1

ADVANCES IN INTRAMEDULLARY NAILING OF TIBIA FRACTURES: SUPRAPATELLAR ENTRY POINT IN SEMI-EXTENDED POSITION

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Statically locked, reamed intramedullary nailing remains the standard treatment for displaced tibial shaft fractures. Establishing an appropriate starting point is a crucial part of the surgical procedure. The goals of surgical treatment are to achieve osseous union and to restore length, alignment, and correct rotation of the fractured tibia. Intramedullary nailing carries the advantage of minimal surgical dissection with appropriate preservation of blood supply. The surgical implant offers appropriate biomechanical fracture stabilization and acts as a load sharing device allowing for early postoperative mobilization. As of today, intramedullary nail fixation represents a well-described and universally performed surgical procedure. In recent years, suprapatellar nailing of tibias in a semi-extended position has gained attention of the orthopaedic community. It is expected that the suprapatellar tibial nail procedure will become the future, regardless of fracture pattern, with evidence of improved alignment in both proximal and distal fracture, decreased setting room and operative time, relaxation of the deforming forces, ease of imaging and positioning. An ad-hoc designed nail, the EstreMO, is presented as well as a heart-shaped sleeve and trocar, commonly known as "the Melania" by the EstreMO nail utilizers Italian surgeons.

✦ Introduction

In the early 1900s, the predominant treatment method for tibia fractures was immobilization using skeletal traction, splinting or casting. It was not until the 1940s that Kuntscher's nail was introduced as a treatment for long bone fractures.[1-3] Improvements have been subsequentially made to intramedullary nails, including material and size of the nails, the addition of multiple interlocking screw options to control for the rotation and shortening of length unstable fractures, and the introduction of a Herzog curve to decrease the insertional force required to implant the nail.[4, 5]

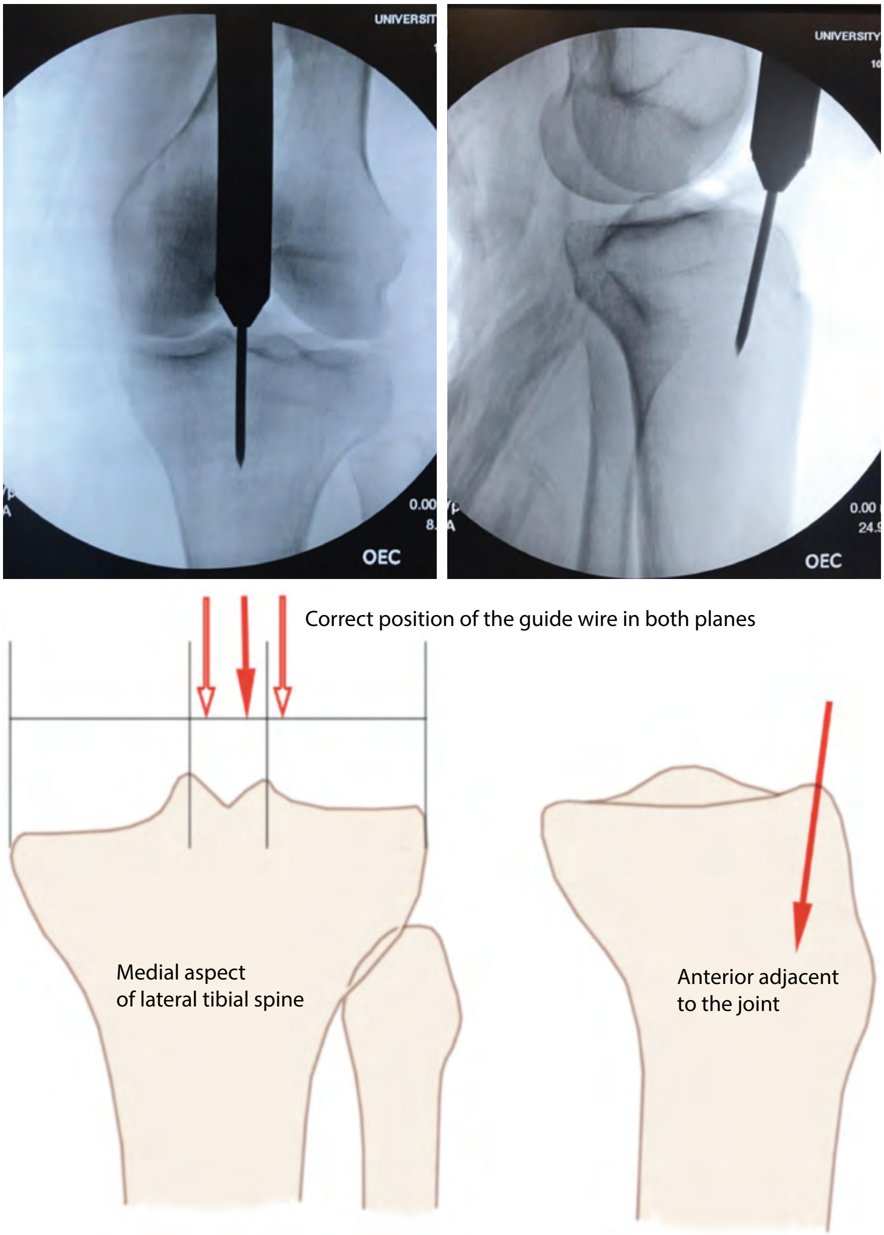

Figure 1.1 • Insertion of the guide wire medial aspect of lateral tibial spine.

More recently, suprapatellar entry point in the semi-extended position has been suggested as a safe and effective surgical technique.[6] It is well described that with infrapatellar tibia nailing (IPTN) techniques the knee needs to be hyper flexed to obtain the appropriate start site and trajectory. This leads to a procurvatum deformity due to the pull of the extensor mechanism on the proximal segment. To place a guidewire down the axis of the medullary canal while avoiding the patella, increasing amounts of flexion need to be obtained. A posteriorly directed guidewire can lead to worsening of the procurvatum deformity once the nail is inserted. Furthermore, fluoroscopic imaging is troubled by requiring the C-arm to dramatically tilt in plane with the flexed knee. Also, the surgeons are required to work on stepstools or with their arms above their shoulders to

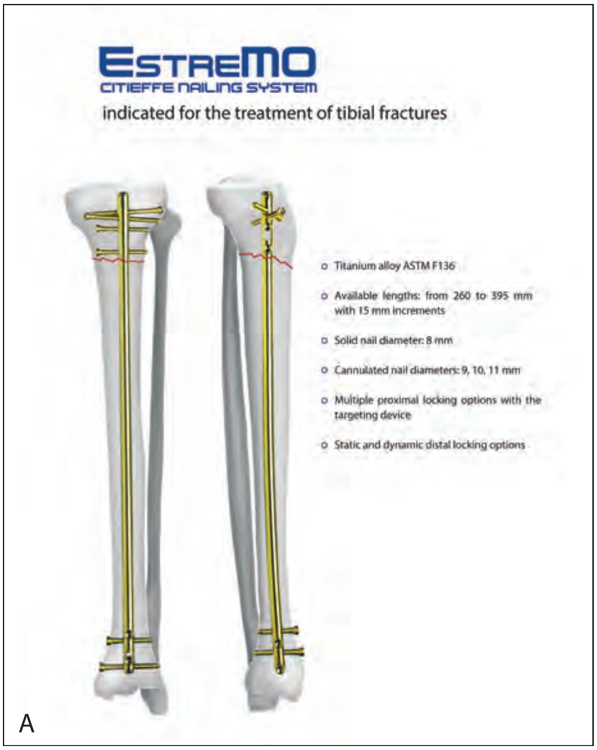

Figure 1.2 • A) Nail specifically designed for suprapatellar entry point with knee in semi-extension. Titanium alloy, cannulated, without Herzog curve, dedicated ad-hoc instrumentation. B) IM nail designed for SPT insertion, without Herzog curve. C) Examples of intramedullary tibia nails. IM: intramedullary; SPT: suprapatellar tibial.

ream in a superior to inferior direction. Due to all these issues, there is a clear advantage to being able to insert tibial nails with the leg in a semi-extended position suprapatellar.

In 1996, Tornetta *et al.*[7] and Cole[8] presented their papers on the semi-extended technique using an open medial parapatellar arthrotomy to improve outcomes in proximal metaphyseal tibial fractures. The authors reported their experience that about 15 degrees of displacement occurs in proximal third tibial shaft fractures when the knee is flexed 80-90 degrees due to the displacing force of the quadriceps on the proximal segment. Proximal third tibial fractures are therefore the most affected by positioning and benefit the most from a semi-extended approach. By keeping the leg in ~15-20 degrees of flexion, the surgeons could neutralize the force of the quadriceps and focus on the proper and safe entry point. The ideal starting site as described by Tornetta is the medial aspect of the lateral tibial spine in the coronal plane and at the articular margin on the sagittal image (**Figure 1.1**).[7]

In the early 2000s, the insertion of an intramedullary nail in the tibia, utilizing a centrally located suprapatellar percutaneous entry point, with the knee in semi-extension, was introduced to the orthopaedic trauma community.[9-27] The nails were conventional intramedullary (IM) nails with an added new external long inserting device. This novel entry point appeared to mitigate the establishment of mal reduction and demonstrated a reduced incidence of knee pain, probably because the suprapatellar route does not directly interact with the patellar tendon. Originally indicated for proximal tibia fractures, this modification of the classical tibial nailing technique has been proved effective in all tibial locations. In 2016 the EstreMO nail (Citieffe S.r.l., Calderara di Reno Bologna, Italy), a straight closed diameter cannulated titanium tibial nail, exclusively designed for the suprapatellar approach and without a Herzog curve, was introduced. It was the first nail specifically designed for the suprapatellar insertion and coupled with a dedicated instrumentation for the semi-extended position and entry point (**Figure 1.2A-1.2C**).[28]

✦ Surgical technique: percutaneous minimally invasive intramedullary nailing technique with suprapatellar approach in semi-extended position

In this approach, the patient is positioned supine on a radiolucent table, with the image intensifier opposite to the surgeon and the video monitor at the foot of the table. The procedure is performed with the knee flexed approximately 15–20 degrees. A hip bump is placed under the ipsilateral gluteus to control the rotation of the limb, keeping the patella facing up (**Figure 1.3**).

The ipsilateral upper extremity is taped over the chest to take tension off the brachial plexus in the bumped position, while the contralateral arm is 90 degrees to the body on an arm board. The operative extremity is elevated on a ramp, which can be a premade radiolucent foam ramp, or one made from folded sheets. This allows for unobstructed lateral and anterior to posterior radiographs from the C-arm (**Figure 1.4**).

The device permits a rapid and stable position of the operative leg above the contralateral one, so that the anterior/posterior and lateral C-arm imaging are easily performed and unobstructed. A sterile bump under the knee can be utilized intraoperative, to increase the excursion in flexion-extension, to facilitate the introduction of the trocar during the entry point insertion. Application of percutaneous reduction clamps, blocking screws, as well as osteosynthesis of fibula or distal tibia can be easily performed in the same setting. Distal locking is also performed with no difficulties because of the stable supine position of the patient coupled with the improved radiographic visualization. The suprapatellar approach in semi-extended position is also advantageous when distal locking is performed first, allowing for subsequent "back slapping" of the nail to achieve further apposition of the bony fragments when needed, to avoid excessive fracture gaps. Both the ramp and the non-operative leg are taped down to the bed, to avoid movements during the procedure. The limb is shaved, prepped, and draped in a standard sterile fashion. It is the author's preference not to use a tourniquet unless a concomitant periarticular injury requires a larger approach.

Figure 1.3 • Positioning for a SPT intramedullary nail entry point on a translucent table. Knee in semi-extension of 15-20 degrees on towels or foam ramp to maintain the limb above the contralateral for unrestricted X-rays images. A sterile bump under the knee can be used intraoperative, to increase flexion of the knee during insertion maneuvers of the trocar. SPT: suprapatellar tibial.

Figure 1.4 • C-arm imaging easily performed.

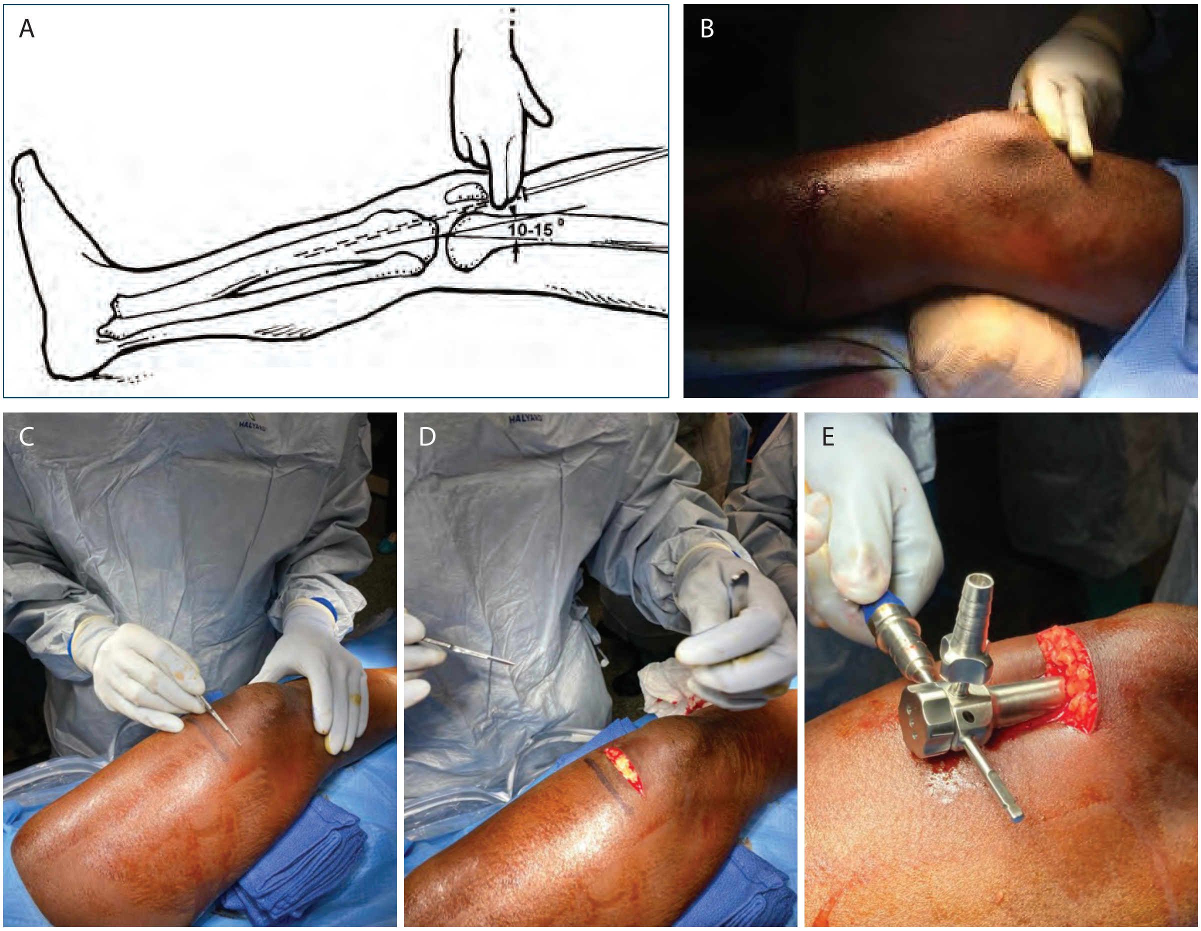

Figure 1.5 • A) Suprapatellar approach: 5 cm transverse cutaneous incision 2 finger breaths proximal to patella. B-E) Cutaneous incision , heart shaped sleeve and trocar in place.

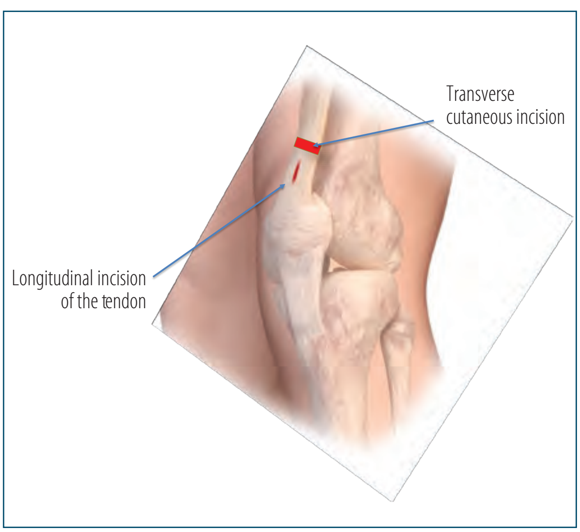

Figure 1.6 • Suprapatellar longitudinal incision of the quadriceps tendon.

The senior author has always preferred a minimal transverse skin incision of about 5 cm located two fingerbreadths proximal to the patella (**Figure 1.5A, 1.5B**). Such incision is parallel with the skin creases and minimizes the formation of large scars, particularly in patients prone to develop keloids. The soft tissues are dissected with electrocautery until the quadriceps is encountered. The quadriceps tendon is split in a longitudinal fashion (**Figure 1.6, 1.7**) from the apex of the patella for about 5 cm and then the patellofemoral joint is entered through further blunt dissection. A commonly utilized round cannula system with a blunt cannulated trocar is inserted through the patellofemoral joint to establish the starting point at the junction of the anterior cortex of the proximal

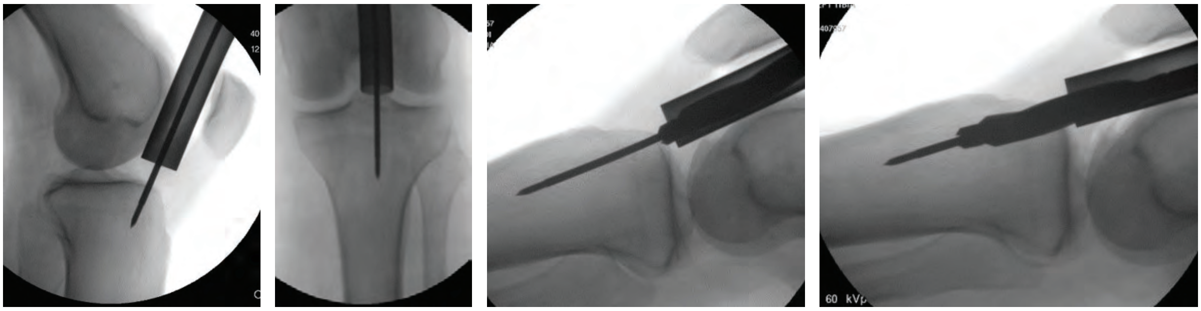

Figure 1.7 • Trochar has been removed and substituted by the rigid reamer.

tibia and the articular surface, medial to the lateral intercondylar tibial spine. If there are difficulties with the insertion of the trocar and cannula at the starting point, just insert the guide pin first and then cannula and trocar over it. The surgeon should maintain distal pressure on the trocar handle to ensure the trocar does not inadvertently back out. It is good practice to utilize suprapatellar tibial nailing (SPTN) systems that allow the trocar to be pinned into the femur to avoid the trocar to back out and to free up the surgeon's hand. Once down on the tibia, the cannulated trocar can be removed from the cannula and replaced with a guidewire sleeve. The guidewire is inserted through the cannula, and the appropriate start site is confirmed using fluoroscopy. Sometimes, in women and thin patients is useful to prepare the tract for the operative cannula performing blunt dissection of capsula and retro patellar soft pad. Flexion-extension movement of the knee can be utilized to slide the cannula with the trocar under the patella. If the insertion of the cannula-trocar complex has been successful, the 3.2-mm guide pin is then inserted and placed in the starting portal for just a few centimeters. A multi holed guide pin sleeve ("honeycomb") is available and may allow for fine adjustments of the starting point, that is generally medial to the lateral intercondylar tibial spine (**Figure 1.8**). Once biplanar C-arm imaging confirms the correct starting point and the guide pin alignment with the medullary canal, a rigid entry reamer is advanced over the guide pin, through the entry tube, to a depth of 5 cm in the tibia (**Figure 1.9**). The utilization of a thin custom-made rigid reamer is of value, because it can further "guide" the entry point in the most appropriate position, just levering the reamer toward the direction of the floor, so that anteriorly angling the reamer ensures appropriate anterior trajectory. Once the position of the entry reamer is checked radiographically, the rigid reamer and guide pin are removed, maintaining in situ the protective sleeve. A ball-tipped guide wire is then introduced into the medullary canal, advanced across the fracture site, and impacted into the subchondral bone of the distal tibia. Sequential reamers are then placed through the entry sleeve, to protect intra-articular structures. The sleeve can accommodate up to a 12 mm reamer. Because of the semi-extended position of the patient, our experience with the EstreMO nail suggests utilizing a short (80 cm) ball-tipped guide wire. A conventional guide wire from competition companies is in fact 100 mm long and could protrude

Figure 1.8 • A multi holes guide pin sleeve ("honeycomb") is available allowing for fine adjustments of the starting point.

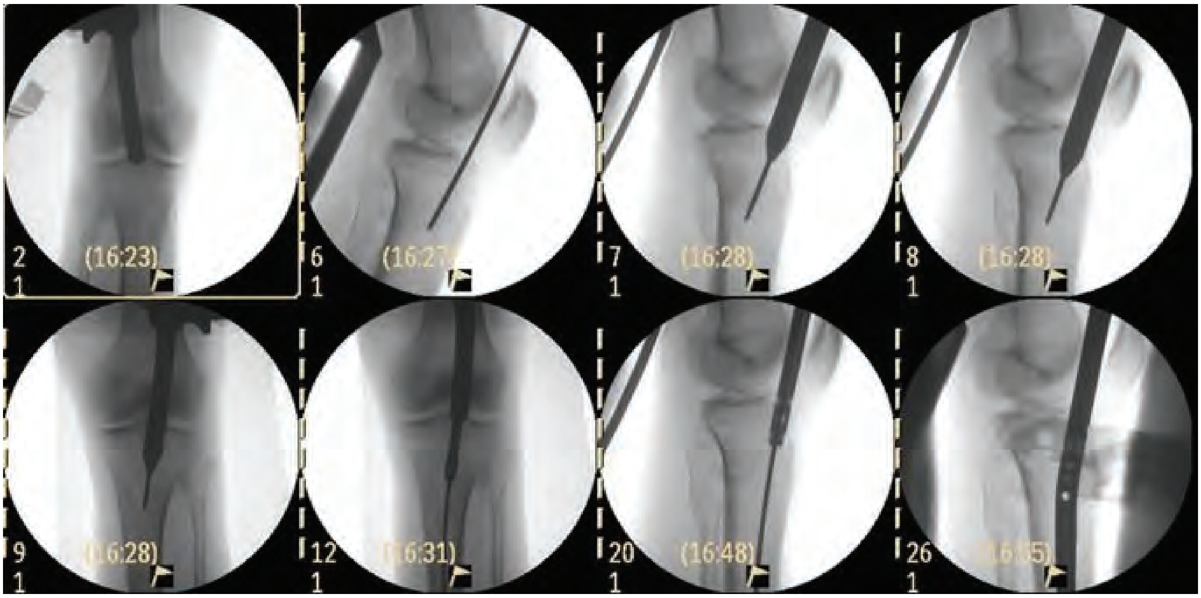

Figure 1.9 • Placement of short guide wire, 12.5-mm entry rigid reamer through a protective sleeve. Sequential reaming over ball tipped guide wire and nail insertion.

Figure 1.10 • Difficulties that may be encountered with the use of inappropriate instruments (too long guide wires, short reamers, obsolete measuring devices). Depuy-Synthes Tibial Nail (Westchester, PA, USA) and T2 Tibial Nail (Stryker Orthopaedics, Mahwah, NJ, USA).

outside the surgical field toward the head of the patient when implemented in a semi-extended procedure, with risks of contamination (**Figure 1.10**). As a result, the measuring EstreMO nail device to read the length of the nail is thus to accommodate such a modified ball tip guide wire. It is also advisable to have in the operating room flexible reamer extensions, in case the combination of the suprapatellar entry point extension and the protection sleeve results in a length discrepancy with the conventional reamers. The senior author also suggests the use of a conical

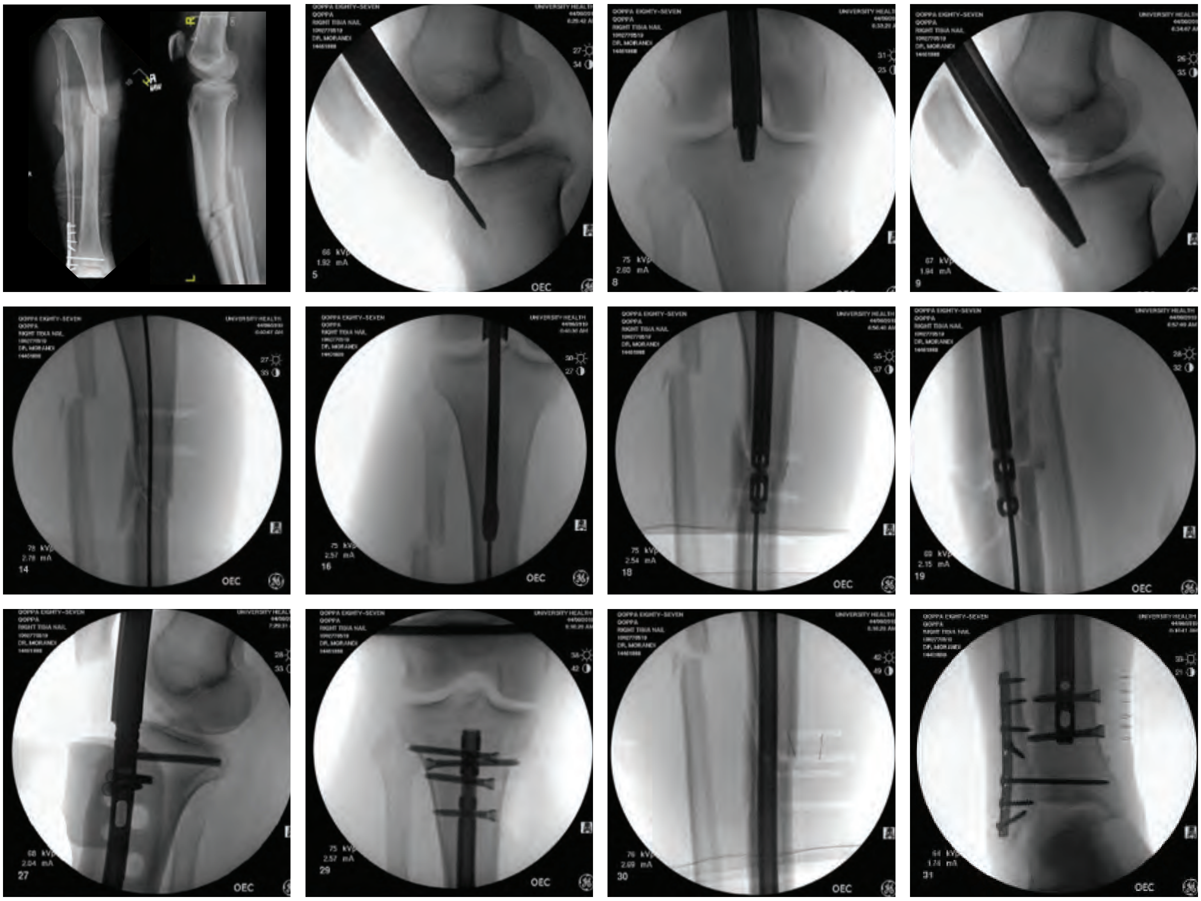

Figure 1.11 • EstreMo nail intramedullary nailing.

measuring device that could be easily introduced in the soft tissue or the sleeve. It is crucial to confirm that on the level of the ankle joint, the ball-tipped guide wire is well-centered both on the anteroposterior as well as the lateral view (**Figure 1.11**).

In fracture with metaphyseal involvement, with valgus deviation, blocking screws or pins are useful tools. Blocking screws (or "Poller" screws) have been popularized by Krettek *et al.*[29] The purpose of blocking screws or pins is to narrow the canal in the metaphyseal area and to substitute a deficient cortex. The blocking screws or pins are placed prior to the reaming process and nail placement. Blocking screws are typically placed in the short, articular fragment and on the concave side of the deformity (**Figure 1.12**).

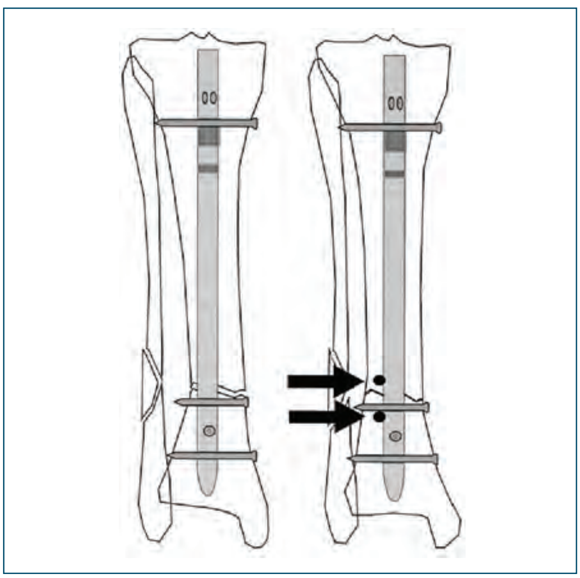

Figure 1.12 • Poller screws (blocking screws) on concave side.