

BIPLANAR OPENING-WEDGE TIBIAL VALGUS OSTEOTOMY FOR MEDIAL KNEE OA: REVIEW OF 20 YEAR'S EXPERIENCE WITH TIPS AND TRICKS

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AUTHORS

Thomas R. Henkel - Hirslanden Andreas Klinik Cham Zug, Cham, Switzerland

Alex E. Staubli - Hirslanden Andreas Klinik, Cham, Switzerland

SUMMARY

Background: Medial compartment gonarthrosis associated with varus malalignment remains a significant cause of cartilage degeneration. While lateral closing-wedge techniques were historically preferred, medial open-wedge biplanar tibial valgus osteotomy using locking plate fixation has emerged as a standard joint-preserving intervention.

Objective: This article provides a clinical algorithm and technical framework for performing medial open-wedge biplanar tibial valgus osteotomy, focusing on patient selection, preoperative planning, and intraoperative maneuvers to optimize alignment and minimize complications.

Key Points: Success depends on precise deformity analysis using the Mikulicz line, medial proximal tibial angle (MPTA), and joint line obliquity. Indications include symptomatic Outerbridge grade 1–3 medial cartilage lesions with varus deformity exceeding 3°. Critical surgical steps involve a subperiosteal release of the superficial medial collateral ligament to prevent increased medial compartment pressure and a multi-chisel technique to create a stable lateral hinge. The biplanar cut protects the tibial tuberosity and allows for sagittal plane adjustments, such as slope reduction to address extension deficits. Locking plate fixation, specifically the Tomofix system, provides primary stability without the necessity for bone grafting in most cases. Long-term data from 92 patients demonstrate high union rates and significant pain reduction, with a mean correction angle of 9.2°. Potential complications include lateral hinge fractures, thromboembolism, and rare neurovascular injuries.

Conclusion: Medial open-wedge biplanar osteotomy is an effective, reproducible procedure for medial gonarthrosis. Adherence to a structured surgical protocol and precise intraoperative alignment control are essential for achieving durable clinical outcomes and delaying the requirement for arthroplasty.

KEYWORDS

Osteotomy; Tibia; Genu Varum; Osteoarthritis, Knee; Bone Plates

INTRODUCTION

Frontal plane leg alignment correction is an important pillar of treatment during joint-sparing knee surgery for medial gonarthrosis. A varus deformity of the knee joint represents a significant risk factor for the development and further progression of medial cartilage lesions [1–3]. Tibial valgus osteotomy, potentially in combination with femoral osteotomy (double osteotomy) has gained significant importance in the past few years, thanks to improved planning and fixation techniques with locking plates. Whereas lateral closing wedge tibial plateau osteotomy was the preferred surgery method in the past, today it is medial open-wedge biplanar tibial valgus osteotomy with a locking plate implant [4–9]. The number of relevant complications could also be reduced using locking implants and refined surgery techniques [10].

Good long-term outcomes can be expected with careful patient selection and precise surgical technique [11]. The authors are presenting a practice-oriented algorithm with tips and tricks of a medial open-wedge biplanar tibial valgus osteotomy based on more than 20 years of experience.

PATIENT SELECTION

Indication for valgus osteotomy of the knee

- Symptomatic patient with Outerbridge Grade 1–3 cartilage lesions [12] of the medial compartment with varus deformity $> 3^\circ$ in the whole leg radiograph, with or without partial loss of the medial meniscus.
- In exceptional cases or in combined procedures with cartilage surgery without arthrosis realignment can also be performed even from 1 to 2° varus deformity only.
- An additional anterior cruciate ligament (ACL) insufficiency can be treated and a pathological slope should also be corrected during this procedure.
- Outerbridge grade 4 cartilage lesions [12] are not a contraindication, but it must be discussed with the patient that the long-term results are somewhat poorer, and a total knee replacement may need to be implanted early.

Contraindications

- Lack of patient motivation: the patient must be aware that there may be prolonged pain after surgery. Furthermore, there is a unilateral change to the leg alignment that can be aesthetically conspicuous in major corrections and needs to be accepted. We have had the experience that this issue often raises concerns with younger male and female patients.
- Extension deficit of $>10^\circ$
- Nicotine consumption that cannot be plausibly stopped 6 weeks prior to surgery. However, use of an autologous tricortical iliac crest bone graft can make surgery also possible for smokers.
- Diffuse chondrocalcinosis
- Arthritic involvement of the lateral compartment $>$ Outerbridge grade 2 [12]
- Untreated osteoporosis
- Vitamin D3 deficiency: we measure the level and substitute it to a high normal level prior to surgery.
- Absent or attenuated foot pulses require further diagnostic workup

- Age: the biological age is more important than the chronological age; as a rule of thumb, an upper limit of 65 years applies in males, 55–60 years in women.

PREOPERATIVE EXAMINATIONS

Clinical examination

Extent of any ROM deficit, tendon instabilities, patella pain, patella maltracking, the hip (impaired mobility), the back and the foot (ruling out a flat foot that can be exacerbated by valgus angle correction of the leg axis), identification of leg length differences, foot pulses (must be present).

Radiological examinations

1. AP radiograph of the knee, lateral view and patella tangential in 30° and 60° flexion
2. PA radiograph of the knee with weight-bearing and 45° flexion (Rosenberg view)
3. Upright whole leg radiograph (patella centred, maximum extension). It is important that the patella is centred, external rotation of the knee increases the varus angle, internal rotation reduces it (the measurement error can be up to 2°). An extension deficit also distorts the alignment. If the patella has a lateral shift or is subluxated the rotation should be adjusted such that one third of the fibula head is covered by the tibia.
4. MRI of the knee, potentially to determine the retropatellar cartilage lesions.
5. In cases with clinically suspected torsion defect of the leg or a (sub)luxated patella in the tangential X-ray image we perform a rotation profile of the leg by CT.

PLANNING THE OPERATION

Preoperative deformity analysis in the frontal plane according to Paley [13]

Determination of weight bearing line (Mikulicz line), MPTA (medial proximal tibia angle), mL DFA (mechanical lateral distal femoral angle) and the mechanical varus angle are the 4 key parameters of analysis in the frontal plane (Fig. 1a). The joint line obliquity (JLO) and joint line congruence angle (JLCA) are used as extended parameters for the planning of a double level osteotomy (DLO) in varus deformities on the femur and the tibia as well as the bony correction angle in any varus thrust (Fig. 1b).



Fig. 1a: Deformity analysis in the frontal plane according to Paley [13]

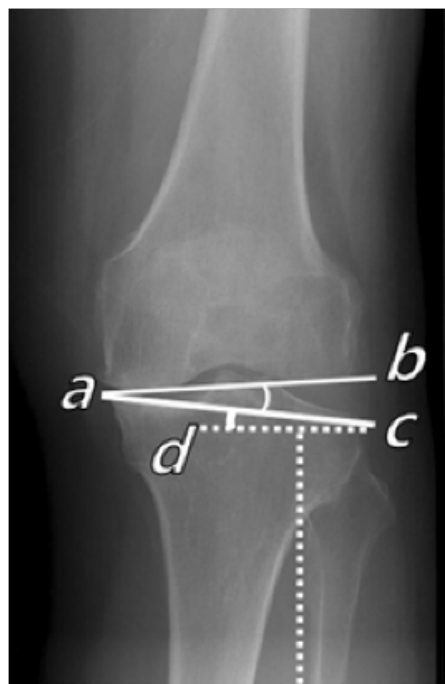


Fig. 1b: Analysis of the joint line obliquity (JLO) and the joint line convergence angle (JLCA) in a varus knee with deformity on the femur and tibia and clinical varus thrust; pathological values with JLO minus 5° and JLCA of 6°. Tibia or femoral osteotomy alone is not sufficient for the correction of this deformity.

Praeoperative Deformitätenanalyse in Sagittalebene (Abb 1 c)

Preoperative deformity analysis in the sagittal plane

In the sagittal plane the tibial slope should be measured to exclude any deformity that should be corrected during osteotomy (Fig. 1 C)



Fig. 1c: The tibial slope is measured in the lateral X-ray, i.e. the inclination of the joint surface to the longitudinal axis of the tibia.

Planning the extent of the correction in the frontal plane

The objective of a correction is the shift of the weight bearing line to lateral of the eminence in a tightly defined target range and simultaneous achievement of full knee extension.

Fujisawa [15] defined the ideal correction at around 35% lateral of the eminence for all grades of cartilage lesions (Fig. 1d).

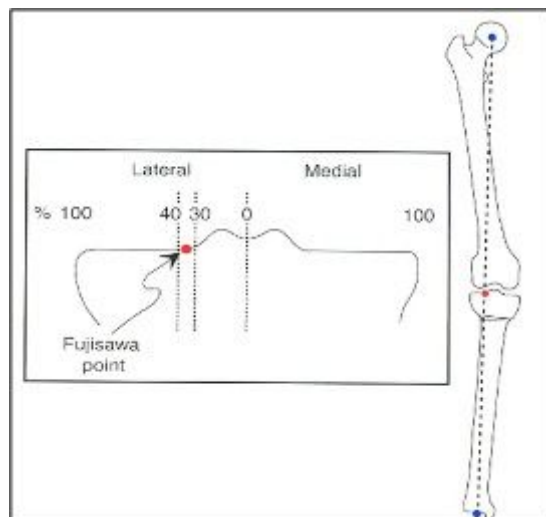


Fig. 1d: The objective of an angle correction in varus gonarthrosis according to Fujisawa around 35% lateral of the eminence.

We adjust the extent of the correction or the lateral shift of the weight line to the individual degree of cartilage lesions [14].

Grade 1–2 10–20%

Grade 3 20–25%

Grade 4 30–35%

With a medial open-wedge correction of the tibia, the MPTA angle should be no more than 94° after the correction, because otherwise the joint line obliquity (JLO) is more than plus 4° , which results in clinically relevant shear forces in the joint and to poorer clinical outcomes.

Cases of major correction ($>10^\circ$) are almost always due to a combined deformity of femur and tibia. If the deformity is mainly on the femur, the correction must be performed at the femur. In around 10–15% of cases no acceptable joint line obliquity (JLO) can be achieved with only one correction on femur or tibia. In these cases a simultaneous double level osteotomy (DLO) correction on the femur (lateral closing wedge) and tibia (medial open wedge) should be performed [16–17].

Planning with calculation of the correction angle was performed according to Miniaci [18] (Fig. 1e). Planning can be performed either manually or using digital software. It is important when planning the bone correction angle that an abnormal joint line convergence angle (JLCA) (see Fig. 1b) is included in the planning (alpha angle minus $JLCA > 2^\circ$) because otherwise the osteotomy will result in an overcorrection to valgus deformity.

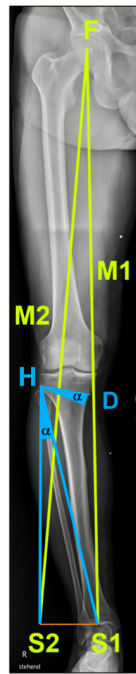


Fig. 1e: Correction planning according to Miniaci [18]

SURGICAL PROCEDURE

The surgery is performed in the supine position either under general or spinal anaesthesia. We administer tranexamic acid systemically and topically [19].

Before disinfection we label the centre of the femoral head and the centre of the ankle joint with the image intensifier (knee in neutral rotation and patella in the centre), draw the Mikulicz line on the knee with a rod and compare it with the preoperatively obtained whole leg radiograph. The whole leg is disinfected including the iliac crest (so that bone can be harvested later if necessary). For complex corrections we use computer-assisted navigation, which we would apply after the arthroscopy (Fig. 2).



Fig. 2: For complex correction additional computer-assisted navigation (on the thigh and lower leg), which is applied after the arthroscopy.

Arthroscopy

We always perform an arthroscopy of the knee, in most cases without tourniquet, with evaluation of the 3 knee compartments, potentially with meniscus surgery. In arthritic knee joints we do not perform any further cartilage surgery (microfracture, mosaicplasty or autologous cartilage transplantation). Osteophytes of the notch and the eminence that impair full extension of the knee are removed. Clinically interfering osteophytes on the medial condyle margin are removed. The lateral meniscus should be intact. Lateral grade I–II cartilage lesions are accepted for osteotomy. In case of simultaneous ACL surgery we use the semitendinosus tendon graft and drill the appropriate channels before the osteotomy.

Access with preparation of an anterior pedicled periosteal flap for subsequent covering of the osteotomy gap

We usually do not use a tourniquet for osteotomy. The skin incision is a medial longitudinal incision, especially with a view to any subsequent revision surgery with knee replacement or if an arthrotomy for a cartilage procedure is required in the same session. Alternatively, an oblique incision can be made at the level of the pes anserinus.

Now the superior margin of the pes anserinus is exposed, then the anterior portion of the superficial medial collateral ligament and the tuberosity. We prepare (with the knife) a periosteal flap from the lateral side at the anterior margin of the medial collateral ligament, and superior margin of the pes anserinus up to the tuberosity. This periosteal flap is pedicled to the tuberosity and by incising it on the cranial portion it can be pivoted and be used to mostly cover the osteotomy site after the plate fixation (Fig. 3).

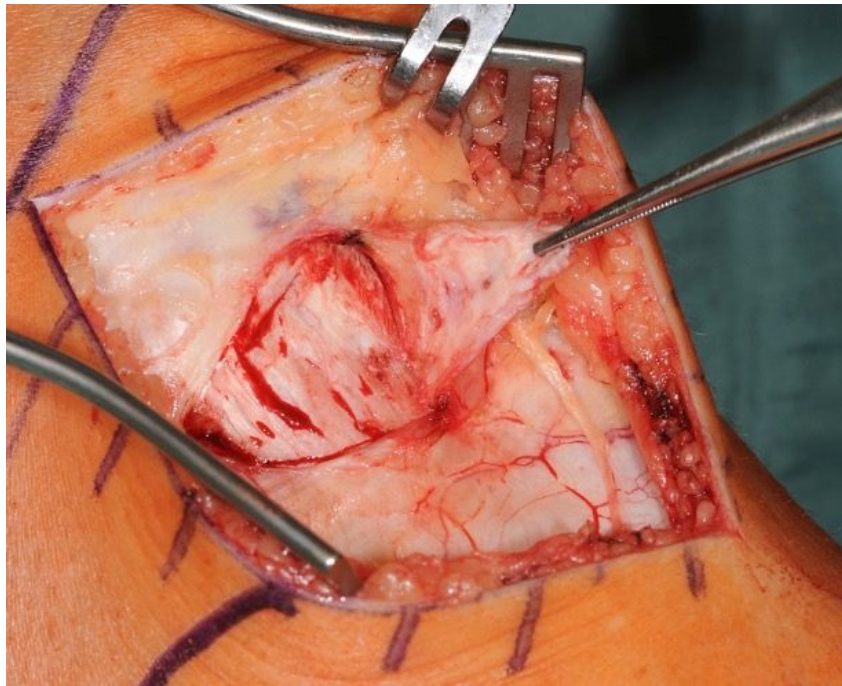


Fig. 3: Medial longitudinal incision and preparation of a ventral pedicled periosteal flap, immediately adjacent to the tuberosity for subsequent covering of the osteotomy gap

Distal release of the superficial medial collateral ligament

Subperiosteal release of the superficial medial collateral ligament at the tibial insertion is a central element to ensure that the pressure in the medial compartment does not increase with the subsequent opening of the osteotomy [20–21]. The periosteal elevator is used to go below to the superficial medial collateral ligament to the distal and dorsal side and to perform complete subperiosteal release [22] (Rule of thumb: there must be space for one finger width below the collateral ligament) (Fig. 4).



Fig. 4: The superficial collateral ligament is detached to the distal tibial insertion with the periosteal elevator.

Insufficient release also has the consequence that the osteotomy opens less well on the dorsal side than on the ventral side, which will increase the slope. Thereafter, the periosteum is detached to the dorsal side with the

angled periosteal elevator. Then a blunt Hohmann retractor is inserted on the dorsal tibia edge along the osteotomy site to protect the popliteal artery/vein and the tibial nerve.

Determination of the osteotomy plane with 2 K-wires.

A first K-wire (3.0) is inserted under image intensifier monitoring from the dorsal superior margin of the pes anserinus to the superior margin of the tibiofibular joint. In order to be able to expose the tibiofibular joint, the knee is brought to 30° IR. The intraosseous length of the K-wire is measured at the same time.

A second K-wire (3.0) is positioned further anterior under image intensifier control so that the two wires are exactly superimposed. This requires that the lateral tibia plateau in the AP image only shows one line. Thus, the osteotomy plane matches the natural tibia slope in the lateral view (Fig. 5a). Thereafter, the length of the two wires is determined (ventrally usually about 10 mm shorter than dorsally).



Fig. 5a: Installation of 2 K-wires from medial to the superior edge of the tibiofibular joint which have to appear superimposed in the image when the lateral tibia plateau in the image intensifier appears as one line.

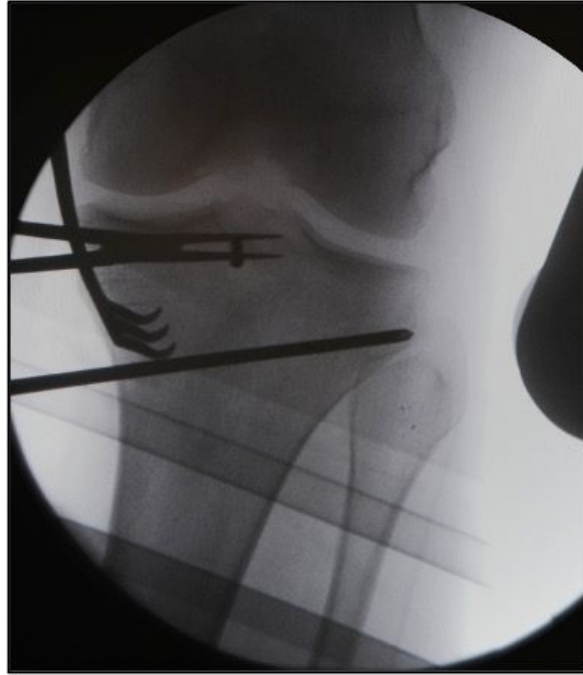


Fig. 5a: Installation of 2 K-wires from medial to the superior edge of the tibiofibular joint which have to appear superimposed in the image when the lateral tibia plateau in the image intensifier appears as one line.

Placement of parallel K-wires for intraoperative control of the tibial slope and rotation

Now a third K-wire (3.0) is introduced centrally in the proximal tibia with neutral rotation (patella in the center). At the same time, the knee should be flexed under image intensifier control so that the lateral tibia plateau appears as one line. This K-wire now has to appear in the image intensifier as a dot and is thus parallel to the tibial slope (Fig. 5 b).

After predrilling, a fourth K-wire (3.0) is inserted parallel to the third K-wire distal to the osteotomy surface on the anterior tibia (Fig. 5 b). Together with the third K-wire this fourth K-wire permits control of tibial slope and rotation change during the operation.



Fig. 5b: Placement of 2 anterior parallel K-wires (3.0); the superior one is in the middle and parallel to the tibial slope (ap k-wire should appear as a dot). The distal K-wire is below the planned osteotomy and parallel to the proximal K-wire and permits control of the slope and torsion changes after the osteotomy.



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Procedure for (ascending) biplanar osteotomy

Now a blunt Hohmann retractor is placed dorsally directly on the bone, which displaces the critical structures (nerves, vessels and popliteal muscle) to the dorsal side and provides protection during the cutting. The knee is then positioned in 90° flexion. For the osteotomy we use three new and different saw blades. The first part of the osteotomy is performed with a short saw blade with markings (50 mm, 0.9 mm thickness) from medial below the K-wires (up to around 10 mm before the lateral cortex); this should be performed with continuous irrigation for cooling (Fig. 6a).

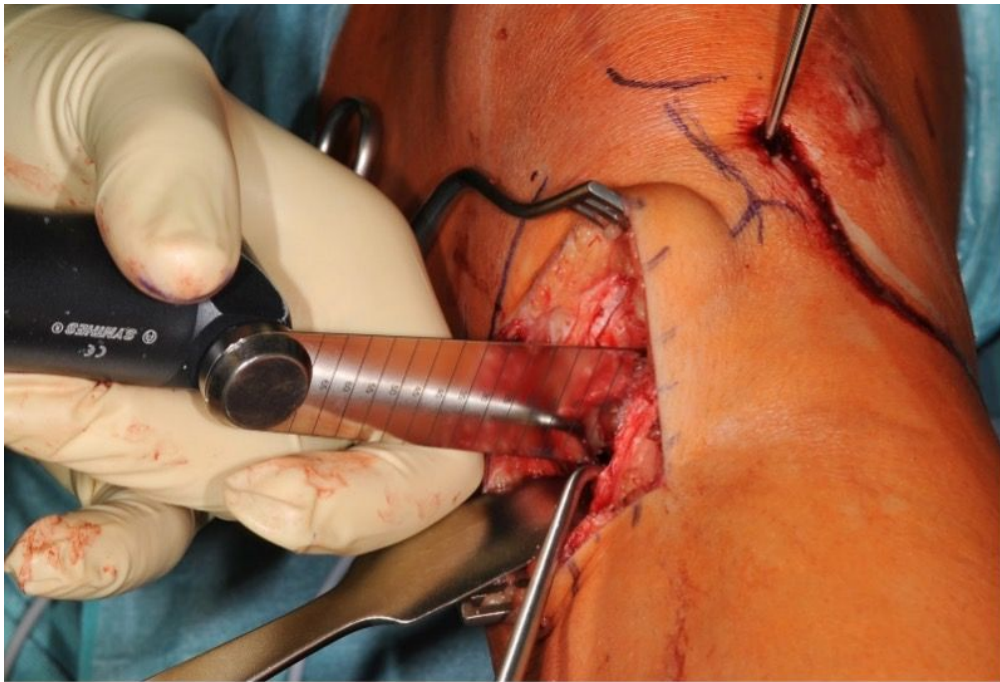


Fig. 6a: New saw blade with marking, dorsal blunt Hohmann retractor directly on the bone to protect the vessels, consistent continuous cooling, sawing below and along the K-wires; thus, the dorsal cortex is cut first completely to the lateral side. Control under image intensifier in internal rotation with imaging of the dorsolateral cortex. Saw blade should stop 1 cm before the lateral tibia cortex.

Thereafter, the anterior cortex is cut with the same saw blade (Fig. 6b). It is important that the dorsolateral cortex is completely divided (we use a second longer saw blade for this). With internal rotation of the tibia this can be presented well under image intensifier control. Due to the triangular form of the tibia the dorsal cut must be longer than the ventral one.

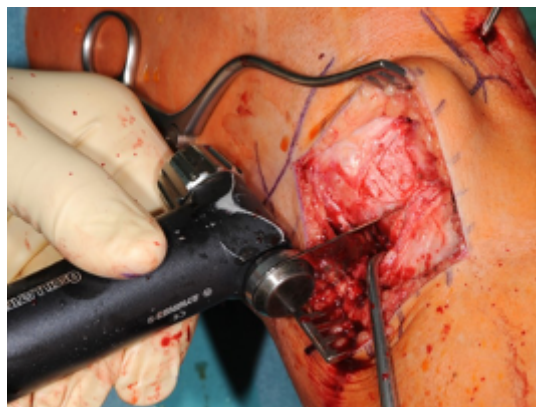


Fig. 6b: Lowering of the saw blade and osteotomy of the anterior cortex

The ascending tuberosity osteotomy is performed with a thinner saw blade (50 mm, 0.7 mm thickness) in 90° flexion with an angle of around 110° to the horizontal and parallel to the ventral tibial edge (Fig. 6c). The thickness of the tuberosity fragment should be 1–2 cm. The tuberosity osteotomy must go through the lateral cortex to facilitate subsequent mobilization.

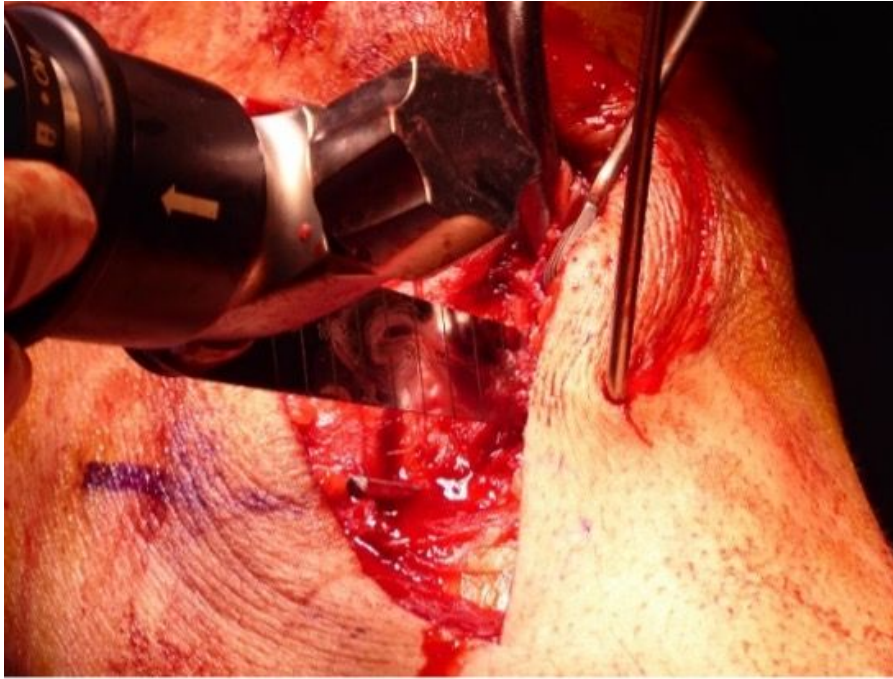


Fig. 6c: Ascending tuberosity osteotomy, the saw blade should be angled about 110° to the osteotomy surface or parallel to the ventral tibia edge; the thickness of the tuberosity osteotomy was 1–2 cm.

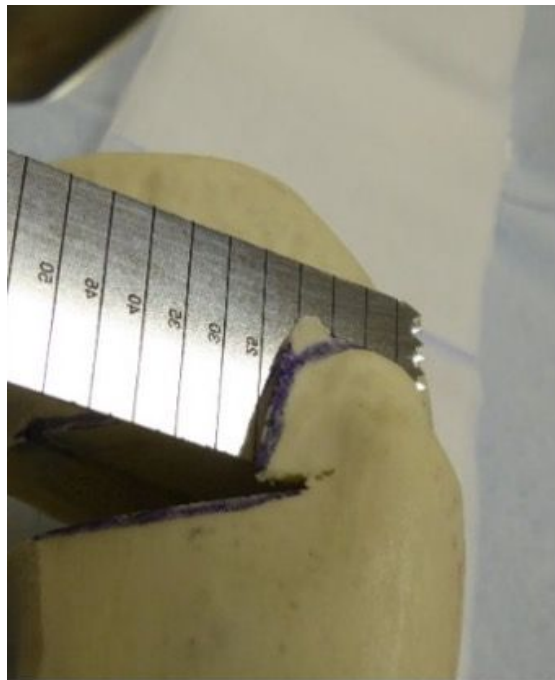


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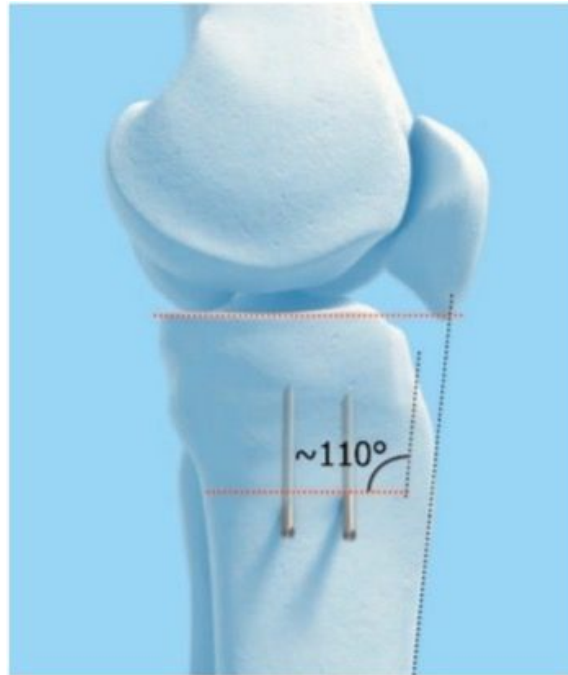


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Distraction of the osteotomy (multi-chisel technique) and plastic deformation of the lateral hinge with the distractor

Introduction of a first chisel (20 mm size) below the K-wires. This is advanced under image intensifier control up to around 5 mm before the lateral cortex. The next chisel (20 mm size) is advanced below it, also up to around 5 mm from the cortex. Thereafter, a further chisel (25 mm size) is carefully advanced between these two chisels up to around 15 mm from the lateral cortex. The chisels should be introduced slowly (Fig. 7a).

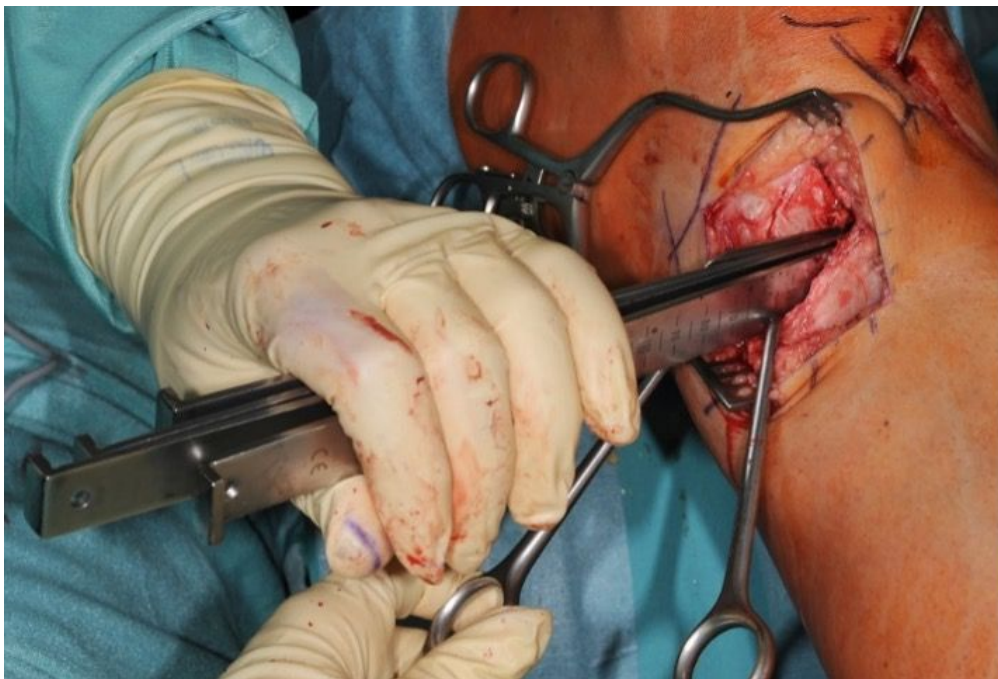


Fig. 7 a: Introduction of chisels with image intensifier control under the two Kirschner guide wires up to 5 mm from the lateral cortex, the two first chisels must be the same distance from the cortex, but with the third chisel between the two first ones we distract them and weaken the lateral cortex, microfractures on the lateral hinge are common with this procedure.



Fig. 7 a: Introduction of chisels with image intensifier control under the two Kirschner guide wires up to 5 mm from the lateral cortex, the two first chisels must be the same distance from the cortex, but with the third chisel between the two first ones we distract them and weaken the lateral cortex, microfractures on the lateral hinge are common with this procedure.

This creates a plastic deformation of the hinge with controlled microfractures that taper parallel to the first two chisels. With larger corrections another 2–4 chisels can be introduced; each one is introduced a little less far than the previous ones. Thereafter we remove the two K-wires and the chisels. At this time in the operation the lateral hinge should still be sufficiently stable under image intensifier control and should not be shifted. However, if the osteotomy tools are advanced too far it can result in uncontrolled fractures of the hinge and even opening up or shifting of the osteotomy at the lateral hinge.

As the next step, an arthrodesis distractor is fully inserted dorsally and slowly distracted. We close and open the distractor carefully several times. This gives an indication of the elasticity of the osteotomy. If there is still a lot of resistance it can be either due to an insufficient release of the superficial medial collateral ligament or to an incomplete dorsolateral osteotomy. With an incomplete osteotomy the dorsolateral cortex can be further weakened with a rounded chisel under image intensifier control. The hinge should have good mobility but must be preserved.

Control of the correction in the frontal and sagittal plane

Now we position the knee in extension, support the heel with a roll. The knee should be fully extended. This is particularly important in knees with a preoperative extension deficit. Any extension deficit has to be corrected during the operation. This is achieved by a reduction of the tibial slope by pushing the knee down in full extension by the assistant. We control the change of the tibial slope with the two anterior K-wires (Fig. 7b).



Fig. 7b: Control of the tibial slope: left before distraction, right after distraction with convergence of the two K-wires with reduction of the tibial slope (here in this case the slope was reduced to be able to compensate the preoperative extension deficit).



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Due to the triangular form of the tibia the biplanar osteotomy is always opened about 30% more dorsally than anteriorly [25]. Now we measure the size of the correction on the central tibia edge and compare it against our plan (Fig. 7c).

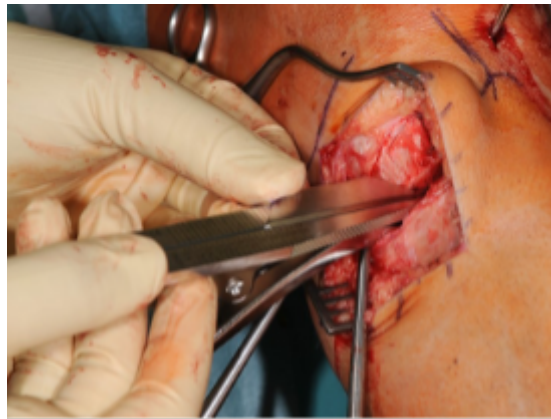


Fig. 7c: Measurement of the central osteotomy height and comparison against the planned opening.

Then the intraoperative Mikulicz line in full extension of the knee is documented under image intensifier control. The anterior K wires introduced at the start of the operation accurately show us any changes to the rotation and the slope (Fig. 7d). The use of computer-assisted navigation is helpful in complex two-dimensional corrections (Fig. 7e).



Fig. 7d: Maximum dorsal placement of the distractor and slow, repeated distraction of the osteotomy until it is elastic and fully corrected. This is followed by intraoperative image intensifier control of the lateral hinge and the corrected Mikulicz line in full knee extension.



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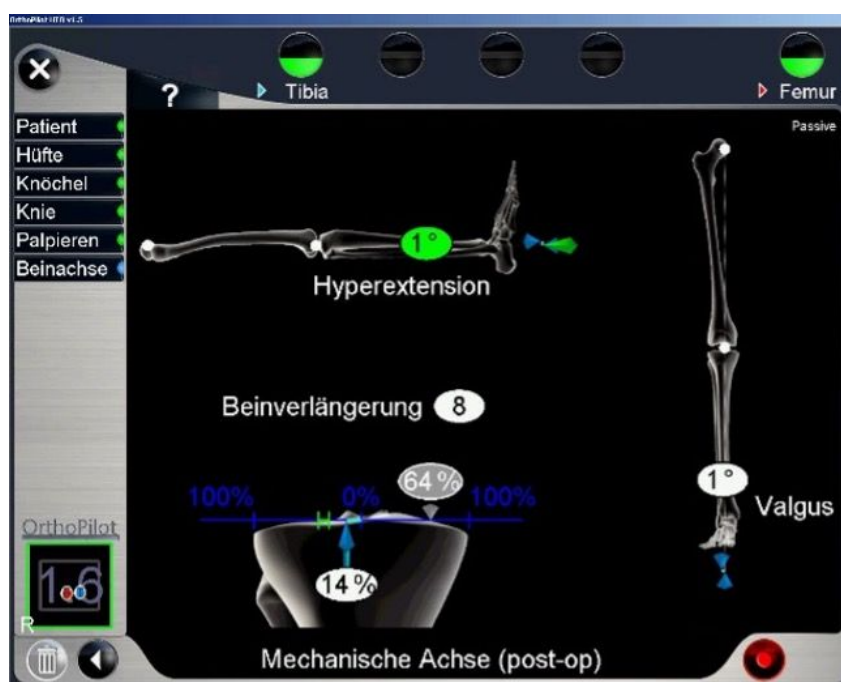


Fig. 7e: Alternatively, the frontal and sagittal alignment can also be controlled by computer-assisted navigation.

Osteosynthesis with locking plate and compression of the lateral hinge

For the osteosynthesis we use the Tomofix plate with locking screws (Depuy-Synthes). Now the Tomofix plate is fitted with distance spacers in positions D and 3 or 4 (Fig. 8a).

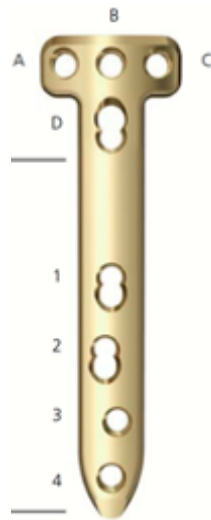


Fig. 8a: Locking proximal medial tibia plate of the Tomofix system (Depuy-Synthes), the holes D, 1, 2 are Combi holes. Screws A-C are angled down by 4° to prevent a screw position that enters the joint. The plate is curved so that it fits to the tibia with corrections of about 10° .

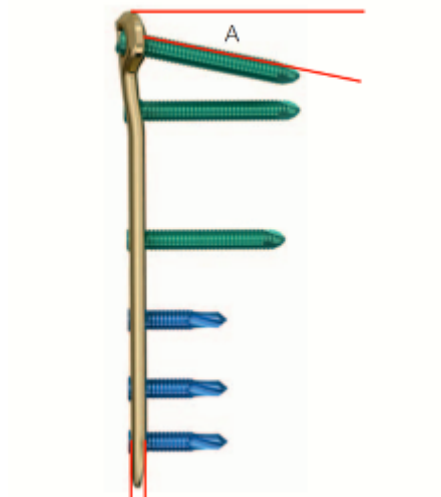


Fig. 8a: Locking proximal medial tibia plate of the Tomofix system (Depuy-Synthes), the holes D, 1, 2 are Combi holes. Screws A-C are angled down by 4° to prevent a screw position that enters the joint. The plate is curved so that it fits to the tibia with corrections of about 10° .

The plate should be positioned 1-2 cm below the joint line and as far dorsally possible at the proximal tibia. The plate is then fixed temporarily on the proximal side with a K-wire through one of the sleeves. The K-wire is advanced and the position versus the tibia plateau is checked in the image intensifier. The long arm of the plate should not overhang at the distal tibia shaft on the dorsal or anterior edge (= centred plate) (Fig. 8b)



Fig. 8b: Attachment of the locking plate, proximal dorsal, 1–2 cm below the joint line in full extension of the knee. Temporary fixation with a Kirschner wire and distal centring of the plate at the tibial shaft.

Then the proximal three locking screws are attached (Fig. 8c); the screws should not be bicortical, because the perforation of the dorsal cortex bears the risk of injury to the dorsal vessels. The dorsal screw is the shortest one.

Now a tension screw is placed in combi hole 1 (below the osteotomy). On the one hand it can effect repositioning in case of distal tibia shift due to an instable lateral hinge, on the other hand this screw results in pretensioning of the plate with subsequent hinge compression (Fig. 8d).

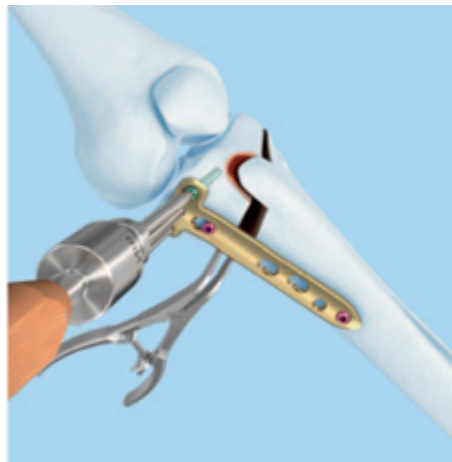


Fig. 8c: Position of the three proximal screws; the screw in the most dorsal position is in immediate proximity to the vessels.



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Fig. 8d: Once the three proximal screws are inserted, the tension screw is placed in hole 1, which pulls the distal osteotomy segment towards the plate and reducing the gap. The tension screw bends the plate and generates pretension thus compressing the hinge.



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With soft bone we fill the distal wholes with bicortical screws, otherwise long monocortical screws can also be used. Once the distance spacer is removed, a screw is placed in hole D. Finally, the tension screw in position 1 is

replaced with a locking screw. As a rule, we do not fill the osteotomy gap with a bone graft. The osteotomy gap is now covered with the periosteal flap prepared at the start. However, this should not fold into the gap and should be tightened against the medial collateral ligament with sutures.

Checking the foot pulses

If a tourniquet was used, it should be now released and the foot pulses are checked. Attenuation or absence of any preoperatively present foot pulse can be a sign of vascular injury. At the same time, it must be checked whether there is any bleeding from dorsal vessels. Two drains without suction are installed (1 intraarticular and 1 above the osteotomy).

Follow-up treatment

Check for incipient compartment syndrome and check foot pulses over the first 12–24 hours. Mobilization with 20 kg weight bearing for 4 weeks, then transition to full weight bearing. In case of lateral hinge fracture partial weight bearing for 6–8 weeks. Consistent postoperative lymph drainage and radiographic monitoring. Thrombosis prophylaxis until full mobilization is achieved.

DISCUSSION

The objective of valgus tibial plateau osteotomy in varus gonarthrosis is to perform an angle correction such that the Mikulicz line or the weight line is lateral of the eminence in the frontal plane and thus brings about easing of the strain on the medial compartment. The size of the correction in the frontal plane is adapted to the extent of the medial cartilage lesions. The tibial slope in the sagittal plane should not be changed. One exception is the reduction of the slope for correction of an extension deficit or in case of insufficient ACL.

Over- or undercorrection: The long-term outcomes are poorer in case of undercorrection in the frontal plane (persistence of the centred or medial weight line) [26–27]. In these cases, a revision can be performed with enlargement of the correction, or in the longer term, a uni- or bicondylar knee arthroplasty can be implanted if the revision fails prematurely. An overcorrection (postoperative Mikulicz line is lateral of the centre of the lateral tibia plateau) is an aesthetic problem on the one hand, on the other hand it is also associated with a significant change to the gait. It can also cause painful traction on the medial collateral ligament whilst walking. We discuss any early revision with correction with the patient if an overcorrection is confirmed in the postoperative radiograph and in a whole leg radiograph.

The preoperative planning to achieve a correct postoperative correction angle is very important, although this is subject to uncertainty factors: for example, a preoperative extension deficit or a rotation defect in the radiograph can be a significant source of error. In one of our studies [28] we investigated the impact of 15° external or internal rotation and the extension deficit on the mechanical axis in the whole leg radiograph. If there is no extension deficit, then the mechanical varus angle is 1–2° larger with 15° external rotation, 0–1° smaller with 15° internal rotation. If an extension deficit persists with 15° external rotation, the mechanical varus angle increases by 2–6°.

Despite careful preoperative planning of the osteotomy size the weight line must therefore be marked and checked during surgery with the image intensifier. The alternative is control via computer-assisted navigation, which has also been tried and tested in our hands.

Full knee extension is the second objective of the correction. A spontaneous improvement of the extension can sometimes already be seen during surgery after correction of the varus angle and complete release of the

superficial medial collateral ligament. On the other hand, the tibial slope can be reduced by 3–6° if there is any extension deficit; technically, the distractor must be fitted on the posterior edge. With the two anterior K-wires the slope change is easily visible and is then checked in the lateral image intensifier image with the long rod (attached laterally). In case of ACL insufficiency we also reduce the slope. However, we generally perform a simultaneous ACL plasty in osteotomies with concomitant ACL insufficiency.

Although the medial open wedge and the lateral closing wedge tibial plateau osteotomies have comparable results in long term courses with correct postoperative alignment [11], the risk of injury to the peroneal nerve is lower in medial open-wedge tibial valgus osteotomy; moreover, it requires no fibula osteotomy and the fine adjustment of the correction angle is simpler [9]. We now perform a lateral closing wedge tibia osteotomy only in cases of a pre-existing leg length difference or a patella baja. However, biplanar descending osteotomy is an alternative in patella baja. There the osteotomy of the tuberosity is tapered towards the distal side and should be fixed with 2 screws (Fig. 9a).

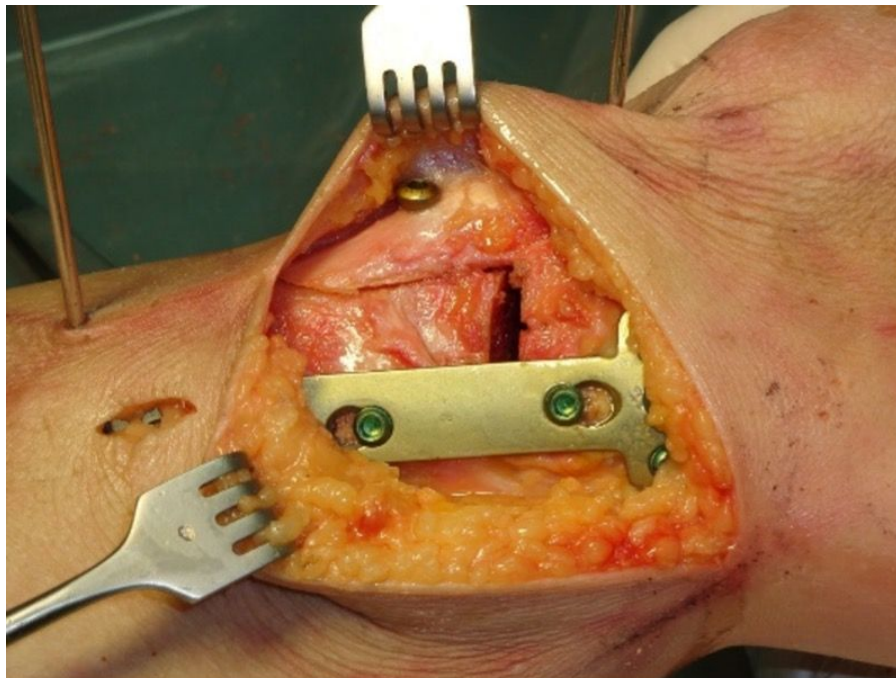


Fig. 9a: Descending tuberosity osteotomy and fixation with 2 screws in patella baja.



Fig. 9a: Descending tuberosity osteotomy and fixation with 2 screws in patella baja.

One of the central questions is how far the proximal metaphyseal tibia angle may be changed, or how much joint line obliquity (JLO) can be tolerated. For Song [29], the limit of the MPTA is between 94° and 96° . Corrections with a greater angle have poorer long-term outcomes. However, Akamatsu [30] reports good short-term results in corrections of more than 95° MPTA. If the extent of the corrections is so large that the critical medial proximal tibia angle is exceeded (MPTA $>94^\circ$) or there is already a JLO $>4^\circ$ during planning, then double osteotomy is the therapy of choice; we then correct the femur first (lateral closing wedge) and can then adjust the tibia correction somewhat (Fig. 9b).



Fig. 9b: Lateral closing-wedge femur osteotomy and medial open-wedge tibia osteotomy (double osteotomy) in large corrections.

Infections: A meta analysis of 26 studies [31] revealed 1–9% superficial wound infections and 0.5–4.7% deep infections. A further study [32] investigated longitudinal versus oblique access and found a significantly higher rate of infection with oblique access. We use a longitudinal access also with a view to any future revision, cover the osteotomy with the above-mentioned periosteal flap and attempt to reduce the risk of postoperative haemorrhage to a minimum with administration of intravenous and topical tranexamic acid, closed-suction drainage and additional careful wound closure with simple interrupted sutures. In cases of late infection in healed osteotomy, the plate can be removed, cleaned up and antibiotic therapy. In case of early infection we attempt cleaning, debridement whilst leaving the plate in situ and antibiotic therapy; alternatively, we fit an external fixator. Early detection of any infection is similar to knee arthroplasty, which is why we perform continuous early monitoring of the CRP values (they should reduce from Day 5 post surgery and be normal after 14–21 days). If there is an early increase of the CRP value, infection is suspected and we perform any puncture under sterile conditions in the area of the osteotomy.

Arterial vascular complications: Klecker [33] reported in an MRI-based study of 1116 knee MRIs a 2.1% incidence of a high branching of the anterior tibial artery before the popliteal muscle with direct proximity to the posterior cortex of the lateral tibia (Fig. 10).

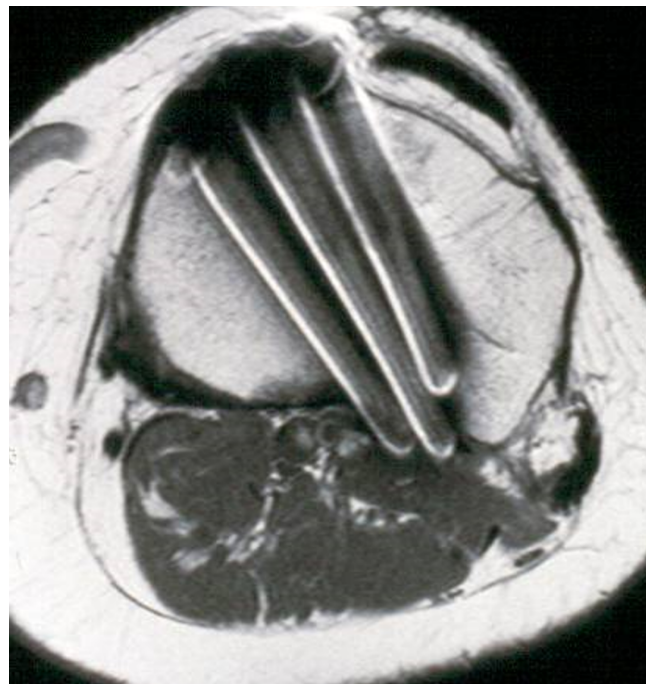


Fig. 10: MRI with overly long screws in immediate proximity to the dorsal vessels.

To prevent damage in these cases it is necessary to introduce a Hohman retractor or a special retractor under image intensifier control during the operation directly on the posterior bone along the osteotomy plane up to the lateral edge. Damage to the anterior tibial artery can cause a pseudoaneurysm and this might manifest as attenuation or absence of the dorsal pedal artery pulse. Therefore, preoperative and postoperative monitoring of the dorsal pedal artery pulse is very important.

The incidence of thromboembolic events is around 2–5% [34, 35] In a venographic study [35] the incidence was as high as 41% although only 15% were clinically manifest, which shows that postoperative thrombosis prophylaxis is useful even for a longer period. We perform drug-based thrombosis prophylaxis combined with support stockings until the patient is safely and fully mobilized.

According to Tunggal et al [34] compartment syndrome is a very rare complication (0.9%). Therefore, monitoring should be performed post surgery for at least the first 12–16 hours.

Hinge fractures on the lateral cortex are classified according to Takeuchi [36] (Fig. 11).

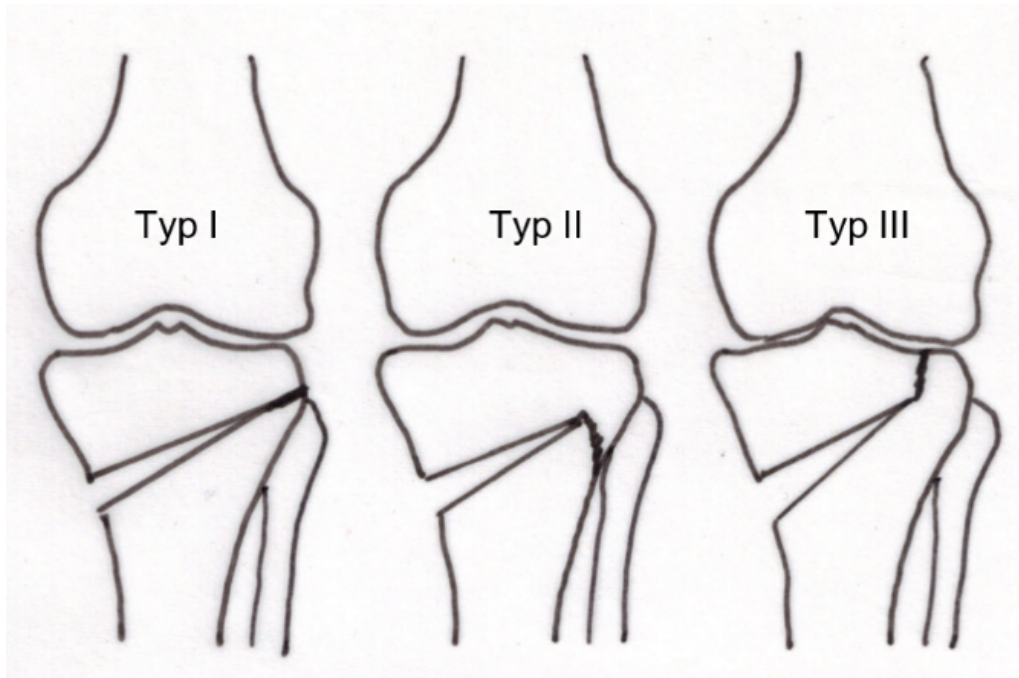


Fig. 11: Classification of hinge fractures according to Takeuchi [36]

The Type I fracture is at the level of the tibiofibular joint and can be easily stabilized by use of the plate fixator. The Type II fracture reaches the distal portion of the tibiofibular joint and can result in instability and overcorrection [37]. The Mikulicz line should be checked again during surgery and the osteotomy reverse corrected if necessary; in our experience, stabilization with a plate fixator combined with a somewhat prolonged partial weight bearing of 6–8 weeks is also sufficient for recovery. Type III fractures reach the proximal portion and can result in intraarticular step formation. These can be treated with a lateral screw osteosynthesis under arthroscopic control [37]. Type II and III fractures can be largely prevented in our opinion with the multi-chisel technique, where two chisels are advanced in parallel almost to the cortex, with a third one then causing a controlled weakening or even opening of the medial hinge.

EMPIRICAL RESULTS

The table shows our long term results following medial opening wedge tibial valgus osteotomy with locking plate [4]

- n = 92
- Follow-up period 2000–2002
- Mean age 50 years (18–75 years)
- Correction angle 9.2 ± 3.41 (2° – 20°)
- All 92 healed (2 with delayed bone fusion in strong smokers)
- No loss of correction
- Full weight bearing after 10 weeks
- Full mobility after 12 weeks
- Pain: VAS 4 pre surgery 2 post surgery
- 3 reoperations (total knee replacement)

CONCLUSION

Medial open-wedge biplanar tibial valgus osteotomy is an important standard intervention in joint-sparing knee surgery. Good patient selection, detailed planning and careful surgical procedures with intraoperative control of the correction in the frontal plane and sagittal plane are the central elements of this method. The rate of complications can be reduced to a reasonable level with the described surgical technique. Additional interventions to the cartilage and anterior cruciate ligament are easily possible.

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