ELSEVIER

Operative Techniques in
Orthopaedics

Distal Medial Closed Wedge Varus Femur Osteotomy Stabilized With the TomoFix Plate Fixator

Ronald van Heerwaarden, MD, PhD,* Ate Wymenga, MD, PhD,* Denise Freiling, MD,† and Phillipp Lobenhoffer, MD, PhD†

Total or near total resections of the lateral meniscus are often followed by a lateral osteoarthritis of the knee. In the past, various possibilities concerning the surgical treatment of lateral osteoarthritis or valgus malalignment were described. The goal of all these different procedures was to unload the lateral compartment of the knee while shifting the mechanical leg axis from the lateral to the medial compartment. Unfortunately, many of these methods often were followed by local complaints or complications in wound or bone healing. Often additional surgeries were necessary as the result of insufficient fixation stability. This is why a new improved surgical technique based on an incomplete closing wedge osteotomy, fixed with an internal plate fixator was developed. We present the indication of this technique, the preoperative planning, the step-by-step surgical technique, and the first results.

KEYWORDS femur osteotomy, lateral osteoarthritis of the knee, valgus deformity, incomplete closed wedge osteotomy, internal plate fixator

The goal of distal medial closed wedge femur osteotomy in patients with unicompartimental osteoarthritis of the lateral compartment of the knee is to shift the mechanical leg axis from the lateral to the medial compartment. Total or near-total resections of the lateral meniscus are often followed by lateral osteoarthritis of the knee. There are various possibilities for surgical correction of valgus malalignment. Open wedge lateral osteotomy or dome osteotomies of the distal femur were used by many surgeons in the last years.[1,2] Unfortunately, local complaints occurred mostly caused by the fixation methods (ie, irritations of the tractus iliotibialis) and stability of fixation method (ie, complications in wound healing or delayed bone healing). This is the reason why a new improved surgical technique based on an incomplete medial closing wedge osteotomy with an internal plate fixator was developed. Biomechanical testing showed that these new implants improve the initial stability of the osteosynthesis which is very important for the rehabilitation treatment (J.M. Brinkman, C. Hurschler, J.D. Agneskirchner, et al, unpublished data, December 2005).

Indications

Indications for closed wedge distal femur osteotomy with internal plate fixator are lateral monocompartimental osteoarthritis of the knee with valgus deformity of the lower limb. The ideal patient should be active, not severely overweight (body mass index <30), and younger than 60 years. In addition, there should be no nicotine abuse. The preoperative range of motion should be at least 90° of flexion. A small degree of extension deficit is tolerable and can be corrected during surgery.

Contraindications

Contraindications of the closed wedge osteotomy are articular cartilage lesions grade III and IV (of the Outerbridge classification[3]) in the medial compartment of the knee joint, medial meniscectomy and morbid obesity. This procedure should not be performed in noncompliant patients or those with a reduced range of motion (flexion <90° or particularly extension lag >20°). It is also important to have an intact soft tissue condition on the site of surgery.

*Limb Deformity Reconstruction Unit, Department of Orthopaedics, Sint Maartenskliniek, Nijmegen, the Netherlands.
†Department of Trauma and Reconstructive Surgery, Henriettenstiftung Hannover, Hannover, Germany.
Address reprint requests to Ronald van Heerwaarden, MD, PhD, Head of Limb Deformity Reconstruction Unit, Department of Orthopedics, Sint Maartenskliniek, Hengstdal 3, 6522 JV Nijmegen, the Netherlands. E-mail: r.vanheerwaarden@maartenskliniek.nl

1048-6666/07/$-see front matter © 2007 Elsevier Inc. All rights reserved.
doi:10.1053/j.oto.2006.09.008

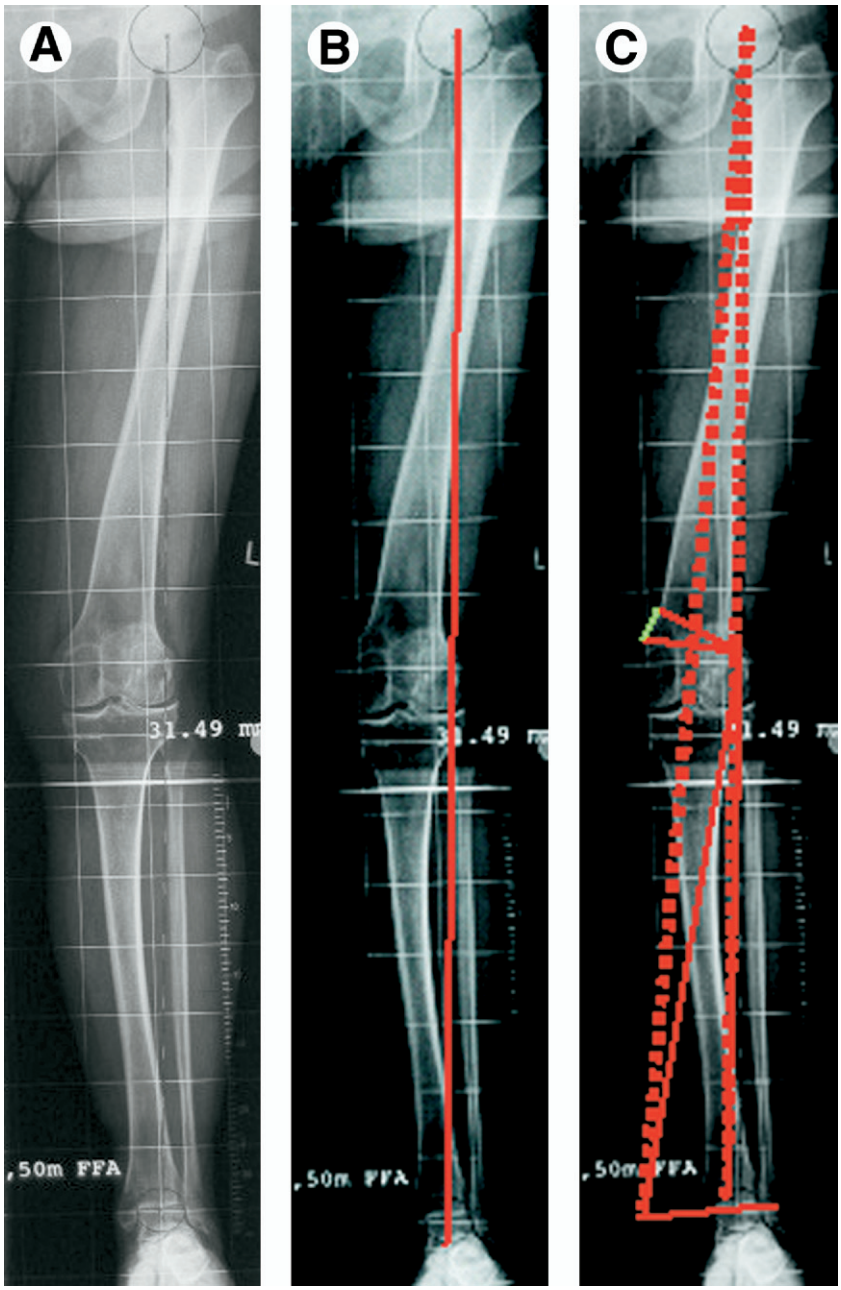


Figure 1 (A) Planning is based on a weight-bearing radiograph of the entire lower limb. (B) The red line shows the preoperative mechanical axis, which starts on the center of the head of the hip and ends in the middle of the ankle joint. (C) The surgeon needs an exact planning of the osteotomy. We use the method according to Miniaci. (Color version of figure is available online.)

Preoperative Preparation

Diagnostics

A detailed physical examination, including measuring the range of motion and the evaluation of the ligament laxity, should be performed. Knee radiographs in 3 planes should be performed; in addition, a frontal weight-bearing film of the entire lower limb is necessary (Fig. 1A). Magnetic resonance imaging (MRI) can give further information, but it is not absolutely necessary. In some cases, a brace treatment unloading the lateral compartment may be helpful to decide whether there is any pain reduction for the patient. Diagnostic arthroscopy under anesthesia immediate before osteotomy may help to evaluate the dimensions of the articular cartilage situation and can be combined with arthroscopic procedures (such as microfracturing, meniscectomy or debridement of the cartilage).

Planning of Surgery

Planning the correction of the mechanical lower limb axis is based on a weight-bearing radiograph of the entire lower limb.

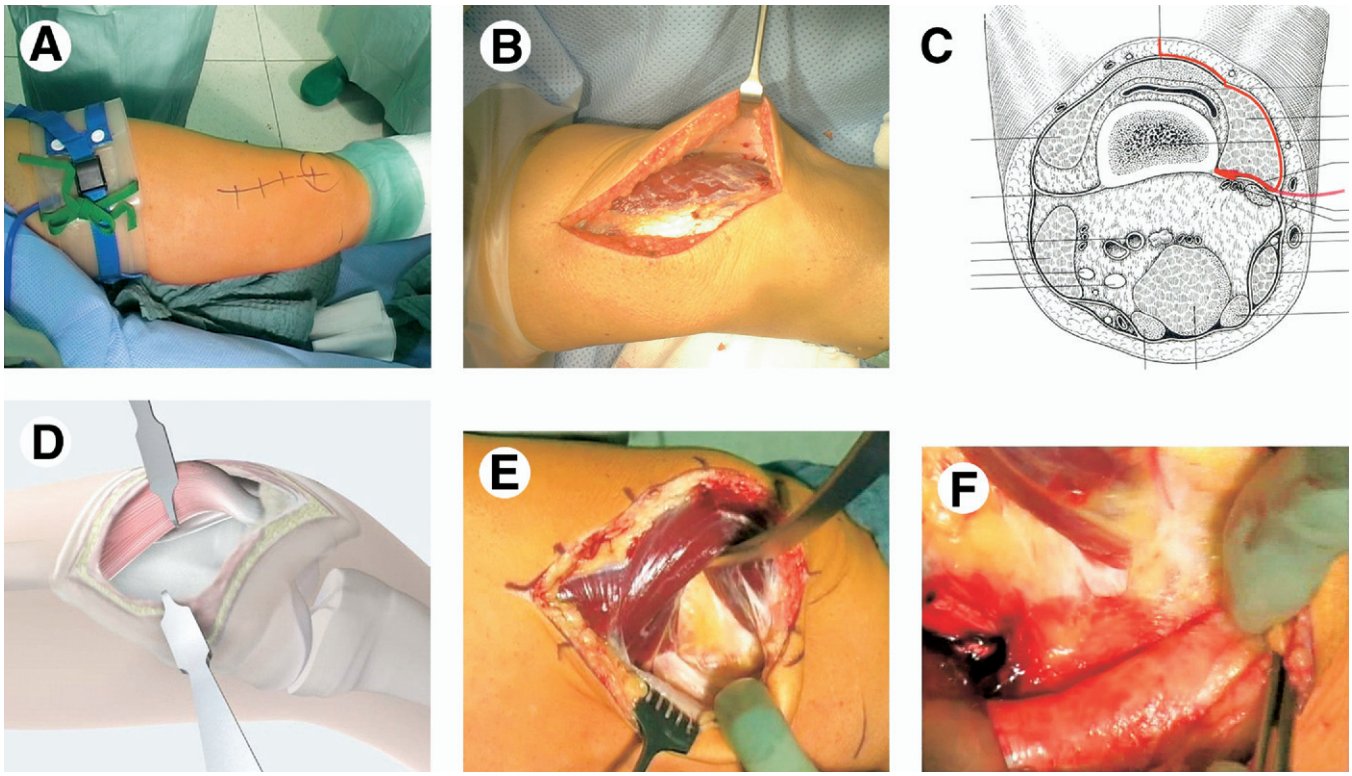


Figure 2 (A) The anatomic landmarks should be marked on the skin. The skin incision runs anteromedial in a longitudinal orientation, starting a hand width above the base of the patella and expanding to the upper one third of the patella distally. (B) After skin incision, the subcutaneous tissues are divided down to the anteromedial fascia. (C) The subvastus approach is used to expose the anteromedial aspect of the supracondylar area of the distal femur. The red line shows the direction of the sharp and blunt preparation around the vastus medialis muscle. Using this approach the danger of vessel and nerve injuries is small. (D and E) Hohmann retractors are positioned lateral and medial of the supracondylar area. (F) To enhance exposure, part of the medial patellofemoral ligament and the distal insertion of the vastus muscle is incised. To avoid patella instabilities, it is important to suture these structures at the end of the surgery.

Digital radiography obviates the need for drawings (Fig. 1). We use the planning method according to Miniaci.[4] In cases of valgus deformity without severe cartilage damage, the correction is planned so that the postoperative mechanical leg axis is in the physiological range (in comparision with the nonaffected leg) whereas in cases of valgus deformity with manifest lateral osteoarthritis the postoperative leg axis should run medial of the medial tibial spine. However, in the latest literature, no agreement exists for calculating the adequate leg axis.[1,5-7] In planning this procedure, Paley's principles of deformity correction should be respected.[2] No undue obliquity of the joint line should be tolerated and, in complex cases, even double osteotomies must be considered.

Positioning

The patient is positioned supine on the operating room table. Fluoroscopic visualization of the hip, knee, and ankle joint is possible during surgery. The entire limb is draped free including the iliac crest. If necessary a sterile tourniquet can be applied (Fig. 2A). A single shot of antibiotic is recommended preoperatively. The image intensifier is positioned at the side of the affected lower limb. The surgeon stands on the inner side of the affected limb. The contralateral leg is lowered in the hip to ease the approach.

Surgical Instruments and Implants

Besides the normal instruments for bone surgery, the following instruments are needed: TomoFix Plate Fixator (Synthes, Oberdorf, Switzerland) (Fig. 3A), bicortical or monocortical locking screws (Fig. 3B), an oscillating saw with a broad saw blade of 90 mm in length, a sawguide or K-wires for marking the osteotomy, an image intensifier, a sterile rigid long leg alignment bar for verifying the leg axis, and a sterile caliper for intraoperative measurement of the osteotomy wedge height.

Anesthesia

Endotracheal or epidural anesthesia is possible.

Surgical Technique

Step 1: Approach

Surgery starts in the extended position of the affected knee (Fig. 2A). The anatomic landmarks should be marked on the skin. The skin incision runs anteromedial in a longitudinal way starting a hand width above the basis of the patella extending distally over the upper one third of the patella. This skin incision can be reused and expanded during future knee

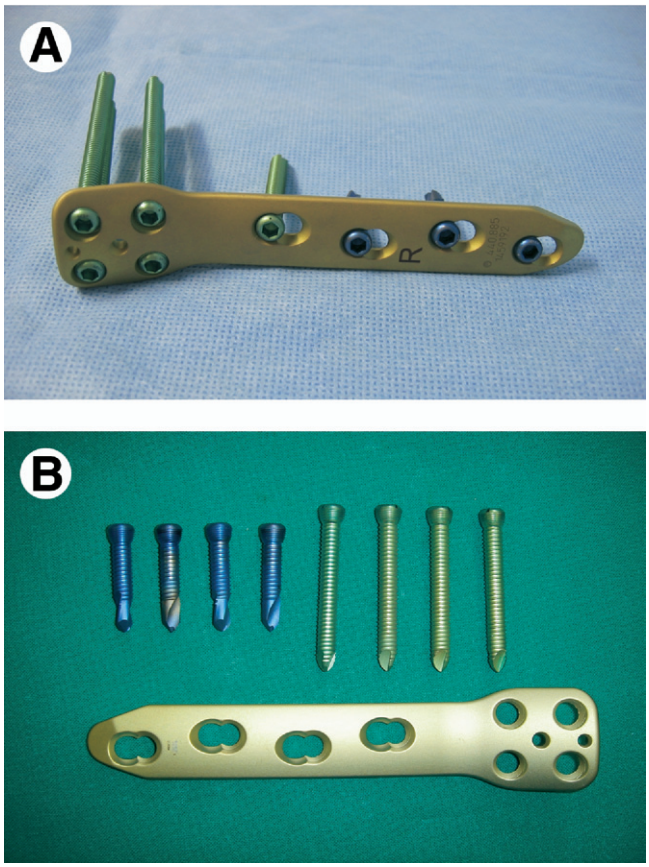


Figure 3 (A and B) TomoFix Plate Fixator for the closed-wedge distal femur osteotomy and the locking bolts. The green screws are self tapping and the blue screws are self-tapping and self-drilling. (Color version of figure is available online.)

surgery thus reducing potential wound problems in the future.

Step 2: Dissection

After skin incision and division of the subcutaneous tissues down to the anteromedial fascia (Fig. 2A and B), the fascia is incised. After blunt and sharp preparation around the vastus medialis muscle (Fig. 2C), the anteromedial part of the supracondylar area is exposed using a Hohmann retractor positioned anterior and posterior of the femur shaft (Fig. 2D and E). Carefully, the posterior side of the femur is approached subperiostially with a rasp to avoid damage to the neurovascular structures localized posterior of the intermuscular septum. Another blunt Hohmann retractor is positioned anterior of the femur, in contact with the bone. To enhance exposure a part of the medial patellofemoral ligament and the distal insertion of the vastus medial muscle are incised (Fig. 2F). To ease correct placement of the fixator plate proximally, the femur shaft is exposed by dissection of the vastus medialis from the septum. The periosteum should not be violated.

Step 3: Osteotomy

The oblique osteotomy starts in the medial supracondylar area and ends in the lateral condyle, approximately 10 mm inside the lateral cortex (Fig. 4A). The distal saw cut of the osteotomy should end about 10 mm above the upper border of the patella groove. For an adequate exposure of the upper border of the patella groove a mini-arthrotomy may be used enabling palpation of the groove. Alternatively, an image intensifier may be helpful. The plate is positioned over the planned osteotomy area and electrocautery is used to mark the lower sawcut height medially on the femur, just proximal to the distal part of the plate. For guiding the sawcuts of the distal femur osteotomy different sawguides (ie, Balansys, Mathys; Fig. 4B) are available. Alternatively, it is possible to use two K-wires and the image intensifier to mark the bone cuts.

After positioning the saw guide (Fig. 4C-E) the saw cuts are made with retractors protecting the soft tissues and vessels (Fig. 4F). The speed of the oscillating saw should be low to not heat the bone as the whole length of the osteotomy cut is made, ending at the K-wire marking the hinge point. Constant rinsing is mandatory to cool the saw blade. The wedge is removed (Fig. 4G) and the depth of the osteotomy can be measured for instance with a sterile ruler. It is important to inspect the area of the resected wedge because remaining bone fragments may cause incomplete closure or even a fracture of the lateral cortex during closure. With a sterile caliper, the wedge base size is compared with the preoperative planned size. At this time, it is possible to make modifications concerning the wedge size.

Step 4: Closing the Osteotomy

Before closing the wedge, electrocautery is used to mark 2 longitudinal alignment lines on the medial side of the femur diaphysis, just proximal and distal of the wedge. Through this, it is possible to avoid false rotational positions of the fragments. In case of fracturing the lateral cortex with instability of the osteotomy, the electrocautary markings are a useful help for restoration of the correct rotation of the leg.

Closing the wedge must be performed gradually by gentle compression of the lower leg laterally, stabilizing the knee joint medially near the area of osteotomy. It may take several minutes to enable plastic deformation of the lateral cortex to close the osteotomy gap (Fig. 5). After closure, the surgeon has to make sure that the rotational alignment is correct checking electrocautary markings. Although initially stable after closing of the wedge, the leg should be handled gently before fixation to prevent fracture and secondary displacement.

Step 5: Fixation of the Osteotomy

The osteotomy may temporarily be stabilized by crossed K-wires placement outside the area of future plate fixation. Leg alignment is checked radiologically after closing with a rigid alignment bar positioned between hip and ankle center (Fig. 6). The bar representing the weight-bearing line should pass the knee joint at the preoperatively defined mechanical axis.

Step 6: Implant Preparation and Insertion

After screwing the threaded LCP drill guides into the 4 distal plate holes using the guiding block (Fig. 7A and B), the plate is

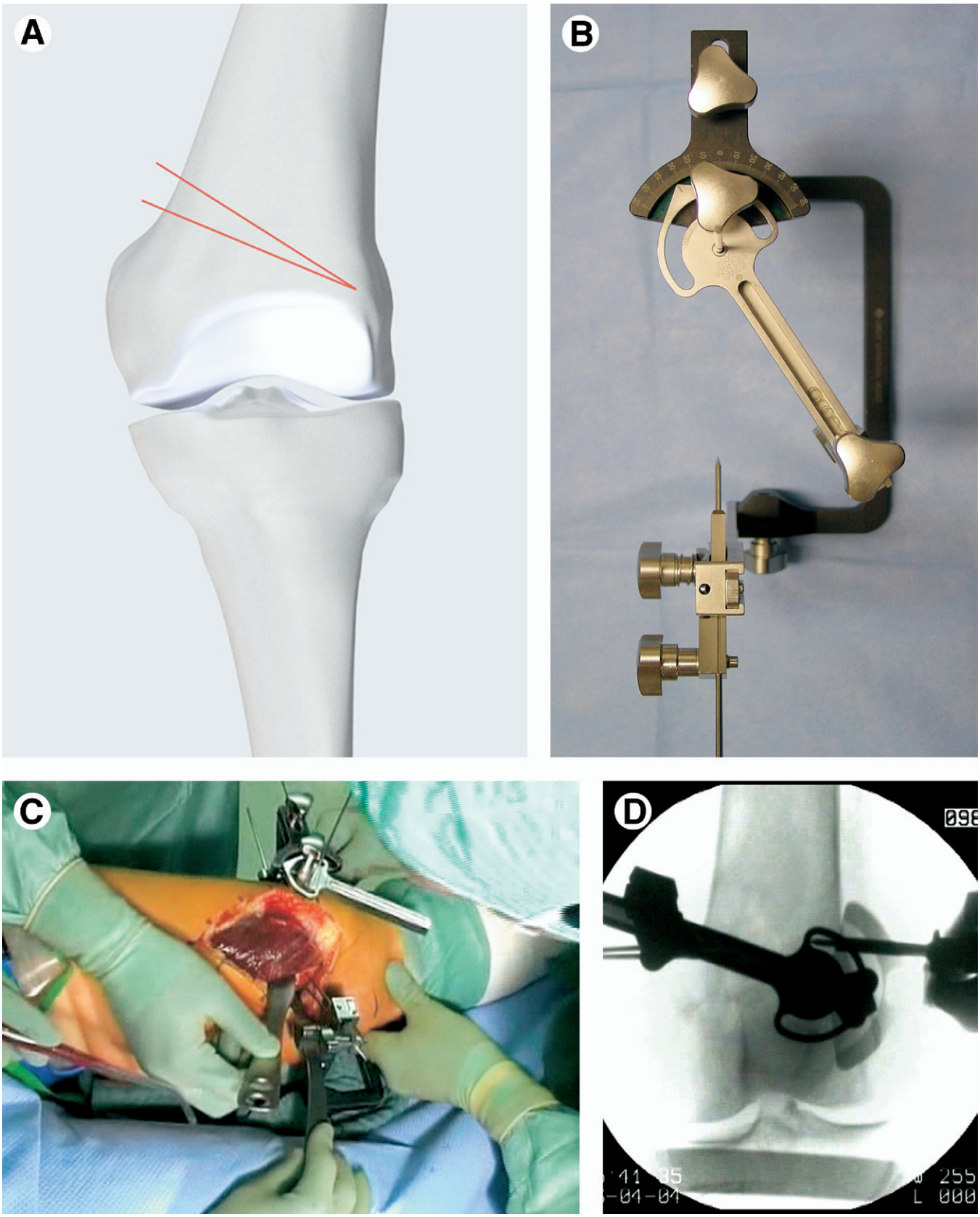
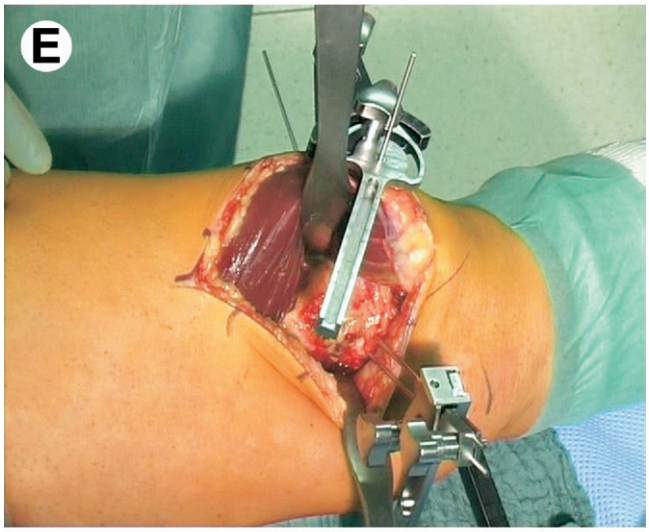
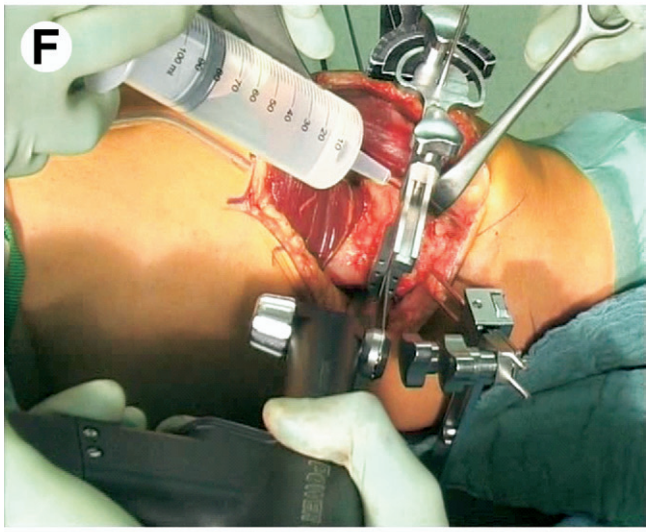


Figure 4 (A) The oblique osteotomy starts in the medial supracondylar area and ends in the lateral femoral condyle. It is an incomplete osteotomy, which means that the bone cuts end approximately 10 mm within the lateral cortex. (B) We use this special saw guide (Balansys, Mathys) for the bone cuts. (C-E) The saw guide is positioned in the supracondylar area of the femur using the image intensifier. (F) To avoid any heat damage of the bone, the saw cuts are made under intensive rinsing with water. (G) The bone wedge is removed.





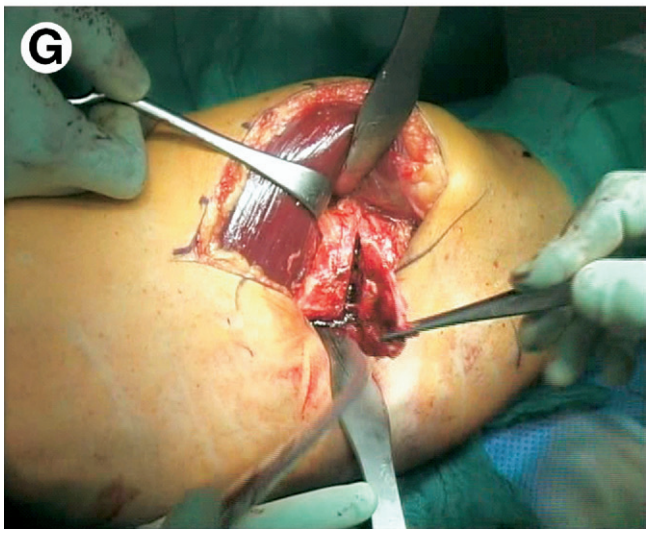


Figure 4 (continued)

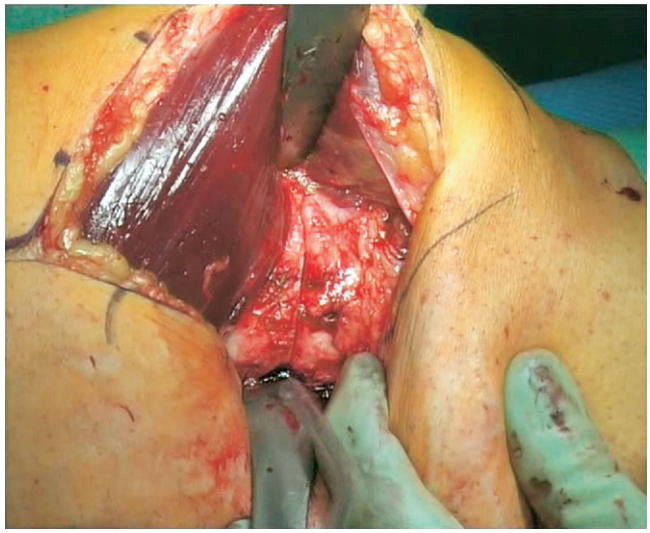


Figure 5 Closing the wedge must be very gentle and carefully. This procedure may take several minutes, caused by the plastic deformation of the bone.

inserted from distal under the vastus medial muscle (Fig. 7C). The distal part of the plate needs to be positioned on the anteromedial part of the femur distal of the osteotomy (Fig. 7D). Keep in mind that there is a right and a left version of the plate. The distal drill holes are oriented in a 20° angle anterior to avoid posterior perforation of locking head screws after anteromedial plate positioning on the distal femur. The shaft of the plate is aligned parallel to the anterior border of the femur and a temporary fixation is performed with a 2-mm-K-wire using a guide sleeve inserted in a drill guide (Fig. 7E). Control the position of the plate and wire relative to the osteotomy using the image intensifier (Fig. 7F). It must be stressed that as the plate is an internal fixator precise fit on the femur is not necessary for a stable fixation. However, no compromise should be made concerning the frontal or sagittal position of the plate as this may

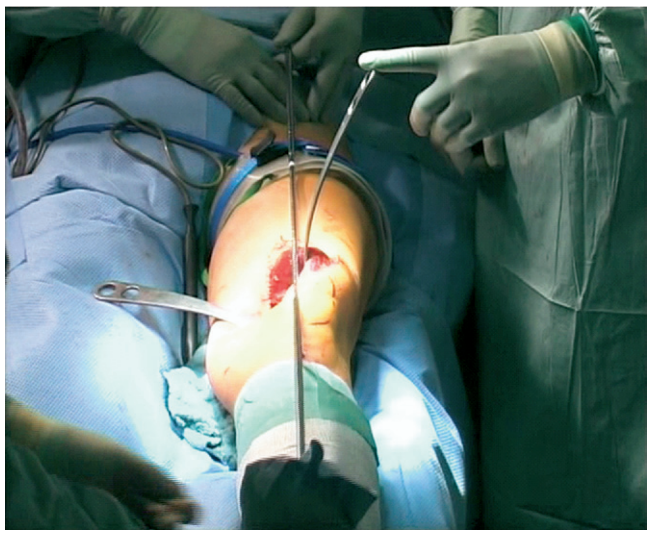


Figure 6 Check of the mechanical axis after wedge closure using a rigid alignment bar positioned at the center of the head of the hip and the middle of the ankle joint.

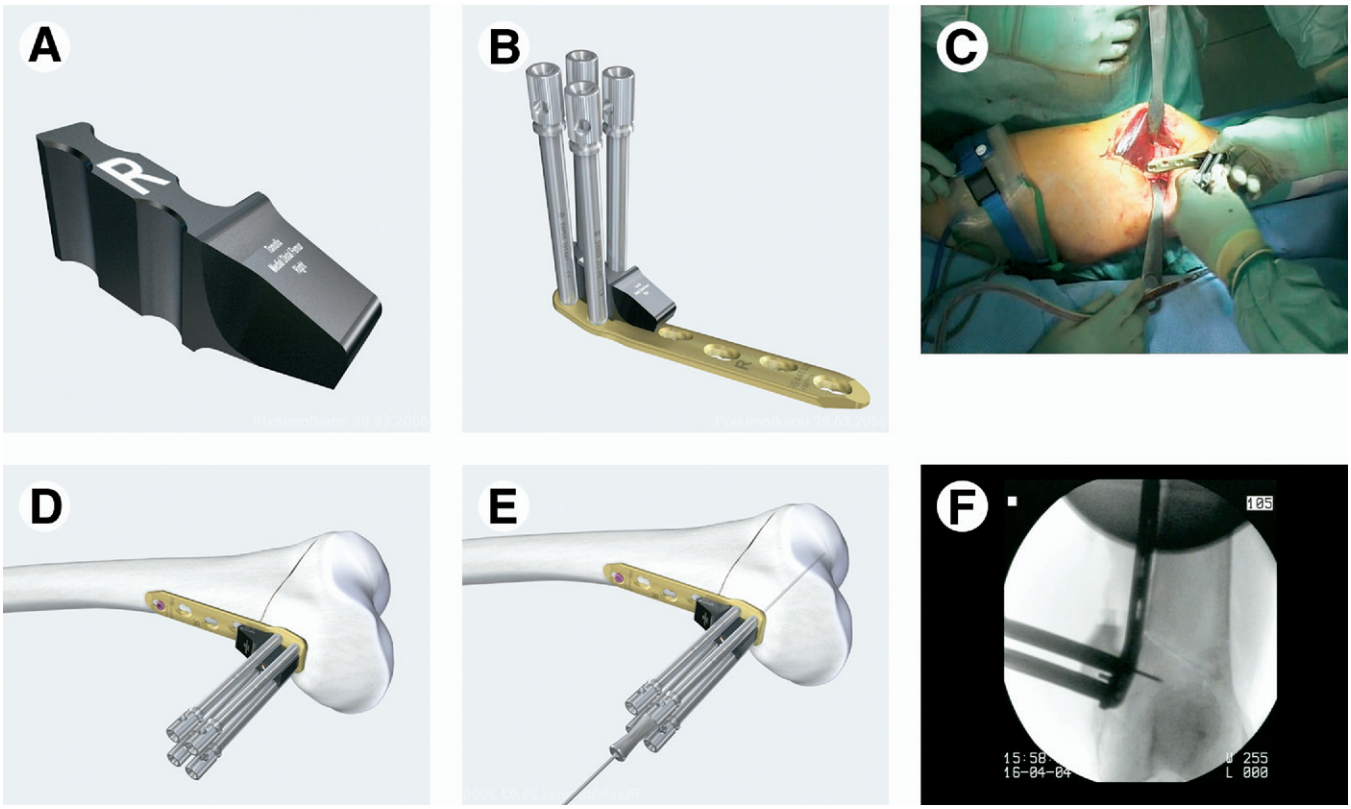


Figure 7 (A) Guiding block. There is a left and a right version. (B) The guiding block is necessary to find the exact position for the LCP drill guides. (C and D) The shaft of the fixator is aligned parallel to the anterior border of the femur. (E and F) The TomoFix plate fixator is fixed temporarily with a 2 mm K-wire. (Color version of figure is available online.)

cause suboptimal position and length of the locking head screws in the femur condyles.

Step 7: Osteosynthesis

After defining the optimal position of the plate insertion the screw holes for selftapping screws (5.0 locking head screws) are drilled through the drill guide with the calibrated 4-mm drill bit. Drill depth and required screw length can be read directly from the drill bit or measured with a standard depth gauge after removal of the drill guide. Insertion of locking head bolts (LHBs) is performed using the power tool and manual locking using the torque-limiting screwdriver to lock the LHB in the plate. A lateral perforation of the screws should be avoided.

Step 8: Compression

Biomechanical studies demonstrate that interfragmentary compression has a positive effect on bone healing. For this reason, a lag screw is positioned in the dynamic hole directly above the osteotomy for compression of the osteotomy site. If more compression is needed a compression unit can be inserted proximally but this necessitates an enlarged incision. In the special situation of intraoperative fracturing of the lateral cortex it is possible to use an alternative compression method. Compression of the lateral cortical hinge of the osteotomy can then be achieved by directing the lag screw more proximally.

Step 9: Completing the Osteotomy

Insertion of monocortical selfdrilling and selftapping LHB in the 3 remaining holes proximal from the inserted lag screw provide for an angular-stable plate fixation on the femur

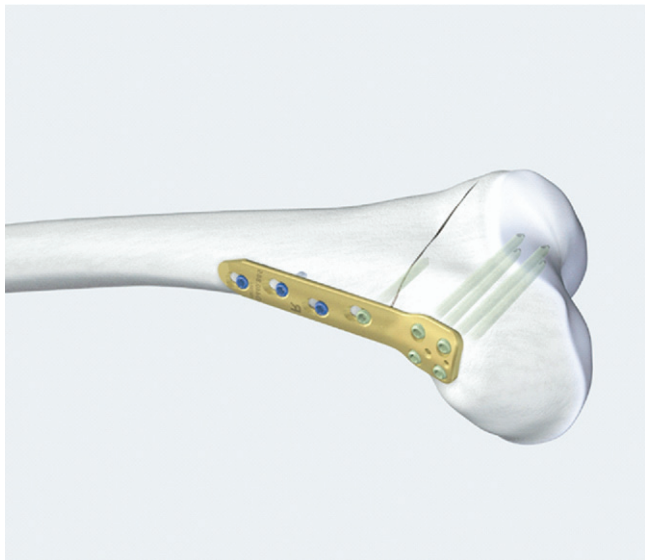


Figure 8 TomoFix Plate fixator with all screws inserted. (Color version of figure is available online.)

shaft. For central positioning of the LHB, the universal drill sleeve may be used to center-punch the hole before screw insertion. Normally, self-drilling and self-tapping LHB with the length of 26 to 30 mm are used for unicortical fixation. The LCB spacer in the most proximal hole is replaced by a monocortical LHB. Finally, the cortical lag screw is replaced by a selftapping bicortical LHB (Fig. 8) Alternatively, a unicortical screw may be used if the lateral cortex is intact after wedge closure (Fig. 9).

Step 10: Control With Image Intensifier

Check of position and length of all screws and stability check of the osteotomy with the image intensifier (Fig. 9).

Step 11: Closure

If used a closure of the miniarthrotomy is achieved with a running suture. In case a tourniquet was used, this may be released at this time and possible bleedings are coagulated. Care must be taken for anatomical reinsertion of the medial patellofemoral ligament and the partly released distal insertion of the vastus medialis muscle. Reapproximation and closure of the fascia of the medial vastus muscle is performed after a redon drain was placed. An intracutaneous skin closure is performed. A compressive bandage is applied to the entire leg and radiographs in 2 planes are made immediately after surgery.

Postoperative Treatment

Careful exercises may be started on day one after surgery. To reduce hematoma and swelling, the exercises should be performed in bed on the first postoperative day (Fig. 10A-C). To alleviate pain, adequate analgesics according to the World Health Organization schema should be applied. First, changing of the surgical dressing, including removal of the vacuum drain, is performed on the first postoperative day. The range of motion is limited to 90° of flexion and the patient's weight bearing should not be greater than 15 to 20 kg for 6 to 8 weeks postoperatively using 2 crutches. The use of an orthesis is only indicated in special situations. To avoid swelling and hematoma, it may be helpful to prescribe lymph drainage as well as to use a vein compression pump. Electric myostimulation also has shown positive effects. Before discharge on the 5th to 7th postoperative day it is important to make a radiographic control (Fig. 10D and E). Weight-bearing limitation needs to be continued until a consolidation of the osteotomy is viewed on the radiographs. In patients with critical bone healing or initially less stable situations, a more cautious weight-bearing protocol be set up. During further treatment, radiographs to evaluate bone healing should be planned 6 and 12 weeks and 1 year after surgery.

Figure 9 (A and B) Radiographic control in two planes after the osteosynthesis.

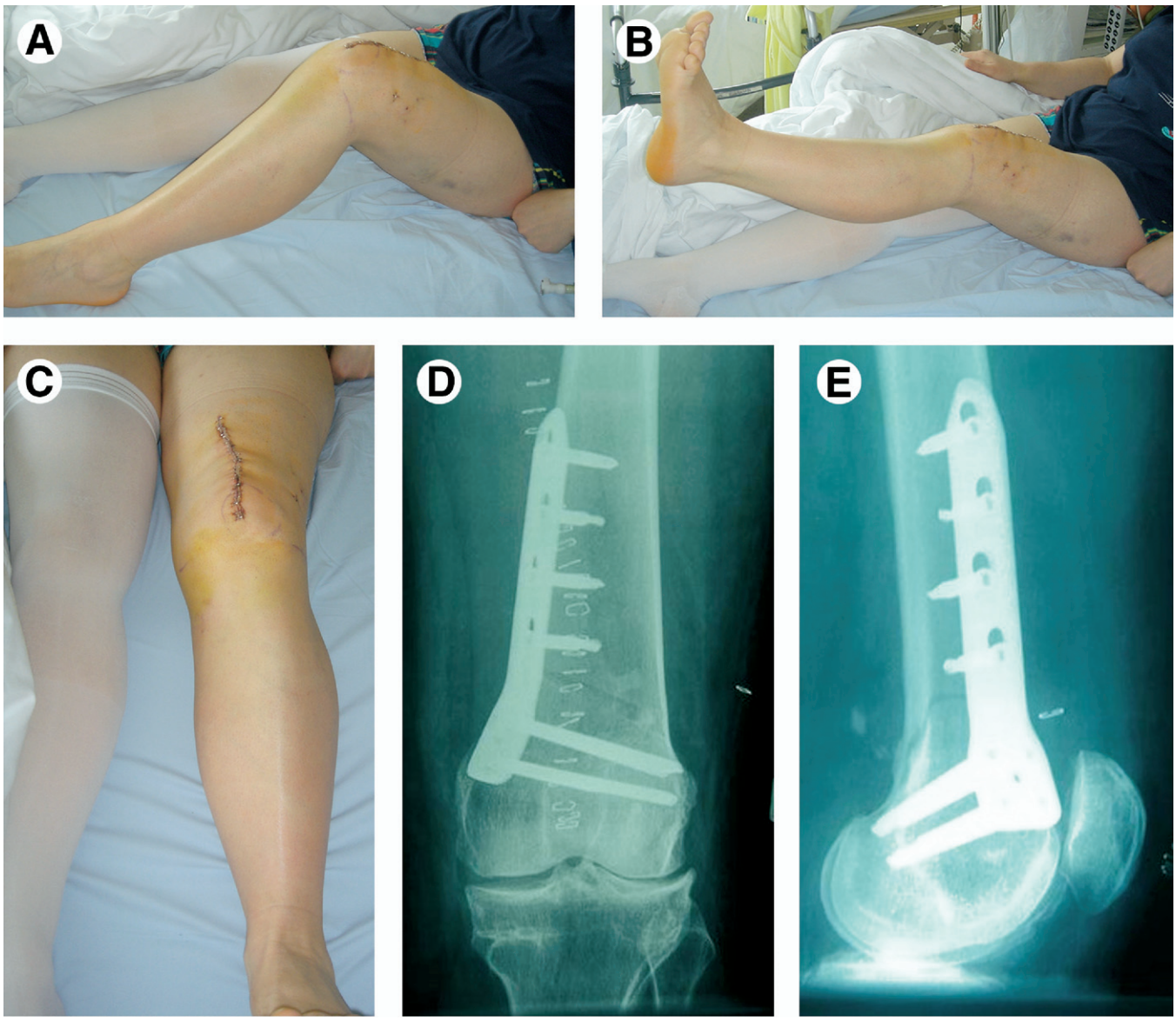


Figure 10 (A-C) Female patient 5 days after femoral closed wedge osteotomy. Normally, there is no need for a brace or an orthesis; (D and E) radiograph control. (Color version of figure is available online.)

Pitfalls

Application of the Tomofix plate fixator requires specific practice with the implant and the technique. The angle stable locking must be done in a precise manner, keeping in mind the predetermined direction for the locking head screws in the plate holes. This is why an accurate positioning of the Tomofix implant on the distal femur is fundamental. The shaft part of the plate should be aligned along the femur parallel to the anterior border. The distal plate head must be positioned anteromedially irrespective of precise plate fit to the bone, since the principle of the plate fixator does not demand a form-closed fit on the bone.

To avoid an overcorrection or undercorrection of the leg axis, it is important to perform a careful preoperative planning. An intraoperative examination of the leg axis is recommended because planning mistakes can be detected and corrected before osteosynthesis with plate fixation. Concerning the soft tissues, it is of outmost importance to reinsert the incised medial patellofemoral ligament and the distal insertion of the vastus medial muscle, otherwise a patella instability with lateral subluxations may result. Osteotomy of the posterior femur cortex runs the risk of injuring the femoral arteria and vein or the ischiadic nerve. This is why it is important to position the Hohmann-retractor with caution. Posteromedially, directly behind the septum intermusculare the descending arterial and venous genicular branches are at risk and should be coagulated.

An accidental lesion of a major vessel during surgery results in a serious bleeding after detaching the tourniquet. In this case vascular repair or reconstruction is necessary using a posteromedial or posterior approach. It is advisible to apply medicamentous and physical treatment at an early stage to prevent a serious soft-tissue swelling and lymphpoedema.

We recommend lymphatic drainage, a vein compression pump, and antiphlogistic therapy.

The risks of pulmonary embolism and deep vein thrombosis have to be considered. Prophylactic use of low fragment heparine is recommended. Also, because the fascia of the vastus medialis muscle is closed again at the end of surgery, a compartment syndrome could develop after surgery in case of a large hematoma, which would require urgent surgical revision.

A postoperative early infection requires surgical revision with debridement and antibiotic therapy. In cases of stabile osteosynthesis and intact soft tissues, the plate fixator does not need to be substituted by an external fixator. Patients with slower bone healing complain of pain when weight bearing is increased. If no consolidation of bone is seen after 3 months, a cancellous bone grafting procedure from the iliac crest is recommended.

Results

A total of 59 procedures were performed in our departments. The average wedge size was 7.3 mm (range, 4-12), and the mean age of the patients was 37.5 years (17-79.57; osteotomies healed uneventfully, 2 patients required secondary bone grafting and reosteosynthesis). There was one infection, which healed after revision, and one hematoma requiring evacuation.

Conclusion

Distal femur closed wedge varus osteotomy stabilized with the TomoFix plate fixator is a safe surgical technique with fewer pitfalls compared to other supracondylar osteotomy techniques for correction of valgus leg alignment.

Acknowledgments

We thank Meike von zur Muehlen, MD, from the Surgical Department of Albertinenkrankenhaus, Hamburg, Germany, for making important contributions to the manuscript.

References

1. Franco V, Cipolla M, Gerullo G, et al: Open wedge osteotomy of the distal femur for valgus knee. Orthopäde 33:185-192, 2004
2. Paley D: Principles of deformity correction. Berlin, Springer, 2000
3. Outerbridge RE: The etiology of chondromalcia patellae. J Bone Joint Surg 43B;752-757, 1961
4. Pape D, Seil R, Adam, et al: Imaging and preoperative planning for high tibial osteotomy. Orthopäde 33:122-134, 2004
5. van Heerwaarden R, Wymenga A: Die suprakondyläre varisierende Femurosteotomie mit speziellem Plattenfixateur, in Lobenhoffer P, Agneskirchner JD, Galla M (eds): Kniegelenknahe Umstellungsosteotomien. Stuttgart, Germany, Thieme Verlag, 2006, pp 93-106
6. Cameron HU, Botsford DJ, Park YS: Prognostic factors in the outcome of supracondylar femoral osteotomy for lateral compartment osteoarthritis of the knee. Can J Surg 40:114-118, 1997
7. Mathews J, Cobb AG, Richardson S, et al: Distal femoral osteotomy for lateral compartment osteoarthritis of the knee. Orthopedics 21:437-440, 1998