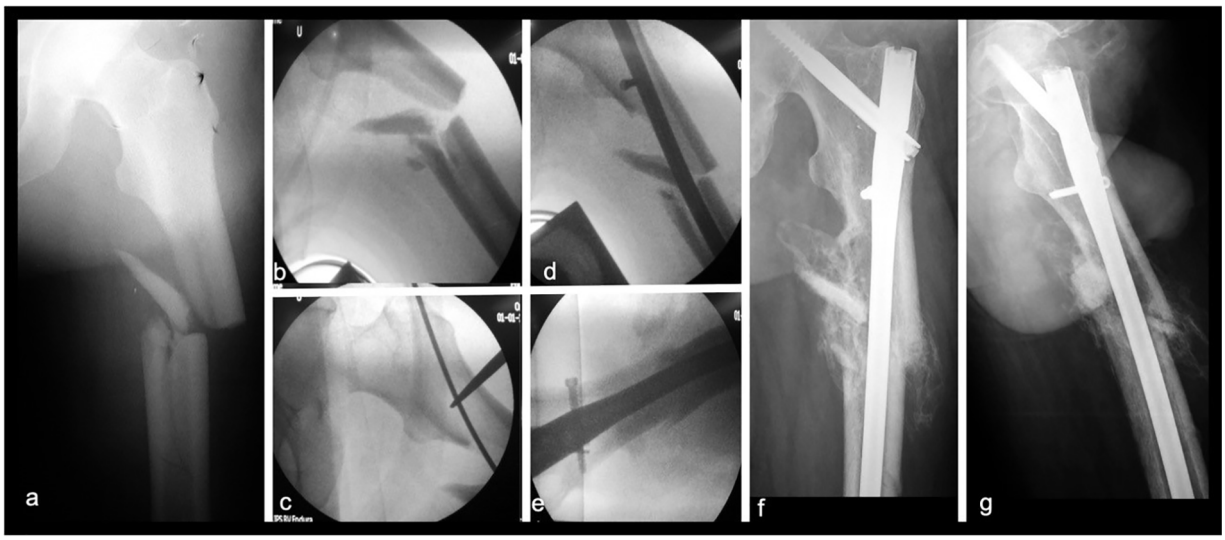

Fig. 5 (a) Preoperative antero-posterior (AP) X-ray of a 65-year-old male that shows a comminuted sub-trochanteric fracture of the left femur with mainly lateral displacement. (b) (c) Intraoperative fluoroscopic images showing the initial position of the fracture site under skeletal traction and the point of insertion of an AP 'blocking' screw. (d) (e) Insertion of nail lateral to the 'blocking' screw reduced the fracture. (f) (g) AP and lateral X-rays at four months show solid callus formation and the patient was instructed to fully weight-bear.

until the fracture site. At this stage, the 'joy-stick' is used as a lever by the surgeon and with elevation and adduction of its handle, the proximal bony segment can approximate the distal bony segment and the guide wire can be pushed to enter the distal segment. The 'joy-stick' is then withdrawn and reaming of the distal segment follows, taking care for the cutting end of the reamer to by-pass the area where the 'blocking' screw has been inserted and thus avoid either damage or displacement of the screw or iatrogenic fracture. The intramedullary nail is then introduced, as usual for antegrade nailing. If the 'blocking' screw has been inserted correctly, the fracture is usually reduced and the nailing procedure is completed with the proximal and distal locking of the nail, as usual for antegrade nailing procedure.

b) *The proximal fragment is displaced mainly laterally (seen on the antero-posterior view)*. In this case, a 'blocking' screw can be inserted into the proximal fragment, at the level of the lesser trochanter in an anterior to posterior direction, in contact with the guide wire on its medial side (Fig. 5). Care should be taken for the screw not to block the nail passage, but to leave enough space within the femoral canal in order to allow the passage of the nail between the screw and the lateral cortex. The 'joy-stick', that was described previously, can be introduced over the guide wire and is advanced until it passes next to the 'blocking' screw reaching the fracture site. At this stage, the 'joy-stick' is used as a lever by the surgeon and with abduction and elevation, the proximal bony segment can approximate the distal bony segment and the guide wire can be pushed to enter the medulla of the distal segment. The 'joy-stick' is then withdrawn and reaming of the distal segment follows, taking care for the cutting end of the reamer to by-pass the area where the 'blocking' screw has been inserted and thus avoid either damage or displacement of the screw or iatrogenic fracture. The intramedullary nail is then introduced, as usual for antegrade nailing. If the 'blocking' screw has been inserted correctly, the fracture is usually reduced and the nailing procedure is completed with the proximal and distal locking of the nail, as usual for an antegrade nailing procedure.

In some cases of long spiral sub-trochanteric fractures, the guide wire can be introduced to the distal bony segment and yet the reduction not be acceptable even after the insertion of the nail. In this case the nail is withdrawn and, with the guide wire within the distal bony segment, the surgeon should proceed with the reaming of the whole femoral canal, without using the 'joy-stick'. The 'blocking' screw can be introduced after the reaming and thus avoid the risk of creating problems with the use of reamers in the presence of a 'blocking' screw.

When adequate experience has been gained, the surgeon may insert the 'blocking' screw before the introduction of the guide wire, ensuring enough space within the medullary cavity for unrestricted passage of the nail between the 'blocking' screw and the relevant cortex.

Discussion

Over the last 40 years, the intramedullary nailing technique has been established as the gold standard for the management of diaphyseal fractures of the long bones. In addition to the biomechanical superiority offered by intramedullary nails, further advantages of the technique are the respect of the soft tissues and the preservation of the fracture haematoma. These advantages are jeopardized when the fracture cannot be reduced by 'closed' means and the surgeon proceeds to an 'open' reduction.

The 'blocking' screw technique has been proposed as an effective alternative for reducing a 'difficult' fracture without exposing the fracture site and thus maintaining all the advantages of a well performed intramedullary nailing procedure. Although references to a technique that can 'block' and divert the intramedullary nail and reduce 'difficult' fractures by 'closed' means can be found from several decades ago, it is the author's opinion that the articles of Krettek et al and Ricci et al highlighted the 'blocking' screw (initially 'poller' screw) technique and contributed to the acceptance of its use in 'difficult' metaphyseal fractures of the tibia.[8–10,18]

Ostrum and Maurer were the first to publish a series of eight patients who had sustained extra-articular distal femoral fractures and were treated with retrograde nailing and the use of a 'blocking' screw aiding the reduction of each fracture.[11] All fractures united uneventfully and the authors concluded that in fractures that demonstrate malalignment, translation, or instability, the addition of a blocking screw can aid in the reduction of the fracture and provide additional stability to the intramedullary nail construct. Seyhan et al, Kim et al and Song published case series of infra-isthmal or distal metaphyseal femoral fractures that were treated successfully with retrograde or antegrade femoral nailing with the supplementary use of one or more 'blocking' screws.[12–14] However, van Dyke et al did not find any significant advantages when 'blocking' screws were added to a retrograde intramedullary nail construct for fractures of the distal femur with respect to union time, union rate, or improvements in alignment, and proposed that additional studies are needed to determine the actual benefit of blocking screws in the treatment of infra-isthmal femoral shaft fractures treated with retrograde intramedullary nailing.[19]

Regarding the use of 'blocking' screws in the management of proximal femoral fractures (mainly sub-trochanteric) Seyhan et al compared clamp-assisted reduction, reduction with cable cerclage and reduction with the use of 'blocking' screw in 22, 11 and 12 'difficult' proximal femoral fractures respectively.[15] The authors concluded that the clamp-assisted reduction group had a statistically high mean time to full weight-bearing and a low mean Harris Hip Score at one year, while the blocking screw group's operation times and fluoroscopy times were statistically longer. The authors did not find statistically significant differences between all groups in terms of early postoperative alignment, one-year postoperative alignment, time to union, complications or additional interventions. However, the authors mention that the 'blocking' screw technique was applied in cases where the clamp-reduction technique failed, therefore it can be assumed that some of the advantages of the 'blocking' screw technique, such as the opening of the fracture site and the loss of fresh fracture haematoma, were lost.

The author of this article has used the 'blocking' screw technique extensively in the management of 'difficult' proximal and distal (infra-isthmal) femoral fractures. Although the successful insertion of a 'blocking' screw requires more operating time and more fluoroscopy, it can be considered rewarding, as the direct exposure of the fracture site is avoided. Advantages include the restoration of the alignment of the limb without direct intervention, respect of the soft tissue envelope around the fracture, maintenance of the fracture haematoma and enhancement of the biomechanical strength of the fixation that allows earlier rehabilitation and weight-bearing. The 'blocking' screw technique was particularly useful in cases of segmental femoral fractures, where the 'floating' middle bony segment was completely detached from the proximal and the distal segments. It should be stressed that the use of the 'blocking' screw technique requires significant experience with the intramedullary nailing technique. Therefore, adequate training is required before the adoption of this technique, especially in segmental fractures and fractures that involve the proximal femur.

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