



# Valgus High Tibial Osteotomy: Lateral Closing and Medial Opening

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## Introduction

In patients who have osteoarthritis of the medial compartment of the knee in association with genu varum, a high tibial osteotomy (HTO) remains an important surgical option. The clinical outcome at 10 years continues to be favorable in more than 70% of the patients if the frontal angular malalignment has been corrected to 3–6 degrees of valgus.

The main reasons for failure are:

1. Initial under correction with the presence of a residual varus deformity. Even if a temporary improvement is often observed, after 3–5 years a reoperation is often required.
2. Overcorrection with progressive lateral arthritis. In cases of overcorrection, the adaptation of the patient to the new alignment is very difficult and takes more than 1 year. During this period, the patient complains not only of ankle pain, but also feels very uncomfortable with the deformity. Most often the patient doesn't accept this overcorrection and a reoperation must be proposed before this, in the 2-year follow-up period. Any distal valgus deformity, for instance hindfoot valgus from posterior tibial tendon disorder, may exacerbate this problem. This needs to be sought preoperatively; it may not be obvious on alignment X-rays (Figs. 17.1 and 17.2).

3. Development of patellofemoral arthritis.

Two surgical techniques are available. The medial opening wedge HTO may require the use of a tri-cortical bone graft from the iliac crest (or bone substitute) for large corrections and the lateral closing wedge HTO requires an osteotomy of the fibula neck. The clinical outcome is more predictable in patients who are not obese. Therefore, we generally provide information on a weight loss program preoperatively. In the young, sports-minded patient, the osteotomy still remains the option of choice above an arthroplasty, particularly if the deformity is from extra-articular bone deformity. We prefer until today to use a plate with locking screws (e.g., Tomofix) in medial opening wedge osteotomies. This technique has the benefit of not requiring a bone graft although with large corrections it may be advisable.

We are working on the development of a customized plate with a new and optimal design. This will allow individualized correction in all planes and the fixation will ensure better control of the rotation, despite using a smaller plate.

*Radiological evaluation:* See the chapter on surgical indications and osteoarthritis. In the case of evolved osteoarthritis, the amount of opening or closing of the osteotomy needed to obtain a valgus correction of 3–6° is calculated with respect to the width of the tibia at the level of the osteotomy and the angular correction needed (Fig. 17.3). In early osteoarthritis, and particularly when the patient wants to continue to practice sports, the target is less and must be adapted (between 0 and 3°).

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## Lateral Closing Wedge HTO

### Set-Up

The patient is placed in the supine position. A tourniquet is generally used. The patient is draped using an extremity sheet (Fig. 17.4). The image intensifier is positioned



**Fig. 17.1** Valgus hindfoot deformity. This must be taken into account when calculating the overall limb alignment

temporarily to ensure sufficient access to the entire limb, including the hip. A slightly oblique, almost horizontal, anterolateral skin incision is used. It starts 1 cm above the anterior tibial tuberosity and proceeds laterally to 1 cm below the fibular head (Fig. 17.5). The fascia of the proximal portion of the origin of the tibialis anterior is released as a Z-plasty. Subsequently, the tibialis anterior muscle and the long toe extensor muscle are released from the tibial metaphysis using a large periosteal elevator (Fig. 17.6).

### Osteotomy of the Neck of the Fibula

The neck of the fibula is identified and exposed. A periosteal elevator is slid around the neck always staying in contact with the bone. This maneuver protects the peroneal nerve (Fig. 17.7).

Four holes are now drilled in the neck using 3.2 mm drill. With the use of the osteotome, the four holes are interconnected and the segment is removed using a large grasper. The two dis-



**Fig. 17.2** The patient needed early conversion to TKA

tal holes are joined first (Fig. 17.8); if the proximal holes are cut first, the distal cut becomes difficult due to the increased mobility of the fibula shaft. Free mobility of the shaft confirms completion of the osteotomy. Care must be taken that the peroneal nerve is not in contact with the osteotomy site.

### Tibial Osteotomy

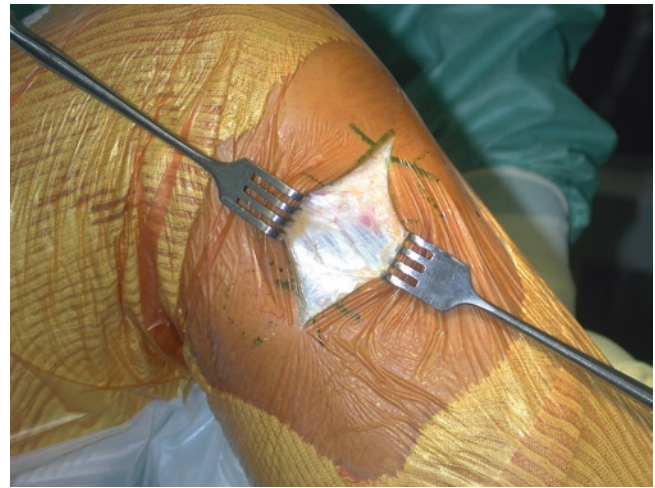
Specific instruments help perform the osteotomy and achieve its fixation in a reproducible way. The osteotomy is performed proximal to the tibial tubercle in an oblique direction in both coronal and sagittal planes.

Identification of both starting point and direction of the osteotomy with imaging is not necessary if the following rules are respected.

- Laterally, the osteotomy should start distal to the proximal tibiofibular joint and should cross the tibia proximal to the tibial tubercle. In this direction, there is no danger to the tibial plateau (Fig. 17.9).
- The patellar tendon should be protected during the procedure.
- Always use imaging to control the amount of alignment correction that is to be obtained during the operation.



**Fig. 17.3** Femorotibial mechanical angle of  $170^\circ$ : a correction of  $13^\circ$  ( $10^\circ + 3^\circ$ ) is planned for the osteotomy



**Fig. 17.5** Oblique skin incision



**Fig. 17.6** The tibialis anterior muscle and the long toe extensor muscle are released from the tibial metaphysis

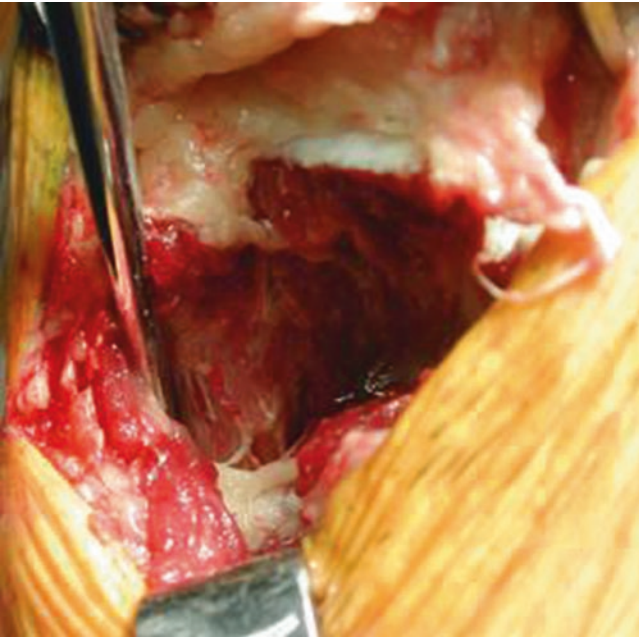


**Fig. 17.4** Patient set-up

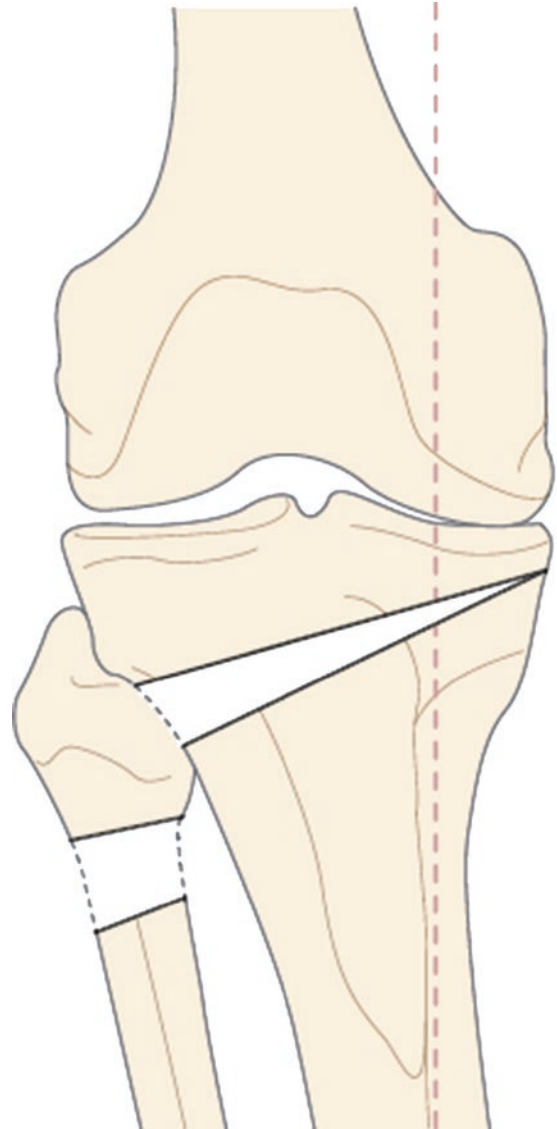
We currently use the Lepine HTO plate for the fixation (Fig. 17.10). This blade plate/screw system has been specifically designed to minimize subcutaneous irritation. The improvement of the fixation is due to the locking screws. We first use a normal 4.5 mm bi-cortical screw, producing good compression. The second screw (6.5 mm locking screw) is placed, followed by exchange of the 4.5 mm screw for another locking screw. The fixation achieved is very rigid and a variety of plate and screw sizes accommodate different tibial widths.

(a) Introduction of the guide pin parallel to the joint line.

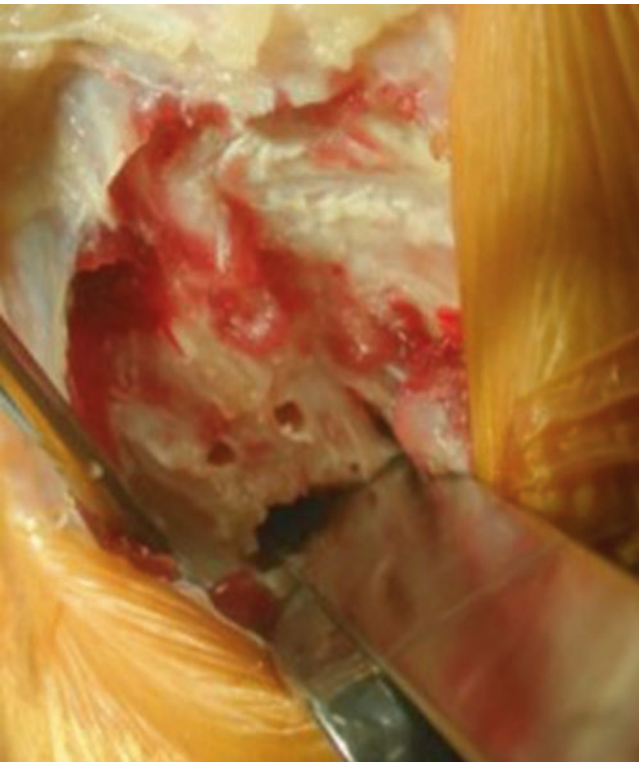
A small guide pin is introduced at the level of the joint line and an alignment guide is placed over it (Fig. 17.11). This guide will position the second guide pin parallel to the joint line and 1 cm distal to it.



**Fig. 17.7** Protection of the peroneal nerve



**Fig. 17.9** The correct direction of the osteotomy



**Fig. 17.8** The two distal fibula holes are connected first with an osteotome



**Fig. 17.10** HTO blade (Lepine®)



**Fig. 17.11** Introduction of the guide pin parallel to the joint line



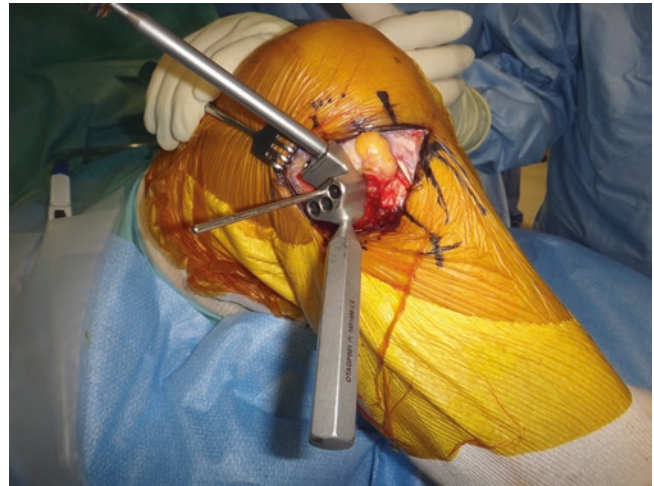
**Fig. 17.13** Blade chisel introduction over the guide pin



**Fig. 17.12** Blade reamer introduction over the second guide pin

(b) Blade reamer introduction over the second guide pin (Figs. 17.12 and 17.13).

The length of the blade should be 1 cm shorter than the total width of the tibia.



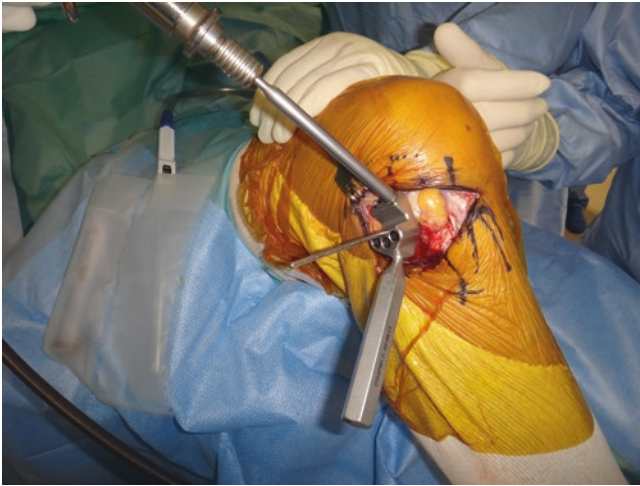
**Fig. 17.14** Preparation of the socket and screw holes for the blade

(c) Socket and screw hole preparation for the blade.

The box preparation guide with drill guides already assembled is introduced over the guide pin and impacted (Figs. 17.14 and 17.15). Four drill holes are made with 6 mm diameter.

(d) Introduction of the HTO blade.

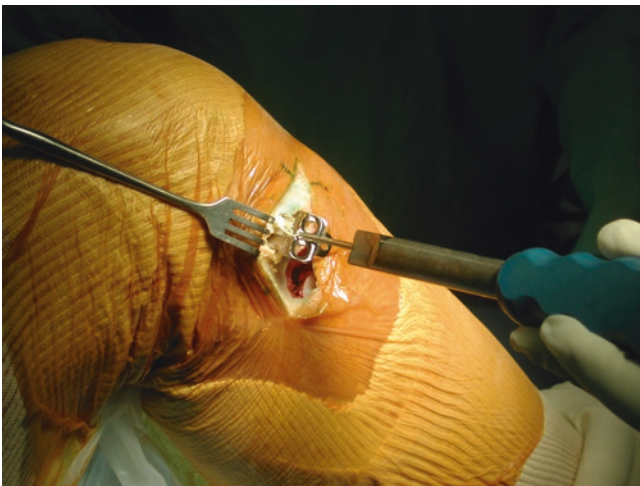
The blade, with screw guides already assembled, is introduced and impacted into the socket (Fig. 17.16).



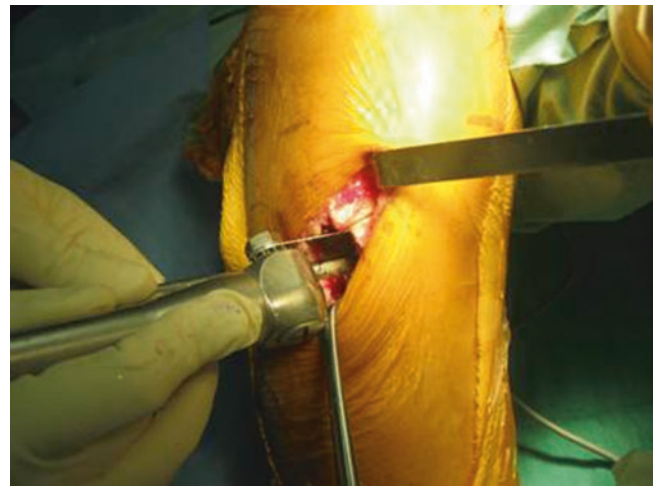
**Fig. 17.15** Preparation of the socket and screw holes for the blade



**Fig. 17.17** The posterior surface of the tibia is protected by a large radiolucent protector, and anteriorly the patellar tendon is retracted



**Fig. 17.16** Introduction of the HTO blade. The screw guides must be in place before seating the blade



**Fig. 17.18** Freehand distal cut of the osteotomy

(e) Distal cut of the closing wedge osteotomy.

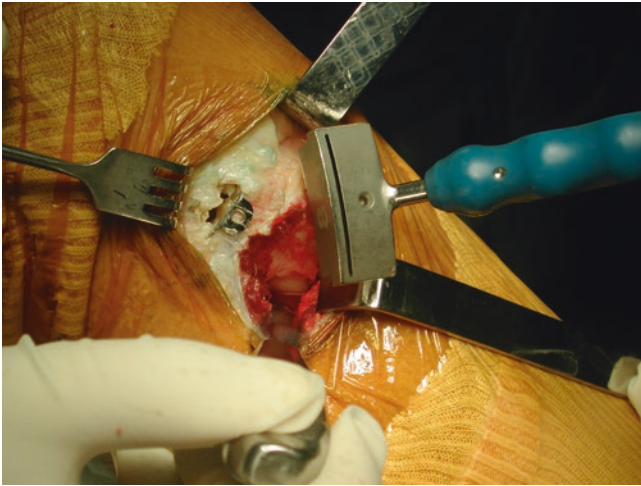
Many surgeons use a guide pin for the distal cut of the osteotomy, but we do not feel this is necessary. The posterior surface of the tibia is protected by a large radiolucent protector, and anteriorly the patellar tendon is retracted (Fig. 17.17). An oscillating saw is used to perform the distal cut freehand (Fig. 17.18).

(f) Proximal cut:

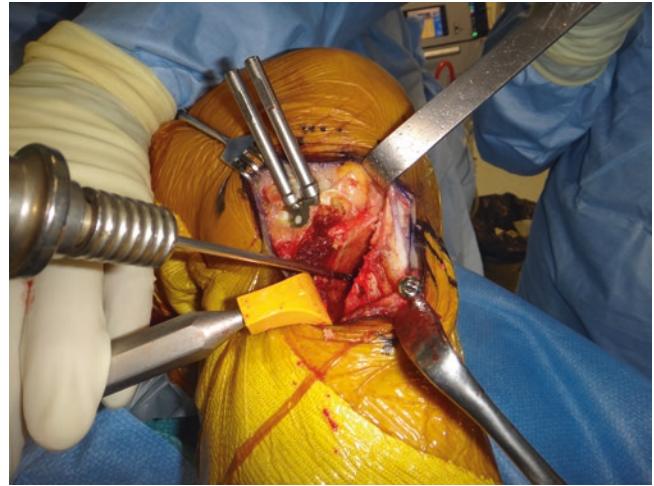
The appropriate angled cutting guide ( $6-8-10^\circ$ ) is introduced in the distal cut of the osteotomy, and the proximal cut is now performed using this angle (Fig. 17.19). The cutting guide should be introduced and fully impacted onto the medial cortex (Fig. 17.20). An oscillating saw is used to make the cut and the bone wedge is removed (Fig. 17.21).



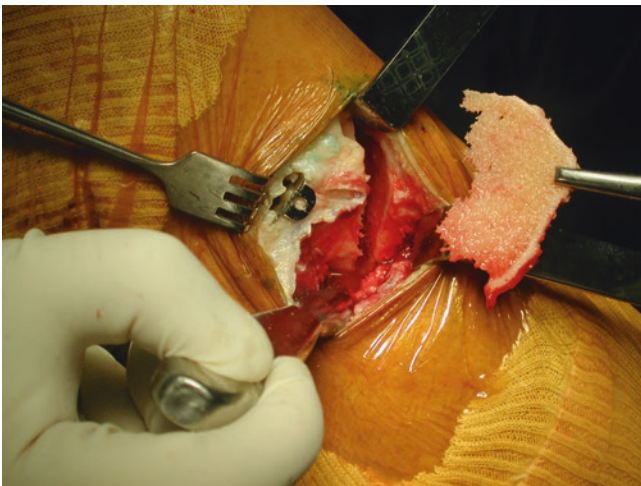
**Fig. 17.19** Proximal cutting guide (6-8-10) being introduced into the distal cut



**Fig. 17.20** The cutting guide should be fully impacted onto the medial cortex



**Fig. 17.22** The medial cortex is weakened with a 3.2 mm drill



**Fig. 17.21** Bone wedge removal



**Fig. 17.23** Closing the osteotomy using the reduction clamp and inserting a temporary compression screw

(g) Closing the wedge and image intensifier control of the obtained mechanical axis:

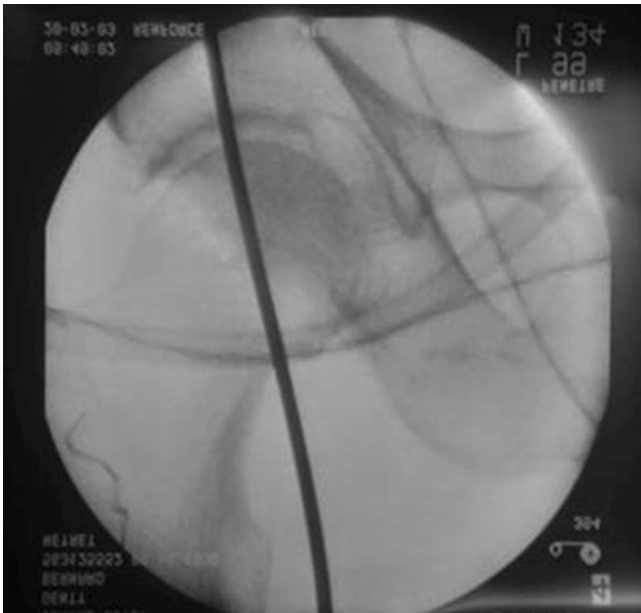
The medial cortex is breached with a 3.2 mm drill (Fig. 17.22). Distal to the osteotomy a temporary unicortical screw is positioned. This screw will be used as the fixation point for the reduction clamp. The wedge is closed with the reduction clamp (Fig. 17.23). Using a long metal rod positioned on the center of the femoral head and in a middle of the ankle joint, the mechanical axis of the limb is evaluated. The axis should pass just lateral to the lateral tibial spine (Figs. 17.24 and 17.25).

(h) Fixation of the osteotomy.

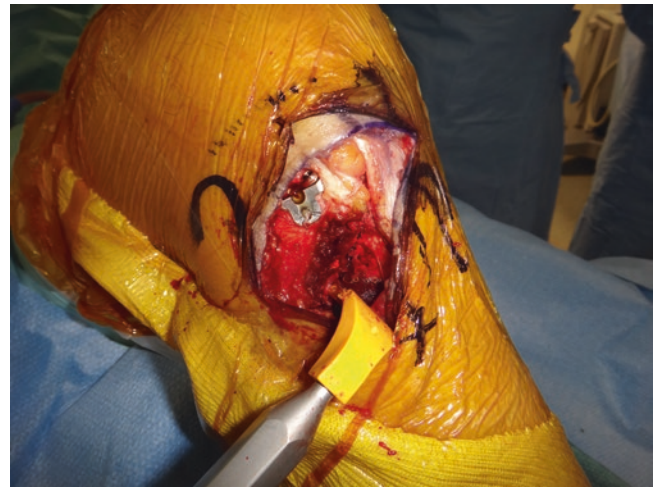
One bi-cortical 4.5 mm screw, and then the first locking screw are introduced through the blade into the distal tibia. The 4.5 mm screw is then replaced by the second 6.5 mm locking screw to complete the fixation (Figs. 17.26 and 17.27). The muscle insertions are closed over a drain. The skin is closed with interrupted sutures.

Two specific complications can be observed after a closing wedge HTO. We must carefully check the neurovascular status at the end of surgery and also to pay attention to uncontrolled pain postoperatively.

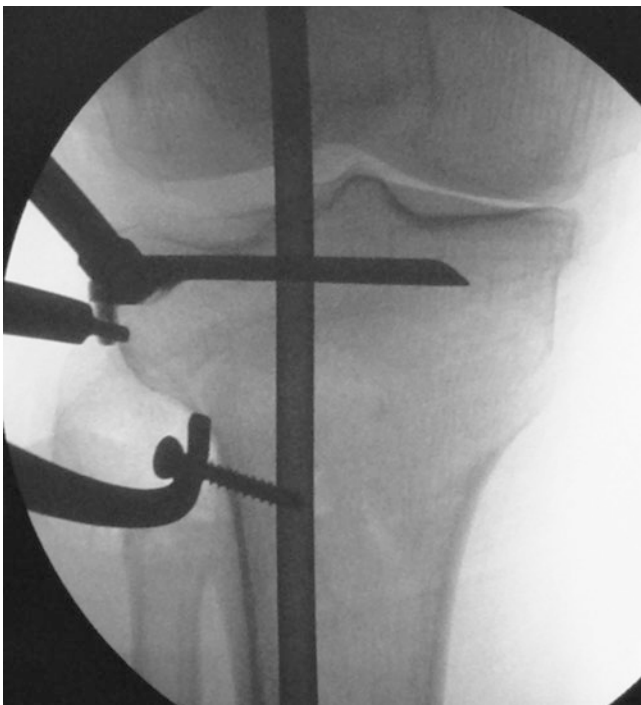
- Common peroneal nerve lesion
- Compartment syndrome



**Fig. 17.24** Preoperative fluoroscopic control using a long metal rod



**Fig. 17.26** Completed fixation



**Fig. 17.25** Note the axis hypercorrection



**Fig. 17.27** Postoperative X-ray



## Medial Opening Wedge HTO

### Set-Up

The patient is placed in the supine position. A tourniquet is applied. An extremity sheet is used for the knee and a small square field is applied over the ipsilateral iliac crest. A small bump is positioned underneath the ipsilateral buttocks to obtain a better exposure of the iliac crest.

### Skin Incision

The joint line and tibial tuberosity are marked with a pen and a 10 cm anteromedial vertical skin incision is used for exposure of the proximal tibia (Fig. 17.28). The pes anserinus tendons are retracted, or partially disinserted at the proximal aspect. The superficial medial collateral ligament is incised at the level of the osteotomy (Fig. 17.29). The posterior surface of the tibia is exposed using a large periosteal elevator. During the osteotomy, this periosteal elevator is left in place. Anteriorly, the patellar tendon is retracted using a Farabeuf retractor.

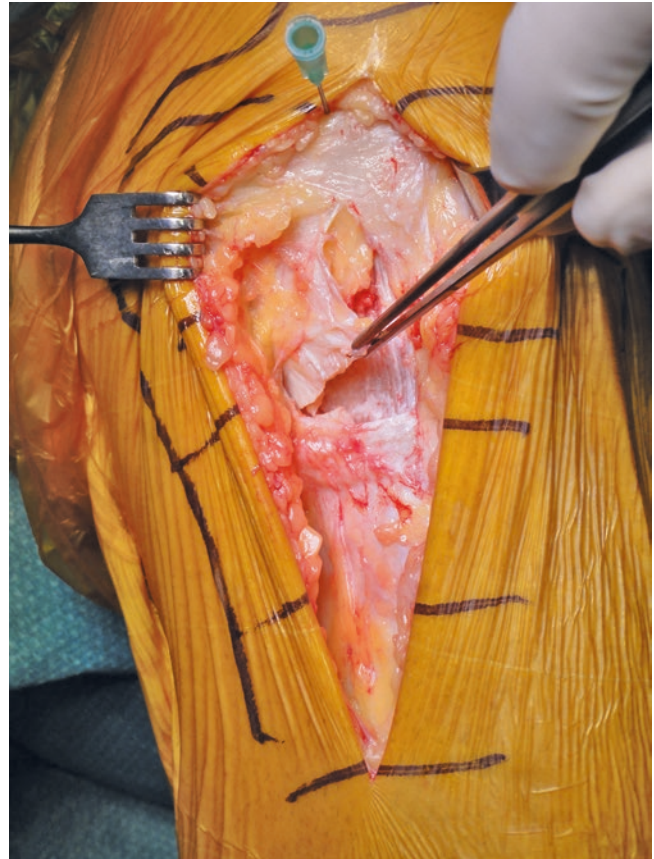


**Fig. 17.28** Skin incision

## Tibial Osteotomy

The osteotomy is performed proximal to the tibial tubercle and through the superficial medial collateral ligament, which has previously been incised. The plane of the osteotomy is almost horizontal in the sagittal plane (different from the closing wedge medial high tibial osteotomy which is more oblique). The option exists to make a biplanar osteotomy, creating a vertical cut in line with the anterior tibial cortex. The tibial tuberosity then may be kept with the proximal or distal fragments (Figs. 17.30 and 17.31). This allows a more distal osteotomy, and placement of a fourth screw in the epiphysis when using the Tomofix.

First, two 2.5 mm Kirschner guide pins are introduced from the medial side (Fig. 17.32). The first one is close to the anterior cortex, and the second close to the posterior cortex. This will allow enough room to pre-position the Tomofix plate between them, and check its position relative to the joint line fluoroscopically. Laterally, the tips of these guide pins should be just proximal to the head of the fibula, particularly if one does not want to increase the tibial slope. An image intensifier is used to correctly position the guide pins, adjusting as necessary (Fig. 17.33). Using an oscillating



**Fig. 17.29** Incision of the superficial medial collateral ligament



**Fig. 17.30** Biplanar osteotomy. The tibial tuberosity kept with the distal fragment



**Fig. 17.31** Biplanar osteotomy. The tibial tuberosity kept with the proximal fragment

saw, the tibial cut is now performed underneath these guide pins, but always staying in contact with them (Fig. 17.34). The center of the tibia is cut first followed by the anterior and posterior cortices. The cuts are completed using an osteotome, especially on the anterior cortex where the patella tendon can be damaged (Fig. 17.35). Subsequently, a Lambotte osteotome (thickness 2 mm, corresponding with approximately 2° of angular correction) is introduced into the osteotomy. A second osteotome is then introduced below the first. To gently open the osteotomy, several more osteotomes are introduced between the first two (Fig. 17.36). The first osteotome should be impacted against the lateral cortex and the second distal to the first, nearly as far. The third osteotome is then introduced, and if necessary a fourth and fifth. Each is impacted less deep than the previous to prevent



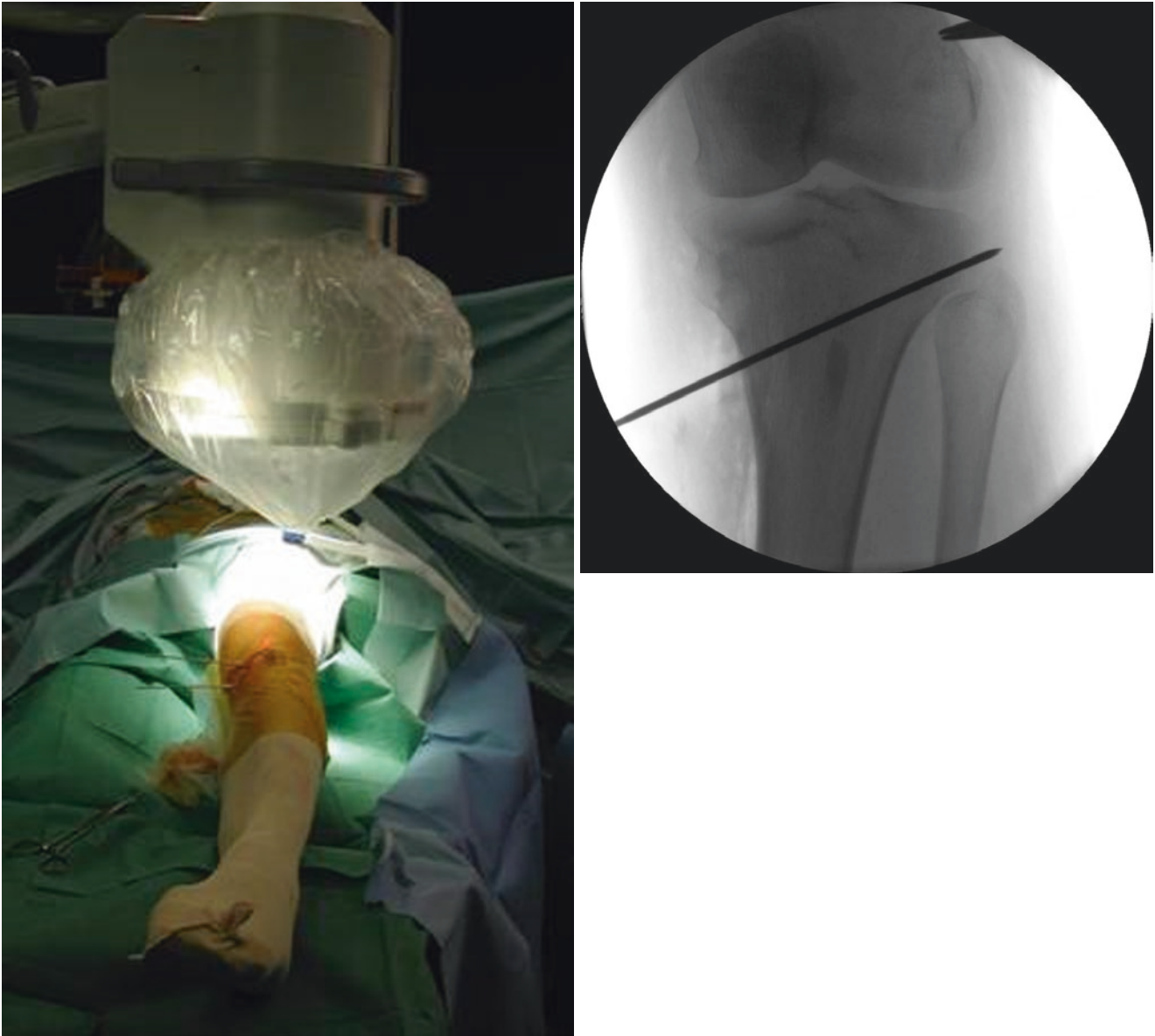
**Fig. 17.32** Laterally, the tips of these guide pins should be just superior to the head of the fibula

breaking the lateral hinge. Using the specifically designed osteotomes with a distance mark and a raised edge at the blunt end limits the risk of an excessive introduction of the osteotomes. If insufficient opening of the osteotomy is obtained, the remaining anterior and posterior bony cortex should be carefully broken using an additional osteotome. Care is taken to open the osteotomy more posteriorly than anteriorly to control the tibial slope.

Two primary complications can be encountered during this type of osteotomy:

- Fracture of the lateral hinge—Frequently observed in significant corrections. This results in an undercorrection of the deformity. In this situation, the lateral displacement of the tibia can be reduced by a temporary distal 4.5 mm compressive screw through the plate just distal to the osteotomy.
- Fracture of the lateral tibial plateau—This complication can occur if the lateral hinge has been insufficiently weakened, if one forcefully tries to open the osteotomy with a valgus maneuver, or if the osteotomes are not placed deeply enough. Usually plate and screw fixation suffice to overcome this complication.

The obtained angle of correction is systematically evaluated using a long metal rod centered on the hip and ankle (Fig. 17.37). The angular correction is evaluated at the level of the joint line (Fig. 17.38). If necessary, an additional osteotome is introduced or removed.



**Fig. 17.33** An image intensifier is used to correctly position the guide pins. Internal rotation of the leg allows accurate assessment of the pin tips in relation to the proximal tibiofibular joint

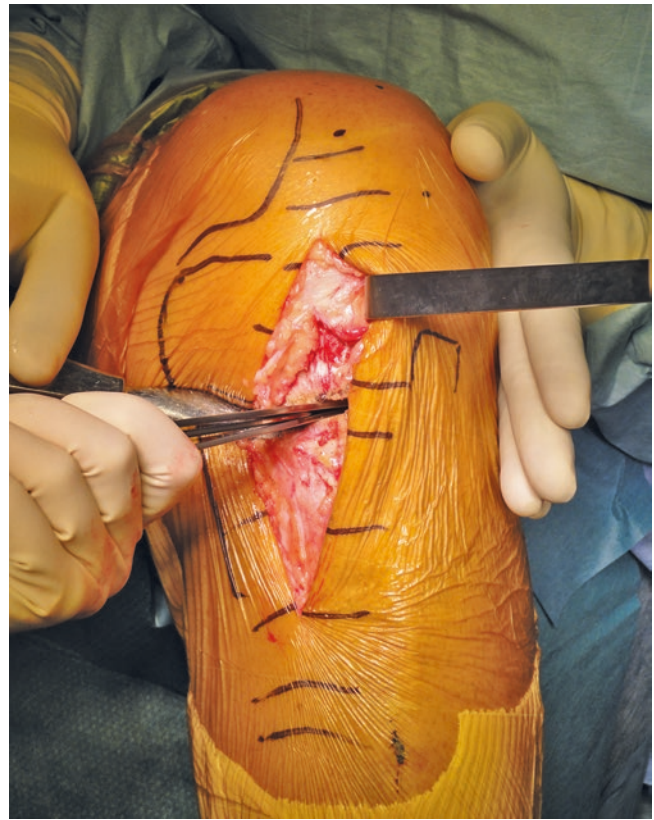
## Osteosynthesis

In order to avoid loss of correction in the postoperative period, the fixation should be strong and stable. We currently use a locking plate (Tomofix, Synthes®) (Fig. 17.39). Other types of fixation are also possible (Staples, Surfix Plate, Chambat Plate). The anatomically pre-shaped Tomofix plate is inserted into the subcutaneous plane and centered on the anteromedial tibia. Proximal fixation is achieved first with three locking screws, which provide wide support for the subcortical tibial plateau. At this stage, a lag screw can be placed in the screw hole just distal to the osteotomy site; this

approximates the plate towards the tibia and induces compression at the lateral hinge. For definitive fixation of the plate, the distal locking screws can now be placed. Finally, the lag screw can be replaced with a locking screw and an X-ray taken to check screw length and overall position. In cases of large correction (over 10°), the osteotomy site is filled with tri-cortical bone graft harvested from the ipsilateral anterior iliac crest (Fig. 17.40). These grafts are impacted, taking care not to overcorrect. Bone substitutes are also available and can be used instead of the bone graft. The superficial medial collateral ligament is now approximated over the staples.



**Fig. 17.34** The tibial cut has been performed underneath the guide pins, always staying in contact with them



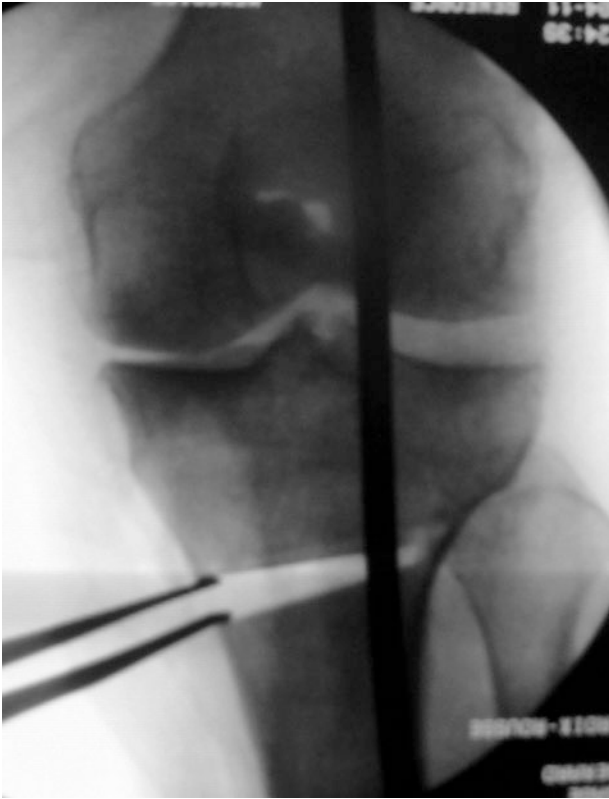
**Fig. 17.36** To open the osteotomy, several more osteotomes are introduced between the first two



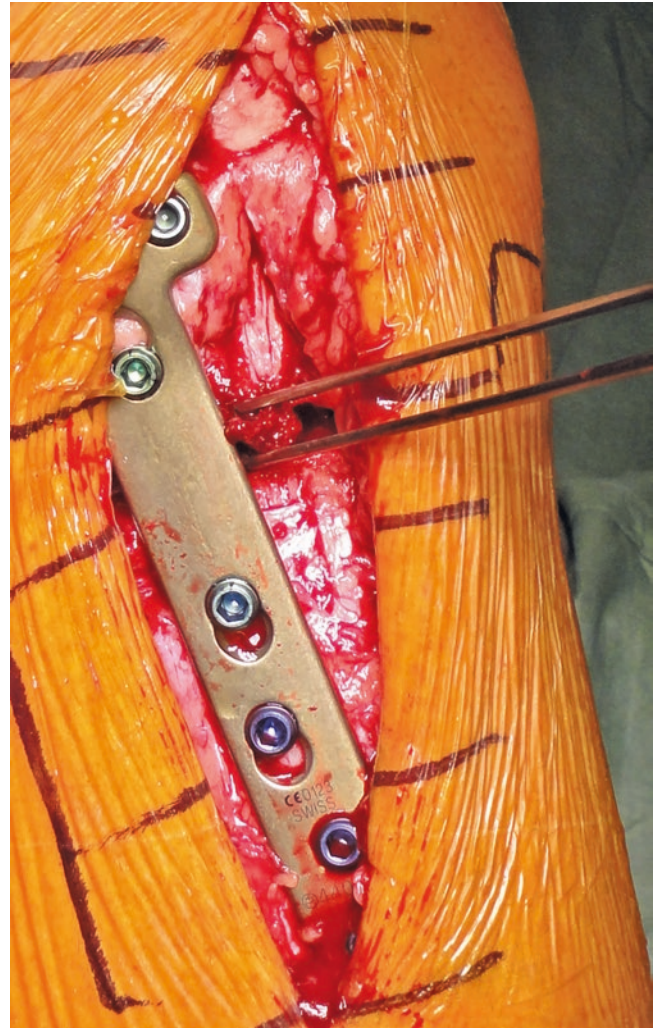
**Fig. 17.35** The tibial cut is completed using an osteotome



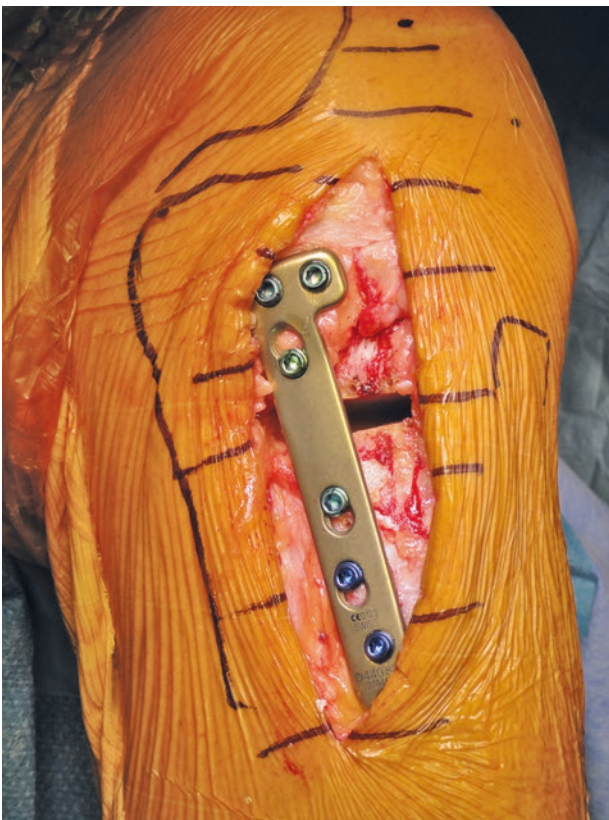
**Fig. 17.37** Intra-operative evaluation of correction using a long metal rod



**Fig. 17.38** The femorotibial mechanical axis is lateral to the lateral tibial spine. The osteotomy is fairly horizontal in this case



**Fig. 17.40** Osteotomy site filled with bone graft in case of correction over 10°



**Fig. 17.39** Fixation of the osteotomy with a locking plate

### Postoperative Guidelines

The postoperative guidelines are identical for the closing wedge as well as the opening wedge HTO.

- With the Tomofix plate patients can be mobilized with partial weight bearing 15–20 kg on the operated leg the day following the operation. The knee is mobilized with active and passive range of movement exercises and the patient is discharged home when ambulating safely on crutches. Progressive weight bearing is allowed from 4 weeks.

- Walking protected by two crutches.
- Thromboprophylaxis for 1 month.
- Skin sutures are removed around day 12.
- Bracing in extension whilst mobilizing for 2 months.

- Flexion is limited to 120° for the first 15 days. Progressive flexion then follows.
- Driving a car is not permitted for 8–10 weeks.
- Physical work is not allowed for 3–4 months.
- Sports with impacts or contact are allowed 2 months after bony union has been achieved.

Radiographs are taken 6–8 weeks after the intervention. If bony healing is observed, full weight bearing can begin. If delayed union is suspected, progression of weight bearing is delayed and the patient is invited to come back 1 month later.

## **Future Improvement**

Future work may include inclusion of the degree of tibial rotation in the preoperative plan and postoperative evaluation. Computer assisted surgery can be used to obtain and evaluate the desired post-osteotomy mechanical axis and is currently under investigation.

We hypothesize that a customized implant, with personalized specific instrumentation using pre-operative CT scan or MRI, will allow exact correction of the deformity according to the preoperative plan, reaching the desired “target.” It would change drastically the technique.