Philippe Neyret
Guillaume Demey
Editors

Surgery of the Knee

Springer

Surgery of the Knee

Philippe Neyret • Guillaume Demey
Editors

Surgery of the Knee

Springer

Editors
Philippe Neyret, MD
Croix Rousse Hospital
Albert Trillat Centre
Lyon
France

Guillaume Demey, MD
Clinique de la Sauvegarde
Lyon Ortho Clinic
Lyon
France

Previously published in French by Elsevier Masson as Traité de chirurgie du genou by Philippe Neyret and Guillaume Neyret, 2012

ISBN 978-1-4471-5630-7   ISBN 978-1-4471-5631-4 (eBook)
DOI 10.1007/978-1-4471-5631-4
Springer London Heidelberg New York Dordrecht

Library of Congress Control Number: 2014949289

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Contributors

I. Albouchi, MD Ben Arous, Tunisia

P. Archbold, MD The Ulster Independent Clinic, Belfast, Northern Ireland, UK

Maad F. AlSaati, MD Saati Medical Center, Riyadh, Saudi Arabia

R. Badet, MD Clinique Saint-Vincent-de-Paul, Bourgoin-Jallieu, France

J. Bruderer, MD Frick, Switzerland

C. Bussière, MD Orthopaedic Center, Dracy-Le-Fort, Dracy-Le-Fort, France

A. Daher, MD Centro Medico Dr Guerra Mendez, Valencia, Venezuela

R. Debarge, MD Clinique Jean Causse, Colombiers, France

G. Demey, MD Lyon Ortho Clinic, Clinique de la Sauvegarde, Lyon, France

R. Desmarchelier, MD Centre Hospitalier Lyon Sud, Pierre Benite, France

L.N. Favaro Lourenço Francisco, MD São Paulo, Brazil

H. Hobbs, MD Sports Science Institute, Newlands Cape Town, South Africa

S. Lustig, MD, PhD Albert Trillat Centre, Croix Rousse Hospital, Lyon, France

Robert A. Magnussen, MD The OSU Sports Medicine Center, Columbus, OH, USA

G. Mezzadri, MD Montelimar, France

P. Neyret, MD Albert Trillat Centre, Croix Rousse Hospital, Lyon, France

M. Ozturk, MD Manisa, Turkey

J.L. Paillot, MD Clinique Herbert, Aix-Les-Bains, France

J. Pernin, MD Clinique Saint-Léonard, Trélazé, France

A. Pinaroli, MD Clinique Médipole de Savoie, Challes-les-Eaux, France

R. Kancelskis Prado, MD São Paulo, Brazil

T. Aït Si Selmi, MD Centre Orthopédique Santy, Lyon, France

E. Servien, MD, PhD Department of Orthopaedic Surgery, Albert Trillat Centre, Croix Rousse Hospital, Lyon, France

Stephen R. Thompson, MD, MEd, FRCSC Fowler Kennedy Sport Medicine Clinic, The University of Western Ontario, London, ON, Canada

F. Trouillet, MD Renée Sabran Hospital, Giens, France

P. Verdonk, MD, PhD Antwerp Orthopedic Center, Antwerp, Belgium

1 The General Principles of Patient Positioning and Setup

G. Demey and Robert A. Magnussen

In this book, we describe several surgical techniques, some of which are technically demanding. Although these operations differ significantly in many ways, the initial positioning and setup of the patient generally remains the same.

- The procedure is performed under general anesthesia or spinal anesthesia. Less commonly the procedure can be performed with a nerve block and mild sedation.
- The patient is positioned on the operating table in the supine position. A padded horizontal post is positioned distally on the table to hold the knee in a 90° flexed position. The use of such a device for positioning has the advantage of allowing the knee to be held at either 90° of flexion (when the heel of the foot rests on the post) or 110° of flexion (when the toes of the foot rest on the post) without changing the post position.
- A lateral support holds the knee in this position, with the thigh resting on the support and slight external rotation of the hip (Figs. 1.1 and 1.2).
- The pneumatic tourniquet is placed as high as possible on the thigh. Once the lower limb has been prepped, it is exsanguinated by elevation. Tightly wrapping the leg or the use of a rubber Esmarch for exsanguination is not necessary. The tourniquet is then inflated to 300 mmHg. If the patient has a history of vascular disease, the tourniquet is positioned as proximally as possible, but generally not inflated.
- The surgical leg is prepped with a Betadine and alcohol solution. After prepping the foot, it is covered with a size nine glove. The leg is then elevated and held by the foot while the rest of the limb is prepped. A stocking is then rolled up the leg to the level of the tourniquet, and an arthroscopy drape is used to complete the sterile field (Figs. 1.3 and 1.4).
- The stocking is opened with scissors. The planned surgical incision and any previous surgical scars are marked with a pen. An antiseptic opsite, Betadine ® Ioban, is applied, always allowing for the possibility of extending the expected incision proximally or distally.

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, 69009 Lyon, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health
and Performance Institute, The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_1, © Springer-Verlag London 2014

Figs. 1.1 and 1.2 Distal and lateral supports maintain the knee in 90° of flexion. Note the slight external rotation of the hip prior to the inflation of the tourniquet

Figs. 1.3 and 1.4 Extension of the knee

Arthroscopy of the Knee

2

P. Archbold, L.N. Favaro Lourenço Francisco, R. Kancelskis Prado, and Robert A. Magnussen

General Information

It is essential that an orthopedic surgeon acquire the skills to perform arthroscopy at an early stage of his/her training. It can be compared to playing golf or driving a car, as when these skills are acquired at an early age they appear to come naturally. The subject of this chapter is not to give a general overview of the surgical options and situations encountered but instead to describe some tricks which can facilitate arthroscopy.

In this chapter, we will provide general concepts. The specific techniques and major indications will be presented in detail in the corresponding chapters.

P. Archbold, MD (✉)
The Ulster Independent Clinic, 245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

L.N. Favaro Lourenço Francisco, MD • R.K. Prado, MD
São Paulo, Brazil
e-mail: lucionuno@hotmail.com; rodrigo27prado@hotmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University, Suite 3100, 2050 Kenny road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

Surgery

Patient Preparation

Following arrival at the hospital and prior to the administration of any medications, each patient puts a bracelet onto the lower limb that is to undergo surgery (Fig. 2.1). This gesture gives more responsibility to the patient and engages him/her in his/her own treatment. The person who prepares the lower limb for surgery then removes the bracelet in the operative theater. Consequently, the operating team is sure of the surgical side. Fortunately, in our institution, we have never had a “wrong side surgery.” General anesthesia is preferred as it offers complete amnesia of the intraoperative period and can be quickly administrated. In the case of older patients, obese patients, and patients with limited respiratory capacity or a difficult airway, regional anesthesia can be used. This technique also allows for optimal pain relief in the operated limb.

Fig. 2.1 A bracelet placed onto the operative extremity by the patient on the eve before surgery (or morning in case of outpatient treatment)

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_2, © Springer-Verlag London 2014

Patient Positioning

The patient is placed on the operating table in the supine position. A vertical post is positioned at the proximal third of the thigh to resist a valgus stress on the knee (Fig. 2.2), and a tourniquet is placed high around the thigh. The quality and ease of the arthroscopy is facilitated by the ability to place the knee in valgus (for improved visualization of the medial compartment) and by the use of the tourniquet to facilitate hemostasis and visualization. A second horizontal post is positioned distally on the table to hold the knee in a 90° flexed position. This technique has the advantage of allowing the knee to be held at both 90° of flexion (when the heel of the foot rests on the post) and at 110° of flexion (when the toes of the foot rest on the post). A further advantage is that this setup can be used to combine arthroscopic and open surgery (e.g., arthroscopic and open surgery on the patella or an osteotomy (Fig. 2.3a, b).

Fig. 2.2 Valgus stress on the knee using a vertical post laterally positioned at the proximal third of the thigh

The lower limb is sterilely prepared using Betadine (or chlorhexidine in the situation of an iodine allergy). The foot is covered with a surgical glove size 9 and then the lower limb is covered with a stocking and subsequently an extremity sheet. The limb is elevated for several seconds and the tourniquet is inflated. The pressure of the tourniquet should be a minimum of 200 mmHg above the diastolic blood pressure or in absolute numbers approximately 300 mmHg. It should never be inflated longer than 120 min.

Instrumentation

The essential piece of equipment is an arthroscopic tower including a camera, a monitor, and a light source. An arthroscopic pump, a shaver, and a recording device are useful aids and are routinely used in our department. Image recording is considered very important not only to document the intervention but also to inform the patient as to the surgical findings in a simple and accurate way.

In our department, we have three fully equipped arthroscopic towers available for three operating rooms and a sufficiently large number of arthroscopes and cameras. The arthroscopic infusion fluid chosen is an isotonic saline solution. A minimal pressure of 50 mmHg suffices to obtain an acceptable distension of the knee joint.

The sleeve for the arthroscope has an inlet and an outlet. We use a 4 mm diameter lens with 30° angulation. In case of reconstruction of the PCL or arthroscopy in the posterior region of the knee, a 70° arthroscope can be used.

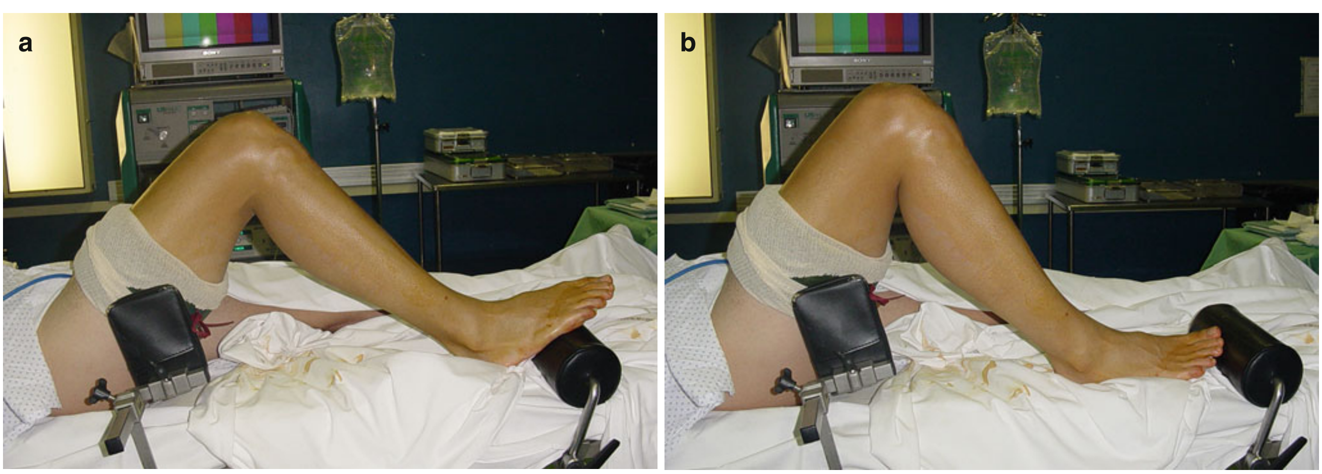


Fig. 2.3 Patient positioning. A horizontal post is positioned distally on the table to hold the knee in a 90° flexed position (**a**) or at 110° of flexion when the toes rest on the post (**b**)

Surgical Instruments

The list of available instrumentation becomes longer each day as arthroscopic techniques advance. Certain instruments, however, are indispensable and make form the "basic toolbox": the probe, the arthroscopic scissors, a punch, a large grasper, and a cannula (Fig. 2.4). The punch, which is the indispensable instrument for performing a meniscectomy, has a straight tip and a slightly angled shaft to facilitate sliding under the femoral condyle (Fig. 2.5).

Fig. 2.4 Surgical devices used in our practice – from left to right: probe, beaver knife, punch, biopsy forceps, grasping forceps (Wolf forceps), and suction cannula

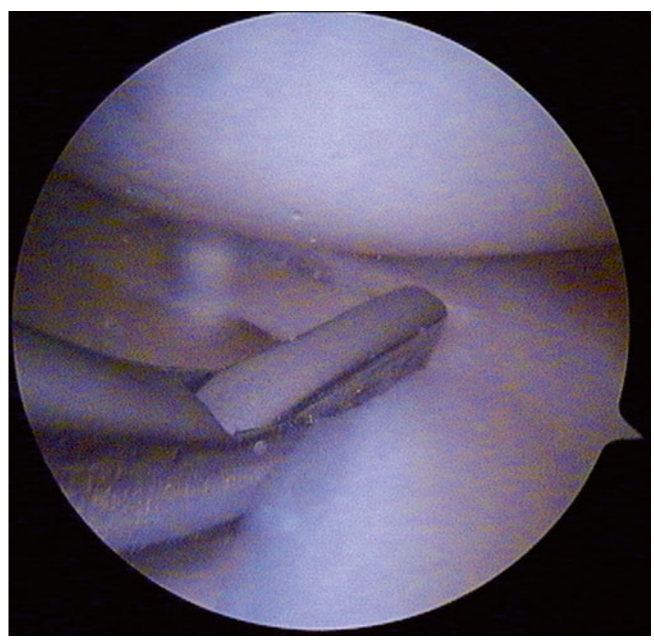


Fig. 2.5 Meniscectomy using the punch

Surgical Technique

Portals

Triangulation is the most effective arthroscopic technique. It requires two portals, which can be made in a variety of positions:

- The anterolateral portal
- Two anteromedial portals
- The superolateral portal
- The superomedial portal
- The posteromedial portal
- The posterolateral portal
- The lateral parapatellar portal of Patel
- The posteromedial and posterolateral portals as described by Ph. Beaufils

The anterolateral and the two anteromedial portals are the most frequently used. Using these three portals, one can perform 95 % of the surgical procedures. The other portals are considered accessory portals (Fig. 2.6). The choice of the medial portal depends on the indication and on the arthroscopic finding. One should never hesitate to make an additional third portal or to reverse the location of the camera and instrumentation between portals. Attempting to use inadequate portals to avoid an additional incision will surely lead to mistakes.

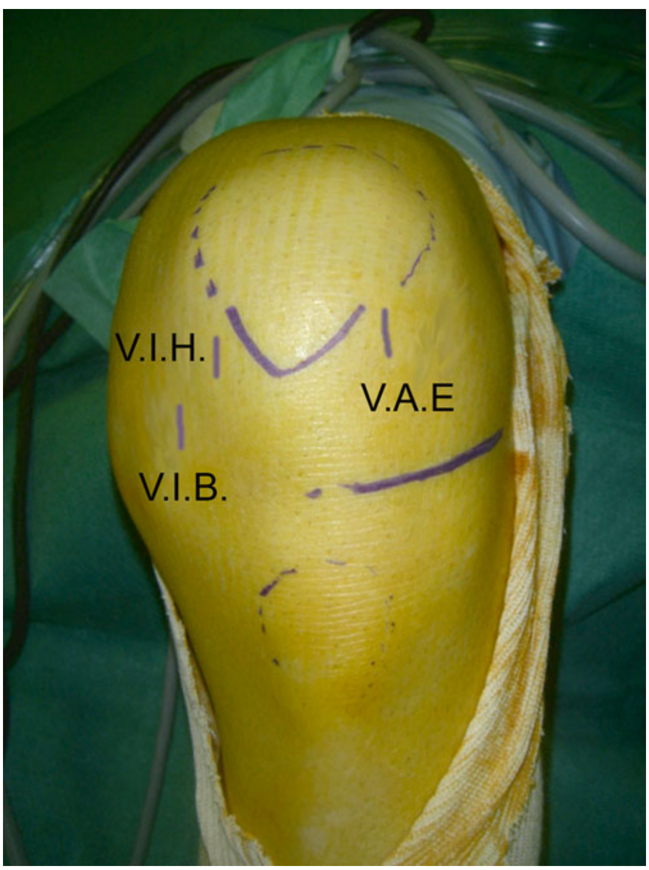


Fig. 2.6 Left knee, anatomical landmarks (anterior tibial tuberosity, patella, lateral tibial plateau), and anterolateral, low anteromedial, and high anteromedial portals

The Anterolateral Portal

This portal is used to introduce the camera. It allows good visualization of the joint. The skin landmarks are medially, the lateral edge of the patellar tendon; inferiorly, the lateral tibial plateau; and superiorly, the lateral femoral condyle. The entry point of the portal is just inferolateral to the patella. An 11 blade is introduced with the blade angled proximally (to protect the meniscus), and a vertical incision is made in the soft spot situated between the lateral tibial plateau, the lateral femoral condyle, and the inferolateral patella.

If the incision is placed too low, the available space to position the camera will be reduced and there is a risk of damaging or cutting the anterior horn of the lateral meniscus. This situation is often encountered in cases of patella baja or when the surgeon opts to reuse a previous skin incision.

The Two Anteromedial Portals

The Lower Anteromedial Portal

This portal provides access to the anteromedial joint space, which is situated just above the medial meniscus. In order to avoid damage to the medial meniscus some strict rules must be adhered to. The knee should be flexed at 90° with the foot positioned on the distal post. Please note that the lower anteromedial portal is situated closer to the femorotibial joint line than the anterolateral portal. The inferomedial portal is also farther from the patella tendon. With the scope in the anterolateral portal, one can transilluminate this medial area for guidance.

This skin incision is again made with an 11 blade directed superiorly (and never inferiorly!). The skin incision is vertical and 5–8 mm in length. Under arthroscopic control, the blade is visualized as it enters the joint just proximal to the superior surface of the medial meniscus. One can now turn the scalpel 90° and widen the capsular incision horizontally just above the meniscus. This portal, which is just above the superior surface of the medial meniscus, allows easy access to the medial compartment for a successful meniscectomy. A portal placed too centrally will enter in the area of Hoffa's fat pad, significantly limiting visualization.

The Superior Anteromedial Portal

Symmetrical to the anterolateral portal, thus more central and more proximal than the lower anteromedial portal, this portal gives improved access to the intercondylar notch. In the figure-of-four position, this portal provides perfect visualization of the lateral compartment and provides optimal access to treat lateral meniscal lesions. Both the lower and superior anteromedial portals can be used in combination.

The Superolateral Portal

This portal, superior and lateral to the patella, gives access to the patellofemoral compartment, the suprapatellar pouch, and the lateral condylar gutter. This portal can be used for the evaluation of patellofemoral cartilage and patellar tracking as well as for arthroscopic synovectomy and arthrolysis.

The Superomedial Portal

This portal is symmetrical to the superolateral portal but on the medial side of the patella. The entry point is slightly more proximal (approximately 2–3 cm above the patella) to allow easy instrumentation.

The Posteromedial Portal

This portal is used to visualize the posterior compartment and posterior horn of the medial meniscus. The tibial insertion of the posterior cruciate ligament can also be visualized. The skin incision should be proximal enough to allow the entry point on the capsule to be in contact with the posterior part of the medial condyle. This positioning allows optimal orientation of the instruments. A skin incision that is situated too distal will increase the difficulty of the surgery.

In order to facilitate the correct positioning of the skin incision, a spinal needle can be introduced. The knee should be positioned in the figure-of-four position and the capsule of the knee completely distended (Fig. 2.7). The capsular entry point of the needle can be visualized by transillumination with the camera placed through the intercondylar notch (Fig. 2.8).

The Posterolateral Portal

This approach can be used to visualize the posterolateral compartment and the posterior horn of the lateral meniscus. As for the posteromedial approach, a spinal needle can be used to help determine the exact site of the skin incision. The needle is introduced just superior to the lateral femoral condyle with the knee in a 90° flexed position.

The tip of the needle can be visualized with the arthroscope placed in the intercondylar notch. The skin incision is subsequently made with an 11 blade guided by the spinal needle and oriented toward the condyle. The combination of the posteromedial and posterolateral portals has been previously described in detail by Philippe Beaufils.

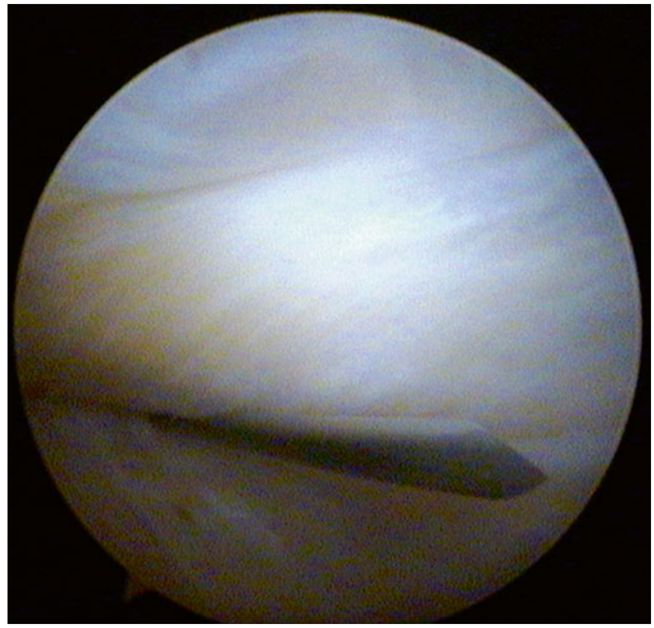


Fig. 2.7 Posteromedial portal, left knee. A spinal needle is inserted through the capsule distended by arthroscopy fluid

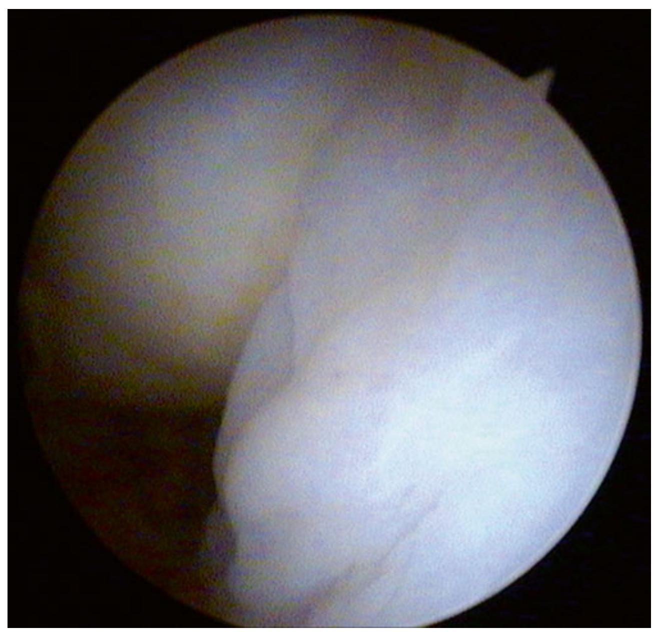


Fig. 2.8 Posteromedial portal, left knee. The ACL (*right*) and the posterior lateral femoral condyle (*left*) are visualized

The Lateral Parapatellar Portal of Patel

This portal is situated along the lateral border of the patella but more laterally and proximally than the classic anterolateral portal. This approach gives an excellent view on the lateral femorotibial compartment and in particular the anterior horn of the lateral meniscus.

All the abovementioned portals can be used for instrumentation, but the anterolateral and anteromedial portals are the most frequently used (Fig. 2.9). We have never used the transpatellar portal described by Gillquist. Some surgeons use it in order to have a better visualization of the posterior aspect of the notch.

Fig. 2.9 Portals, left knee. Anterolateral portal (arthroscope, *right*) and low anteromedial portal (instrument, *left*)

Arthroscopic Steps

After anesthetic induction, the knee is reexamined to complete the physical examination. The sleeve and obturator are introduced through the anterolateral portal in the direction of the femoral notch with a knee in the 90° flexed position. The sleeve is then directed to the suprapatellar pouch while extending the knee. The inflow cannula is subsequently connected and the joint is distended. The obturator is removed and the camera is introduced. The intra-articular examination is performed in a systematic fashion. The sequence of the surgical steps is inspection, then palpation, and subsequently treatment. By beginning with the inspection of the knee, one can adapt and choose the necessary portals for instrumentation.

The knee cavity is inspected in a systematic sequence:

- The patellar femoral compartment
- The medial and lateral tibiofemoral compartment
- The intercondylar notch

The Patellofemoral Compartment

The lower limb is extended in neutral rotation to rest on the operating table. The exploration starts in the suprapatellar pouch. We do not use an outflow sleeve for lavage except in cases of a significant hemarthrosis. The camera is introduced through the anterolateral portal and the lens is angled

Fig. 2.10 Placing the arthroscope to examine the patellofemoral joint

proximally (Fig. 2.10). The intra-articular space is opened up by distention.

With the camera lens oriented proximally and in the direction of the patella, one can examine the medial facet, the lateral facet, and the central ridge of the patella (Fig. 2.11).

Excellent visualization of the patellofemoral compartment can also be achieved through the suprapatellar portal (frequently used in the case of episodic dislocation of the patella). After inspection of the patella and trochlea, the arthroscope is progressively retracted to the point where adequate visualization of the patellofemoral compartment is lost. The arthroscope is now rotated into the neutral position with the camera lens orientated at 90° looking toward the suprapatellar pouch. This maneuver allows simultaneous inspection of the patella and trochlea. In particular it allows inspection of the part of the trochlea just above the notch. Although generally not inspected, this zone is frequently damaged (deceleration lesions).

The camera lens remains at the 90° and now slides along the medial femoral gutter while the hand that is holding the camera is now directed proximally, bringing the camera distally into the medial tibiofemoral joint.

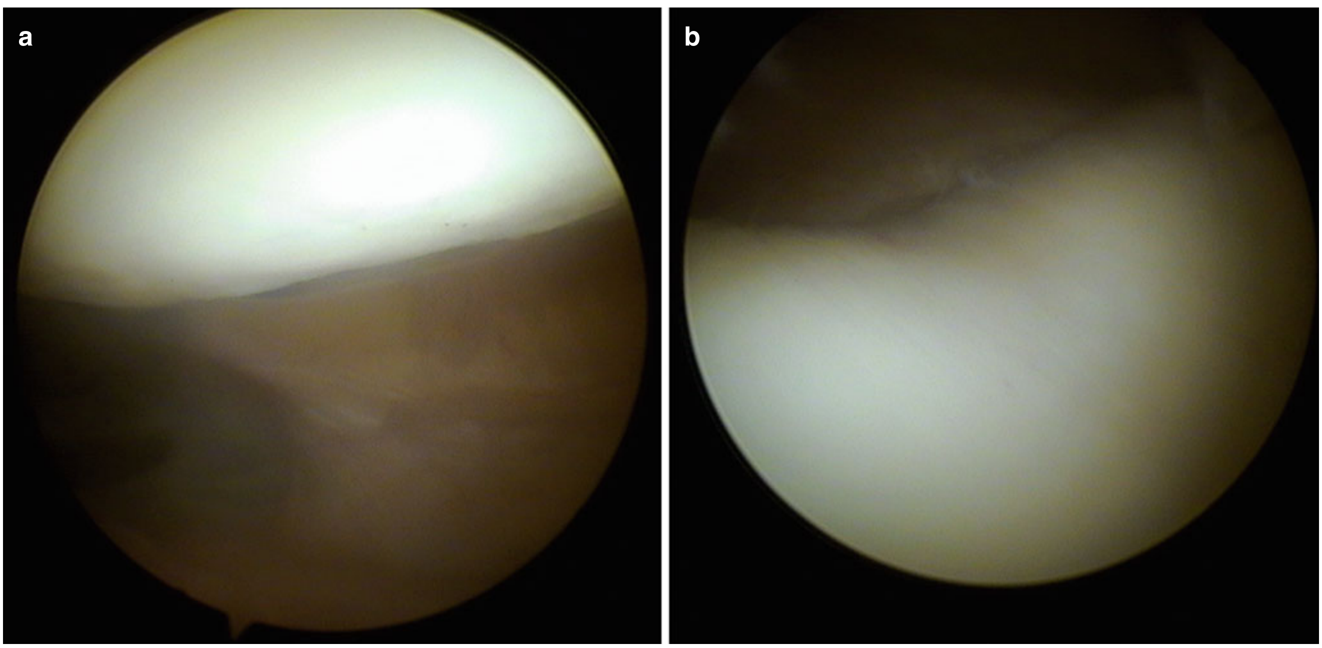


Fig. 2.11 Patellofemoral compartment: (**a**) Patella, (**b**) trochlea

The Medial Tibiofemoral Compartment

The lower limb is now elevated off the table and held in position by placing it on the contralateral iliac crest of the surgeon (Fig. 2.12a). Subsequently, the medial femoral condyle and the medial compartment can be visualized with the knee in about 30° of flexion (Fig. 2.12b, c). The knee can now be placed into valgus (the patient's foot is moved laterally while the thigh is held by the post) (Fig. 2.12d). It is often helpful for an assistant to place a downward force on the thigh at the level of or just distal to the tourniquet to prevent excessive knee flexion (Fig. 2.13). This maneuver helps open up the medial compartment allowing the entire body of the medial meniscus to be easily visualized. The synovial fringes can be easily identified because of the slight pink color. The free meniscus border is checked as well as the anterior and posterior horns (Fig. 2.14). As yet we have not performed a percutaneous release of the deep fibers of the MCL to improve visualization, as has been described by H. Paessler. Pushing in the popliteal fossa with the fingers can help bring the posterior horn of the meniscus more anteriorly. Palpating the medial meniscus can be done with a probe introduced through the anteromedial portal (Fig. 2.15). The peripheral attachments of the meniscus can be evaluated, potential meniscus lesions investigated, and the quality and texture of the meniscus assessed.

The articular cartilage of the medial femoral condyle and the medial tibial plateau are palpated (Fig. 2.16). Slowly flexing the knee allows evaluation of both the integrity of the articular surface as well as the quality of the cartilage.

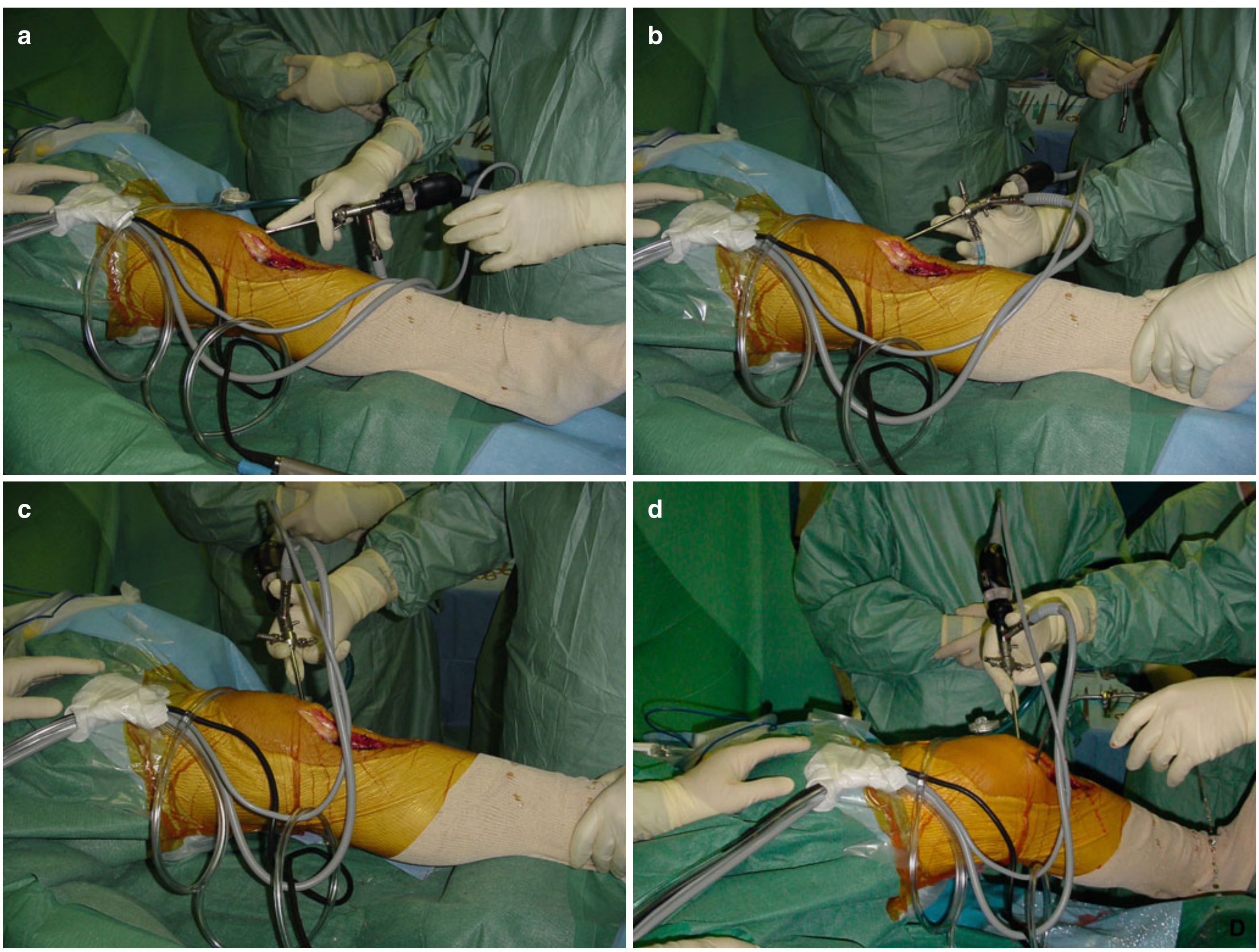


Fig. 2.12 Changes in the position of the arthroscope from the patellofemoral compartment to the medial tibiofemoral compartment. The arthroscope looks at the suprapatellar recess (**a**), it is switched to the neutral position parallel to the joint space (**b**), the arthroscope is rotated down in the medial tibiofemoral compartment (**c**) while the leg is positioned in valgus (**d**)

Fig. 2.13 Position of the surgeon and assistant during a medial meniscectomy

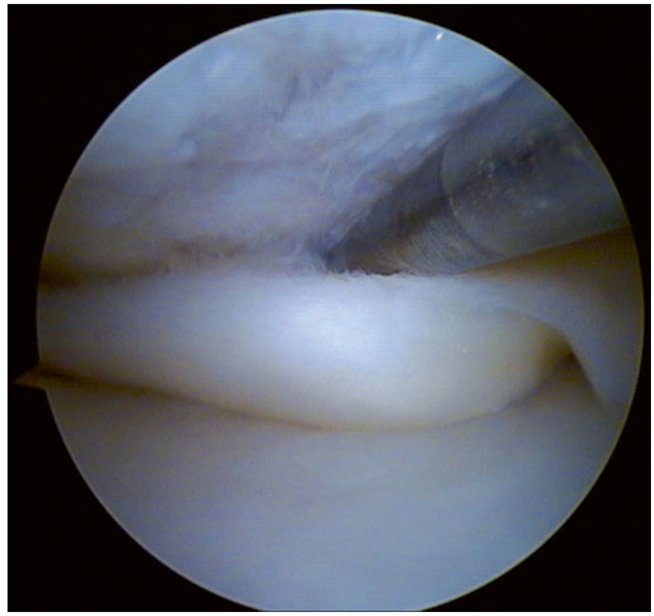


Fig. 2.15 Palpation of the medial meniscus, showing an unstable lesion. Note the femoral chondral lesions

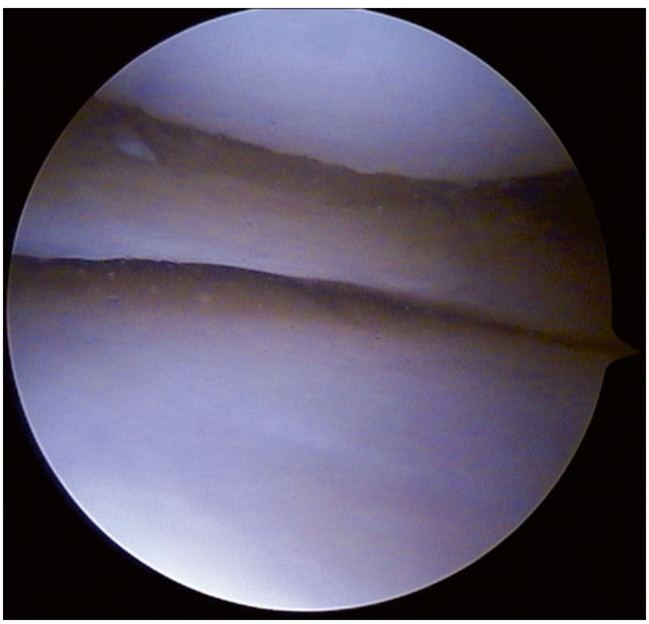


Fig. 2.14 Normal medial meniscus, body

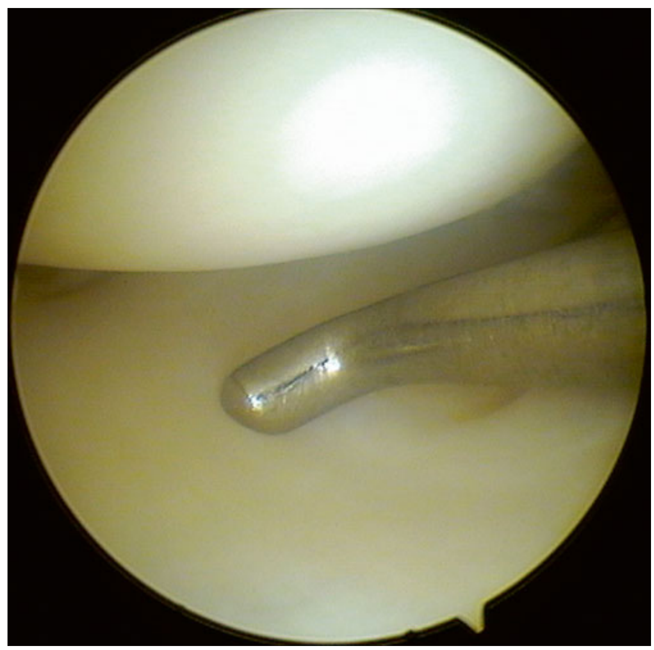


Fig. 2.16 Palpation of tibial plateau cartilage

Lateral Tibiofemoral Compartment

The arthroscope is not removed from the joint and the knee is now positioned in the Cabot (Fig. 2.17) position, i.e., the knee in varus and flexed to 90°. The foot rests on the contralateral tibia. The hip is flexed, abducted, and in external rotation. This maneuver opens up the lateral compartment (Fig. 2.18). The superior and inferior surface of the anterior, body, and posterior horn of the lateral meniscus can be visualized. The intra-articular course of the popliteal tendon can be seen. It runs anteriorly and superiorly from its origin posterior tibia to its insertion on the lateral femoral condyle. It is necessary to check the tendon and the hiatus since specific anatomic variations have been observed (Fig. 2.19). The meniscal wall and the meniscopopliteal attachments can be well visualized. Anatomical variations of the lateral meniscus can be observed and potentially treated (discoid meniscus, hypermobile meniscus).

Fig. 2.17 Cabot (figure-of-four) position to assess the lateral tibiofemoral compartment

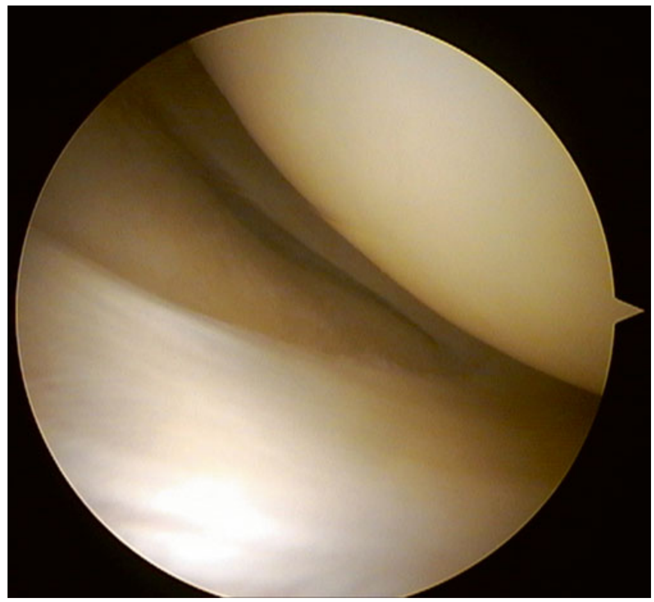


Fig. 2.18 Normal lateral meniscus. Note that the meniscus is inclined to the horizontal on the screen

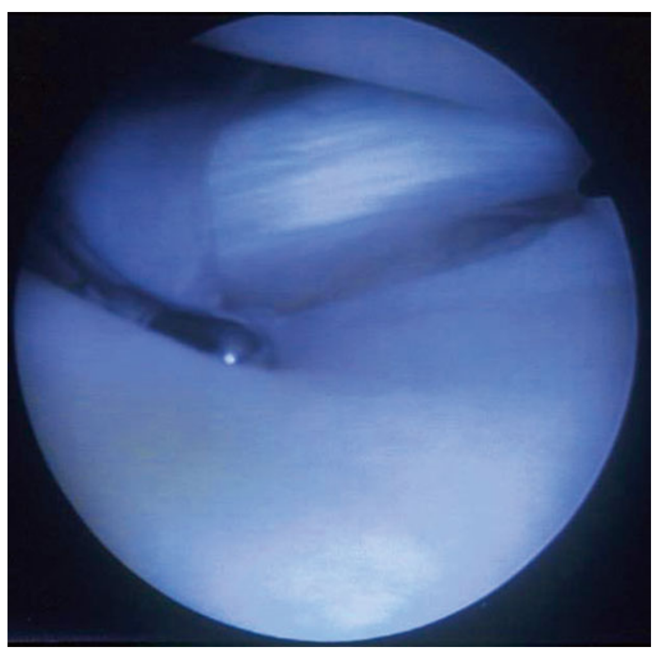


Fig. 2.19 Popliteus tendon

The Intercondylar Notch

To visualize the intercondylar notch, the knee is flexed to 90° with the foot resting on the post (Fig. 2.20). A synovial extension between the Hoffa fat and the lateral condyle also known as the ligamentum mucosum or infrapatellar plica can obstruct adequate visualization of this region. If this is the case, we routinely resect this ligamentum mucosum with the shaver at its attachment superior to the notch, allowing it to fall out of the way of the camera.

The ligament of Humphrey and the PCL can now be observed in the upper part of the intercondylar notch. They occupy the medial two-thirds of the intercondylar notch while the anterior cruciate ligament has a more horizontal course to the back of the notch where it inserts on the lateral femoral condyle. The appearance of the intercondylar notch as an inversed "U" or a capital "A" is noted in the operative report as well as the presence of any osteophytes.

The anterior cruciate ligament can be easily recognized due to its white color and covering with a thin, vascularized synovium (Fig. 2.21). The two separate bundles of the ACL can be frequently discerned. Its origin is very posterior on the lateral condyle and "low" with the knee in flexion. The tension of the ACL can be tested by palpation. The posterolateral bundle is only under tension near full extension.

The posterior cruciate ligament is covered by the more horizontally oriented ligament of Humphrey and by synovial tissue (Fig. 2.22). The ligament of Humphrey, also known as the anterior meniscofemoral ligament, should not be mistaken for the PCL. It originates from the posterior horn of the lateral meniscus then crosses the PCL anteriorly to insert just in front of the PCL on the medial femoral condyle. The PCL can be palpated at a level of its insertion on the femoral condyle. The surface area of the ligament of Humphrey is less than 30 % of the PCL (Fig. 2.23).

Despite the presence of the cruciate ligaments in the intercondylar notch, access to the posterior knee compartment is possible. This can be done by gently gliding the sleeve and the round-tipped obturator along the medial femoral condyle underneath the PCL with the knee at 90° of flexion.

While pushing the sleeve and obturator, the knee is gently flexed up to 110°. The obturator is removed. The camera is introduced and the posterior compartment is now visualized. The insertion of the PCL (Fig. 2.24) on the tibia can be observed.

At the end of the arthroscopy, we manually apply pressure to the suprapatellar pouch and flex the knee in order to evacuate the intra-articular fluid.

Small meniscal or cartilaginous fragments can sometimes be found in the portals. As these can result in persistent irritation and induration of the wound, we pinch the portal between two fingers to remove them.

Fig. 2.20 Position for the examination of the intercondylar notch

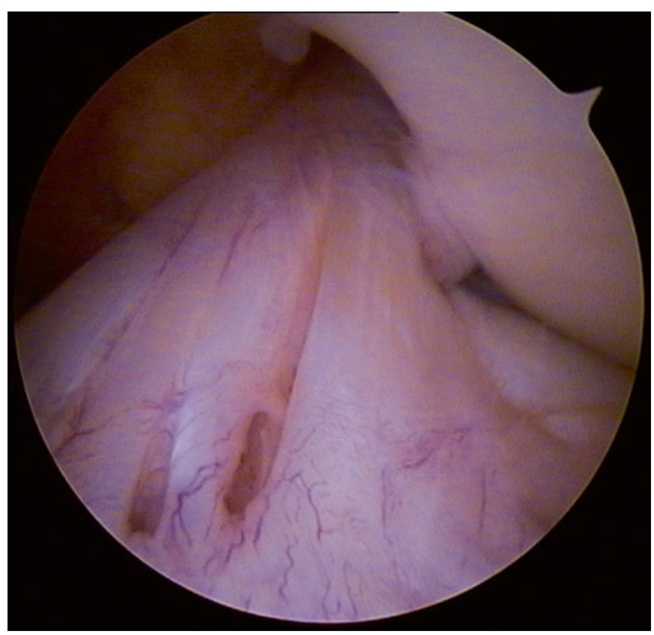


Fig. 2.21 Anterior cruciate ligament (ACL)

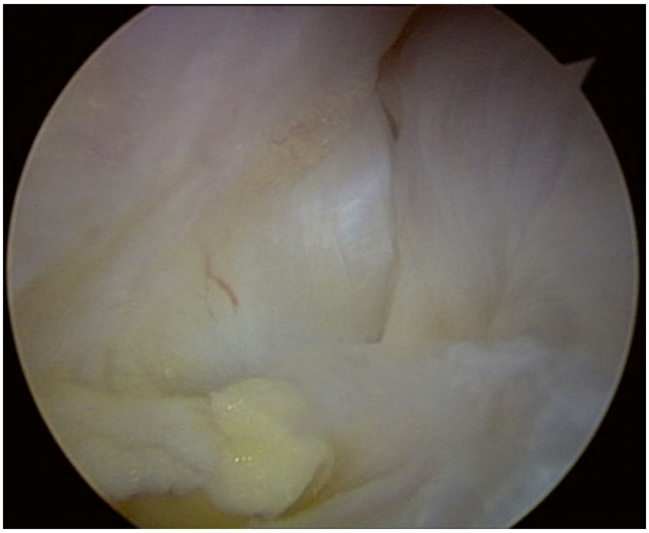


Fig. 2.22 The intercondylar notch, left knee. The femoral origins of the PCL (*right*) and ACL (*left*, in front of the PCL) are observed

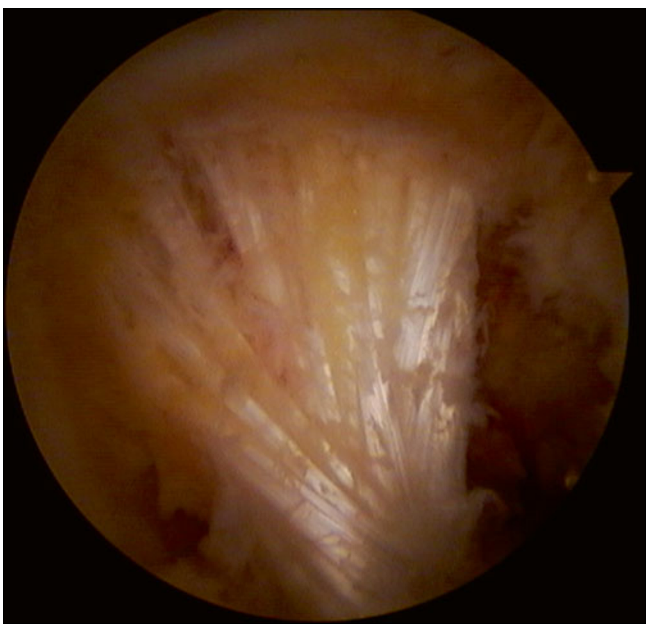


Fig. 2.23 The ligament of Humphrey in front of the PCL, left knee

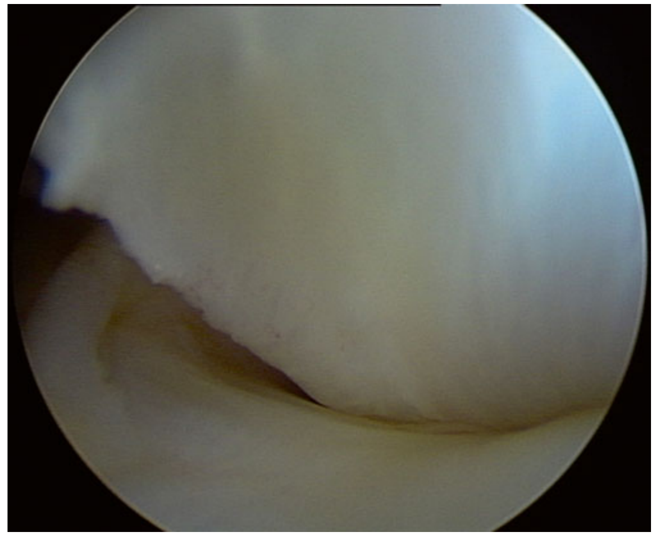


Fig. 2.24 The tibial insertion of the PCL (left knee)

Postoperative Care

No drain is necessary. Nonabsorbable skin sutures are removed on the tenth postoperative day. Thromboprophylaxis is not necessary except for patients at higher risk for DVT. The use of routine prophylactic antibiotics is not recommended.

Outpatient treatment is preferred unless specific medial or social concerns require an inpatient stay.

Mobilization of the knee is performed immediately and physiotherapy is prescribed for nine sessions. We allow the patients to drive a car on the third or fourth postoperative day (this delay is probably too short but a longer delay is not acceptable).

Activities of daily life are limited for the first week and professional activities are limited for 2–4 weeks, depending on the profession. All patients are reviewed at day 45 to assess postoperative recovery. Sport activities are allowed at 4–6 weeks.

The patients should always be informed before the intervention of the rare but real risk of infectious complications as well as the possibility of a longer than usual rehabilitation period. This information is essential. Arthroscopic surgery should not be considered nor presented to the patient as being harmless. Treatment failures or persistent lesions are observed in 1 % of our patients.

Complications

Paresthesia and hypoesthesia are not commonly observed after an arthroscopy. By systematically transilluminating the skin during creation of the anteromedial portal, one can limit the frequency of lesions to the sensitive nerve branches in this area. Dysesthesias have also been reported and can lead to a complex regional pain syndrome (algodystrophy).

We have not observed skin necrosis. A possible reason could be that we do not perform arthroscopic lateral patellar release with an electrocoagulator. We have never observed tibial or femoral fractures during an arthroscopic procedure. We have observed three cases of a complete medial collateral ligament tear in our long experience over 20 years. These lesions have always healed uneventfully with conservative treatment. We have always been able to extract parts of broken instruments or meniscal fragments. Stopping inflow of the irrigation fluid can facilitate extraction.

Other Complications

Iatrogenic intra-articular injuries can be reduced if not completely eliminated through careful attention to detail. Perhaps most importantly, the head of the shaver should always be visualized before shaving, especially in the posterior compartment in order to avoid an injury to neurovascular structures.

3 Meniscectomy

P. Archbold, L.N. Favaro Lourenço Francisco,
R. Kancelskis Prado, and Robert A. Magnussen

Medial meniscectomy is one of the most frequently performed surgical procedures. The technical difficulties associated with this procedure are not always appreciated. Sometimes it can be harder to perform a medial meniscectomy than to perform an ACL reconstruction.

When confronted with a meniscal lesion, the following questions should always be asked:

- Is the knee stable or is there ligamentous laxity?
- Is it a degenerative tear or a traumatic tear?

Before surgery it is critical to document the clinical history including patient activity level and to perform a detailed physical examination. AP and lateral radiographs of the knee are necessary, and a Rosenberg view is required after the age of 50.

In patients above age 60, we routinely perform an MRI to look for any degenerative change in the underlying subchondral bone. If this is the case, a conservative rather than surgical management is preferred.

This detailed patient workup allows us to choose the most appropriate mode of treatment for each patient. Sometimes it is useful to utilize contrast-enhanced imaging techniques. The arthro-MRI is a novel technique, the full potential of which we do not know currently. Arthro-CT is useful when patients have a history of meniscectomy or meniscal suturing as well as for the evaluation of the articular cartilage.

P. Archbold, MD (✉)
The Ulster Independent Clinic, 245 Stranmillis Road,
BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

L.N. Favaro Lourenço Francisco, MD • R.K. Prado, MD
São Paulo, Brazil
e-mail: lucionuno@hotmail.com; rodrigo27prado@hotmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health
and Performance Institute, The Ohio State University,
Suite 3100, 2050 Kenny Road,
Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_3, © Springer-Verlag London 2014

The Medial Meniscectomy

A partial medial meniscectomy is a quick and reliable procedure with excellent short- and long-term results. The outcome is better in traumatic meniscal injuries within a stable knee joint with no cartilage damage (Fig. 3.1a, b).

A medial meniscectomy is typically performed while working through an anteromedial portal, keeping the following rules in mind: (1) the meniscus wall should always be respected, (2) one has to be "economical" with the resection, and (3) iatrogenic cartilage damage should be avoided.

In the case of a degenerative tear, the meniscectomy should be more aggressive; however, the integrity of the meniscal wall should always be respected. With degeneration, the meniscal tissue undergoes structural changes (Fig. 3.2). This deterioration in the quality and mechanical characteristics of the meniscus means that a flap or tear left in situ can result in the failure of the treatment.

In this instance (older patients, degenerative lesions), one has to compromise. We perform a more aggressive meniscectomy but always with respect for the meniscus wall (Fig. 3.3). In many cases a stable tear, such as a horizontal cleavage tear in the meniscus wall, is left in place and not resected.

A medial meniscectomy is generally performed using the anteromedial portal while viewing through the anterolateral portal (see chapter on surgical approach and exploration). A straight punch is adequate in the majority of cases to perform the meniscectomy. A 4 mm shaver can be used to debride frayed meniscal tissue as well. Surgeons should be aware that the degenerative meniscal tissue is softer than the normal meniscus and aggressive use of the shave or punch can quickly lead to a loss of the meniscal wall and effect total meniscectomy in these patients, if care is not taken.

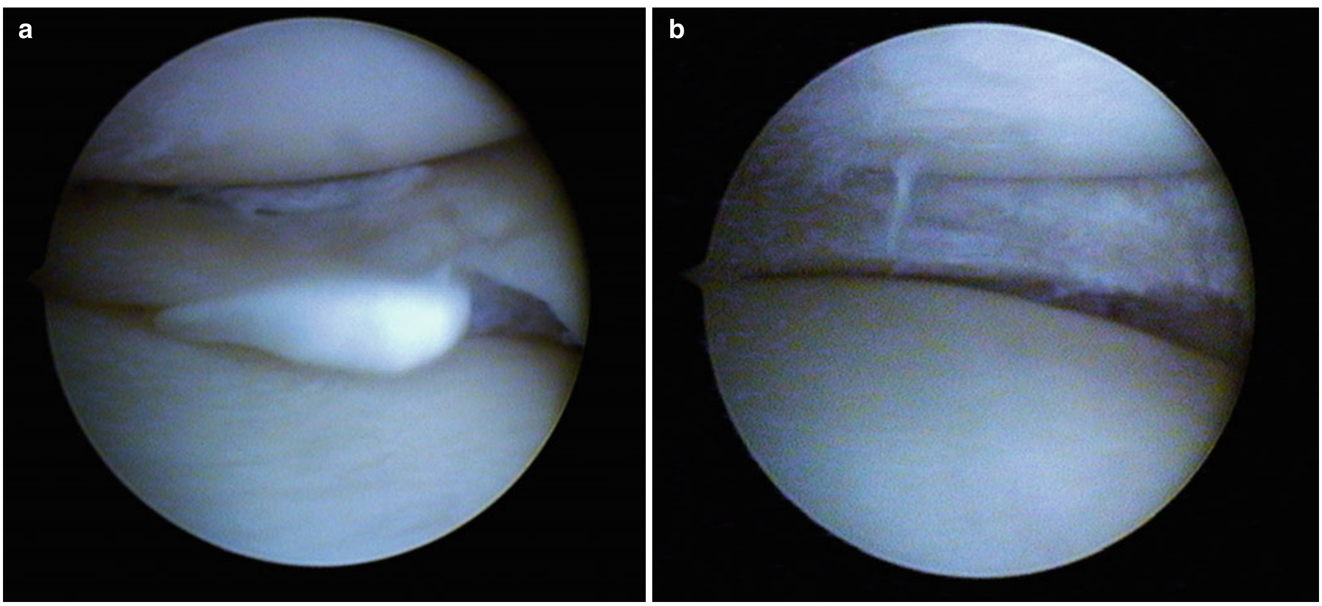


Fig. 3.1 Medial meniscal tear (flap) (**a**) treated by partial meniscectomy (**b**)

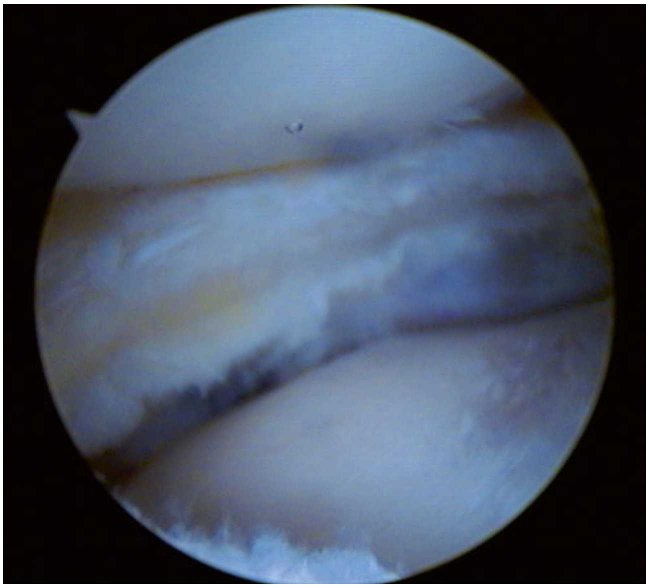


Fig. 3.2 Degenerative tear of the medial meniscus demonstrating structural changes

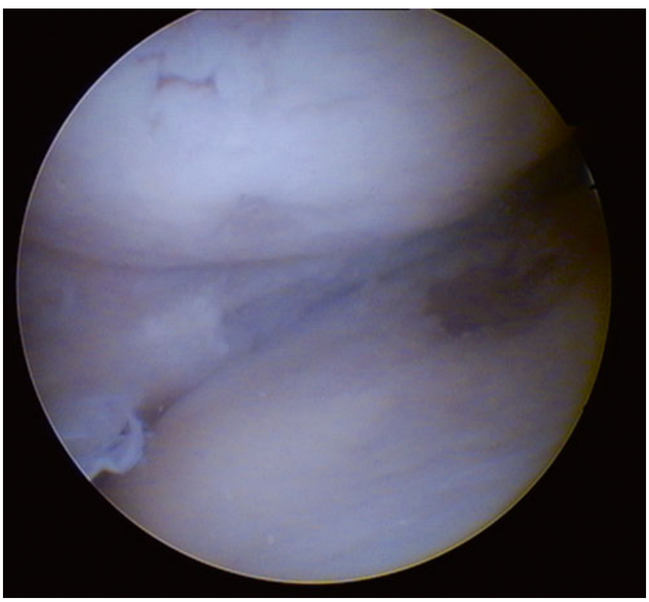


Fig. 3.3 Degenerative tear of the medial meniscus and cartilage lesions

Specific Cases

In some cases, access to the posterior horn of the medial meniscus is difficult. In these cases, it is often helpful for the assistant to place downward pressure on the thigh just distal to the tourniquet. This maneuver allows the surgeon to apply valgus load to the knee more effectively without the knee going into flexion. Applying pressure in the posteromedial crease of the knee joint is often helpful in delivering the posterior horn of the medial meniscus into a position where debridement can be performed. In spite of these tricks, a peripheral posterior tear associated with anterior cruciate ligament laxity remains difficult to treat. The posterior horn has a frequent tendency to escape behind the femoral condyle. Fortunately, many of these lesions can be sutured, improving outcomes and avoiding the need for partial meniscectomy.

In the case of a bucket-handle tear that cannot be sutured, we usually start by cutting the tear at its anterior root. The anterior cut should not leave a large stump of torn tissue behind because this piece of meniscus will be difficult to excise later in the case. For this procedure we prefer the banana knife rather than the punch. The banana knife is a slightly curved scalpel fixed on a tubular scalpel holder. Cutting of the anterior part is easier if the bucket-handle tear is reduced. After the anterior resection, the posterior resection of the bucket-handle tear is performed. With a punch, the most posterior part of the tear is addressed by creating a curved progressive resection of the torn piece's posterior attachment and then removing the entire torn piece of meniscus in one piece.

Lateral Meniscectomy

The surgical technique is the same for a degenerative lesion as for a traumatic lesion.

Radial tears in the middle segment are treated with a meniscectomy in the form of an arc. The popliteal hiatus should always be respected if possible. If this hiatus is resected, the clinical outcome in the midterm will be worse. The posterior horn and the middle segment are easily accessible with the punch with a knee in the figure-of-four position. In very posterior lesions, access can be limited by the tibial spines. In this case the viewing and working portals should be reversed. It can be very difficult to excise tears of the anterior horn with the punch; however, they can be addressed more easily using the shaver, taking care not to resect the insertion of the anterior horn or to damage the articular cartilage.

The Meniscal Cyst

A meniscal cyst is most frequently found in the lateral meniscus. The general treatment principle is to preserve the meniscus wall. Additional investigations such as MRI and arthro-CT can help in the diagnosis of the lesion (Fig. 3.4a, d). In some cases, the cyst is in continuity with the joint space, while in other cases no clear communication with the joint can be found.

In order to preserve the meniscus, we usually combine an arthroscopic procedure to debride any intra-articular meniscus lesions with a direct open approach to resect the cyst and close the connection to the joint with vertical sutures (Fig. 3.5a, b).

In rare cases, the cyst can only be treated all arthroscopically from within the joint (no intact meniscus wall, small cysts).

Patients undergoing meniscal cyst resection should always be informed in advance of the possibility of an additional skin incision, the risk of a residual swelling, and the possibility of recurrence.

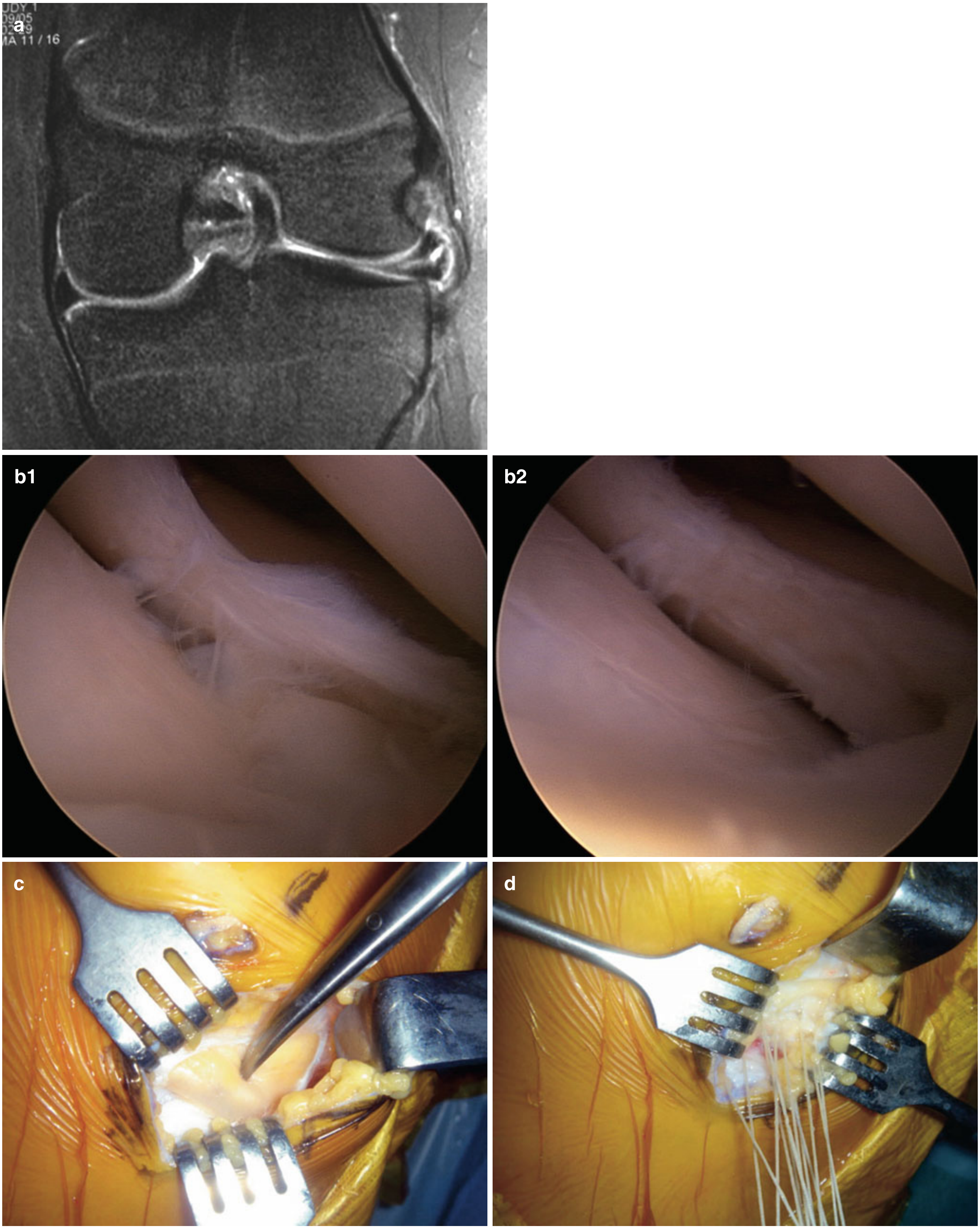


Fig. 3.4 Meniscal cyst of the lateral meniscus. (**a**) Preoperative MRI. (**b1**, **b2**) Arthroscopic views. (**c**) Cyst resection using a direct open approach. (**d**) Vertical sutures to close the connection to the joint

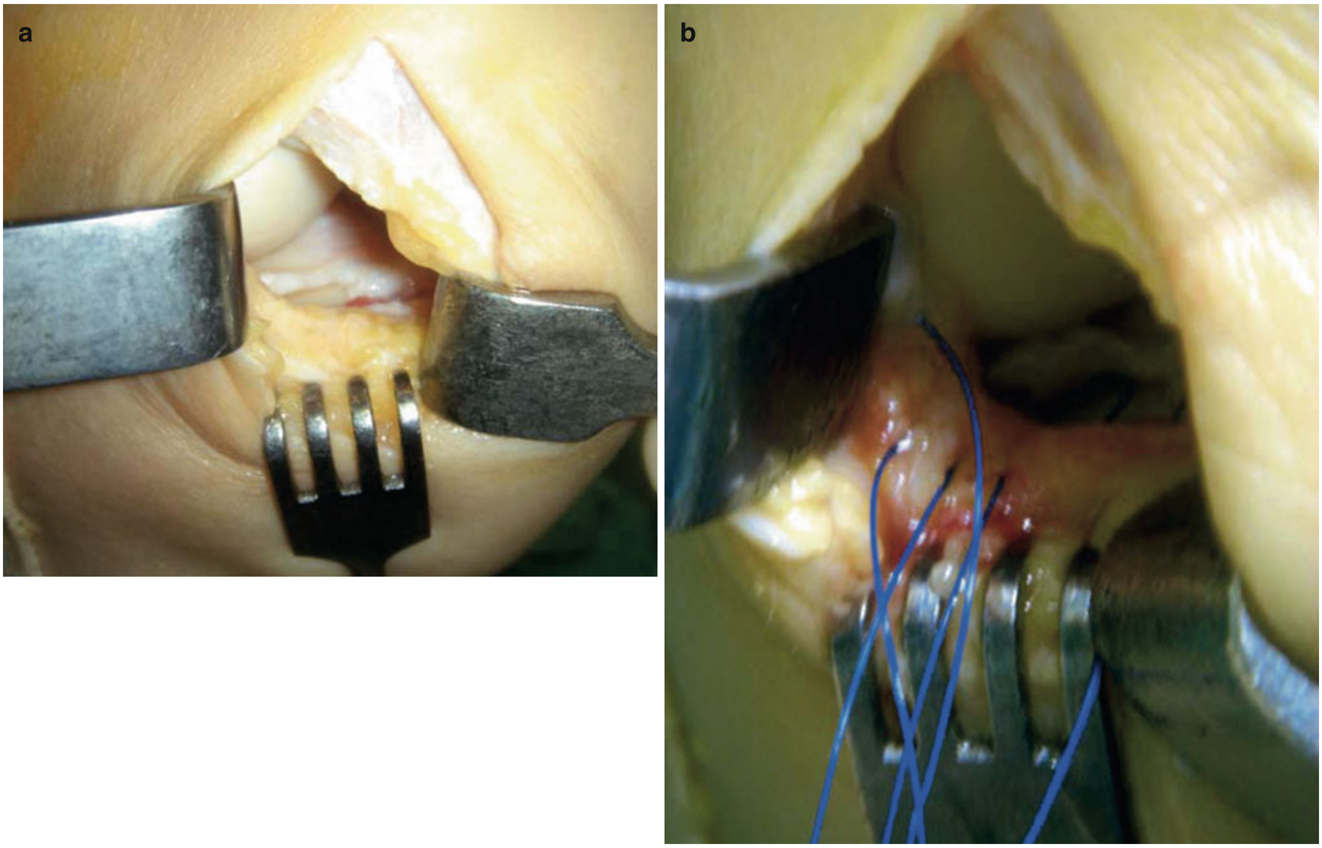


Fig. 3.5 Suture of the anterior horn. (**a**) Rare case: disinsertion of the anterior horn of a lateral discoid meniscus. (**b**) Absorbable sutures are used to preserve the meniscus tissue

4 Meniscal Sutures

Maad F. AlSaati, Stephen R. Thompson, R. Desmarchelier, and G. Demey

Introduction

The menisci are intra-articular fibrocartilaginous structures that have multiple functions, including shock absorption, control of anterior tibial translation, lubrication of the joint, and possibly proprioception. Owing to its many functions and the risk of meniscectomy-associated osteoarthritis, the management of meniscal tears should include "meniscus-preserving" procedures wherever possible.

Studies on meniscal healing have demonstrated that the prognosis of meniscal tears is closely related to their location within the meniscal tissue and meniscal blood supply. The most peripherally located lesions in the "red-red" zone have an excellent prognosis owing to the relatively abundant blood supply. Lesions in the middle third "red-white" zone are on the edge of the vascular zone and are also likely to heal based on reasonable blood supply. The most central lesions, located in the avascular area or "white-white" zone, have a limited capacity to heal.

Classically, open meniscal repair with vertical sutures via a posteromedial or posterolateral approach to the knee is considered to be the gold standard of meniscal-saving surgery. However, there are complications of an open approach, including hypoesthesia, neuroma formation, and often the need for a longer hospital stay than is required for a simple arthroscopy. Accordingly, we now prefer an all-inside technique for repair of the body and posterior aspect of the meniscus.

M.F. AlSaati, MD
Saati Medical Center, 88591, 11672 Riyadh, Saudi Arabia
e-mail: maad.saati@gmail.com

S.R. Thompson, MD, MEd, FRCSC (✉)
Fowler Kennedy Sport Medicine Clinic,
The University of Western Ontario, London, ON, Canada
e-mail: theskip@gmail.com

R. Desmarchelier, MD
Centre Hospitalier Lyon Sud, Chemin du Grand Revoyet,
69310 Pierre Benite, France
e-mail: romainde@hotmail.com

G. Demey, MD
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources 69009 Lyon, France
e-mail: demeyguillaume@gmail.com

Classification

We use the ISAKOS classification, which takes into consideration the length, depth, and location of meniscal lesions. The meniscus can be divided into three zones according to its width (zone 1, synovial-meniscal junction or "red-red" zone; zone 2, "red-white" zone; and zone 3, free edge of the meniscus or "white-white zone") and three areas from front to back (anterior horn, middle segment, and posterior horn). There are several types of lesions according to their appearance: vertical, horizontal, radial, flap, complex, and finally discoid meniscus.

Indications

The ideal indication for repair is a tear of the lateral meniscus that is located peripherally and occurs in a young patient. It is important to note, however, that tears less than 10 mm in length are likely to heal spontaneously and can be left in place.

General contraindications to meniscal repair include tears with a radial, flap, or complex configuration. These lesions should be treated with partial meniscectomy, leaving as much normal meniscus as possible.

A variety of meniscal suturing techniques exist. The open, "all-outside" method is considered to be a reference standard. However, owing to the popularity of arthroscopy and demand for less invasive solutions, several new meniscal repair methods have been developed.

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_4, © Springer-Verlag London 2014

Whatever the technique, a number of principles should be followed:

- The lesion should be perforated to create vascular channels that are conducive to healing.
- The junction between the meniscus and capsule should be debrided using a rasp or a synovial knife.
- The knee must be stable or stabilized.

We primarily describe the techniques used in our experience:

- Open technique (De Haven)
- Inside-out technique (Henning)
- Outside-in technique (Warren)
- All-inside technique (Morgan)
- Fixing the tears using normal sutures
- Implants: Fast-Fix or Fast-Fix 360

The choice of technique depends on the location of the lesion:

- Posterior horn lesion: all-inside or inside-out technique
- Middle segment lesion: all-inside or outside-in technique
- Anterior horn lesion: outside-in technique
- Very peripheral lesion not visible at arthroscopy: open or outside to inside technique

All-Inside Technique Using FastFix 360® Implant

Surgery is performed through the standard anterolateral and anteromedial arthroscopic portals. The procedure begins with the identification of the lesion, assessment of its stability, its potential for healing, and technical capability to be sutured (Fig. 4.1). The lesion is then refreshed using a rasp or with perforations.

Prior to introduction into the joint, the FastFix 360® device is prepared by cutting the protective sheath to ensure passage of the implant beyond the meniscal wall and is typically set at 16–18 mm. It is then introduced through the anteromedial portal, with its removable protective sheath still in place (Fig. 4.2). The sheath is removed, and the positioning of the implant is determined by the type of lesion and suture configuration desired (vertical or horizontal sutures). The first implant is inserted until the protective sheath comes into contact with the meniscus (Fig. 4.3a–d).

Passage of the implant through the outer rim of intact meniscus is easily felt by the surgeon. The device is rotated 90° to facilitate the docking of the anchor. The inserter is retracted back into the joint, and the second implant is loaded (Fig. 4.4a, b). It is introduced into the meniscus in the same manner as before (Fig. 4.5a–c). The free end is then tightened carefully by gentle traction. The knot-pusher is used to adjust the suture and optimize the tension of the suture construct (Fig. 4.6a–c). The free end is cut. Additional devices can be placed depending on size and stability of the tear. The stability of meniscal repair is determined with the arthroscopic probe.

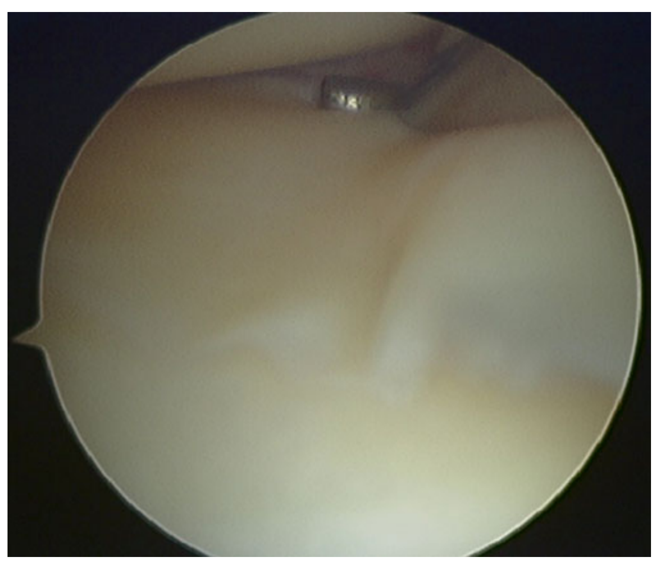


Fig. 4.1 Arthroscopic view identifying the lesion

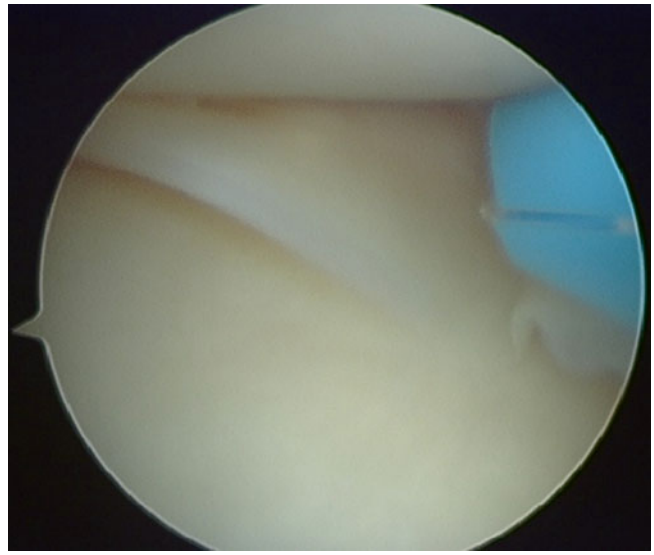


Fig. 4.2 Introducing of FastFix 360® with its protective sheath

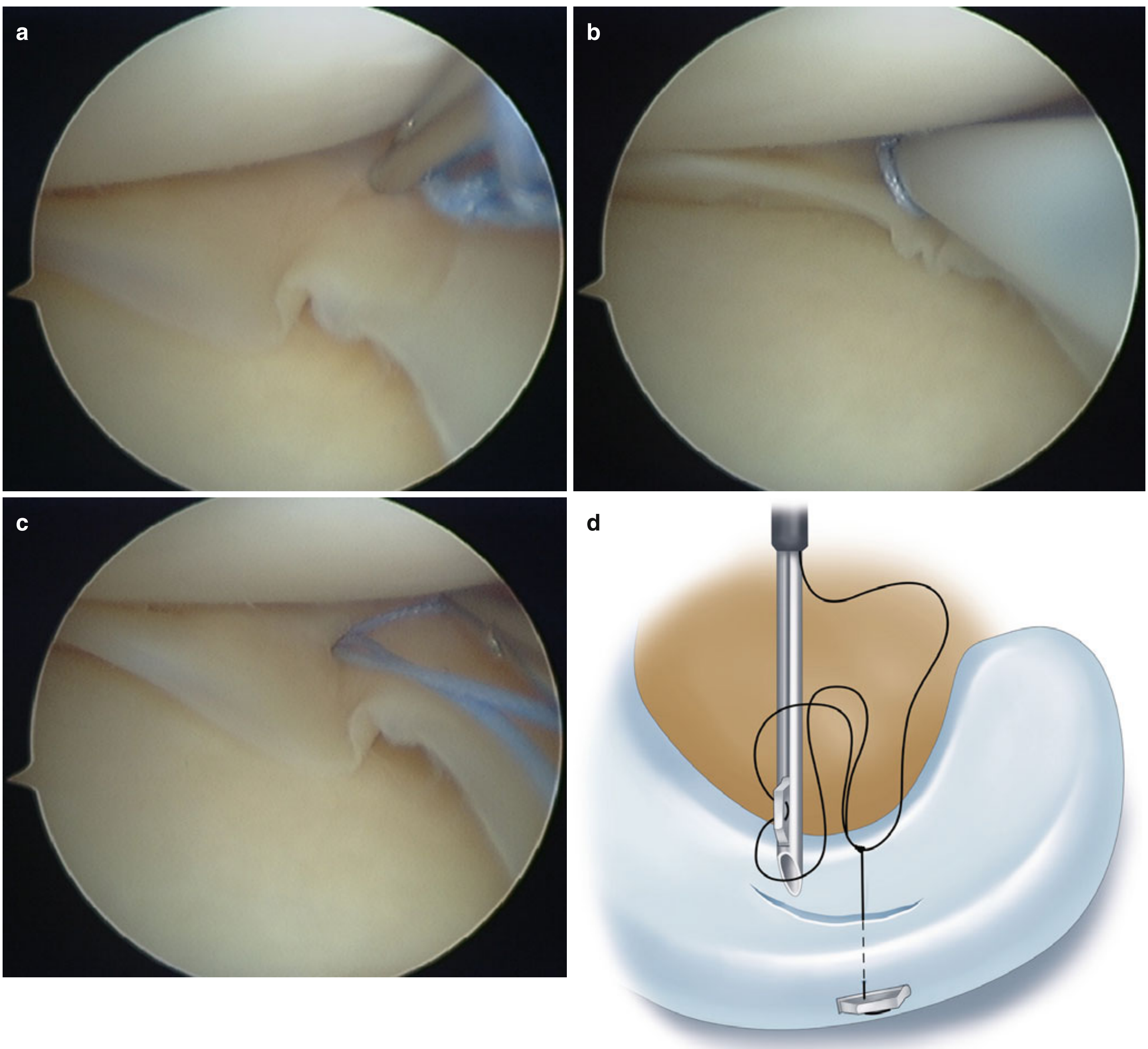


Fig. 4.3 (**a**–**d**) Implementation of the first implant

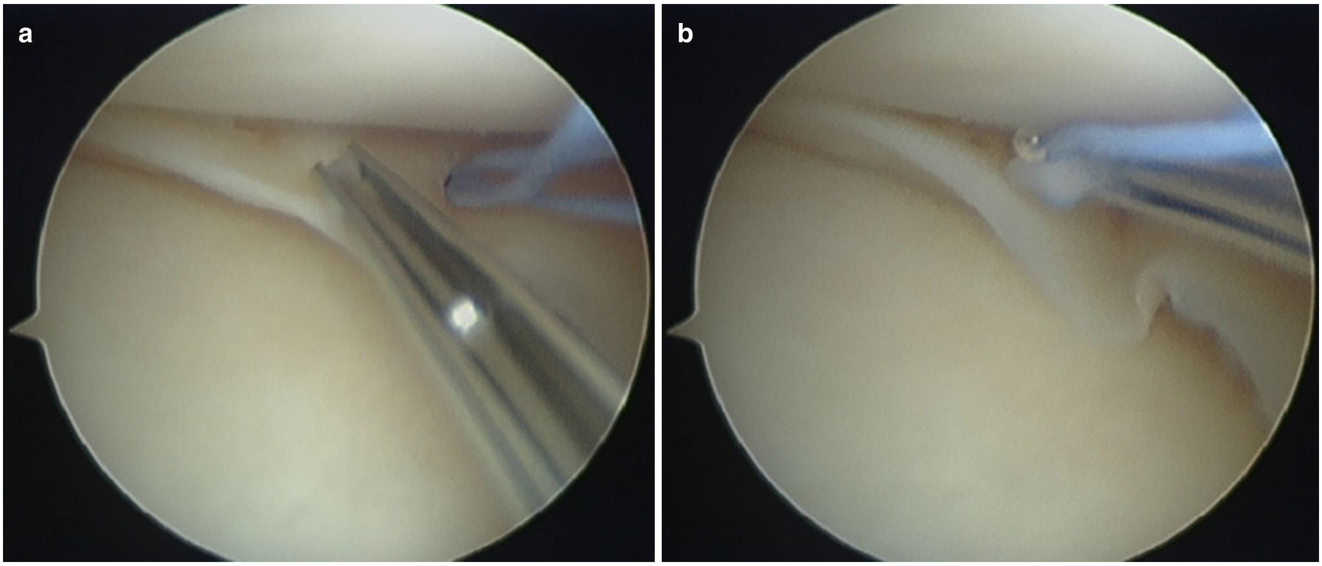


Fig. 4.4 (**a**, **b**) Loading the second implant

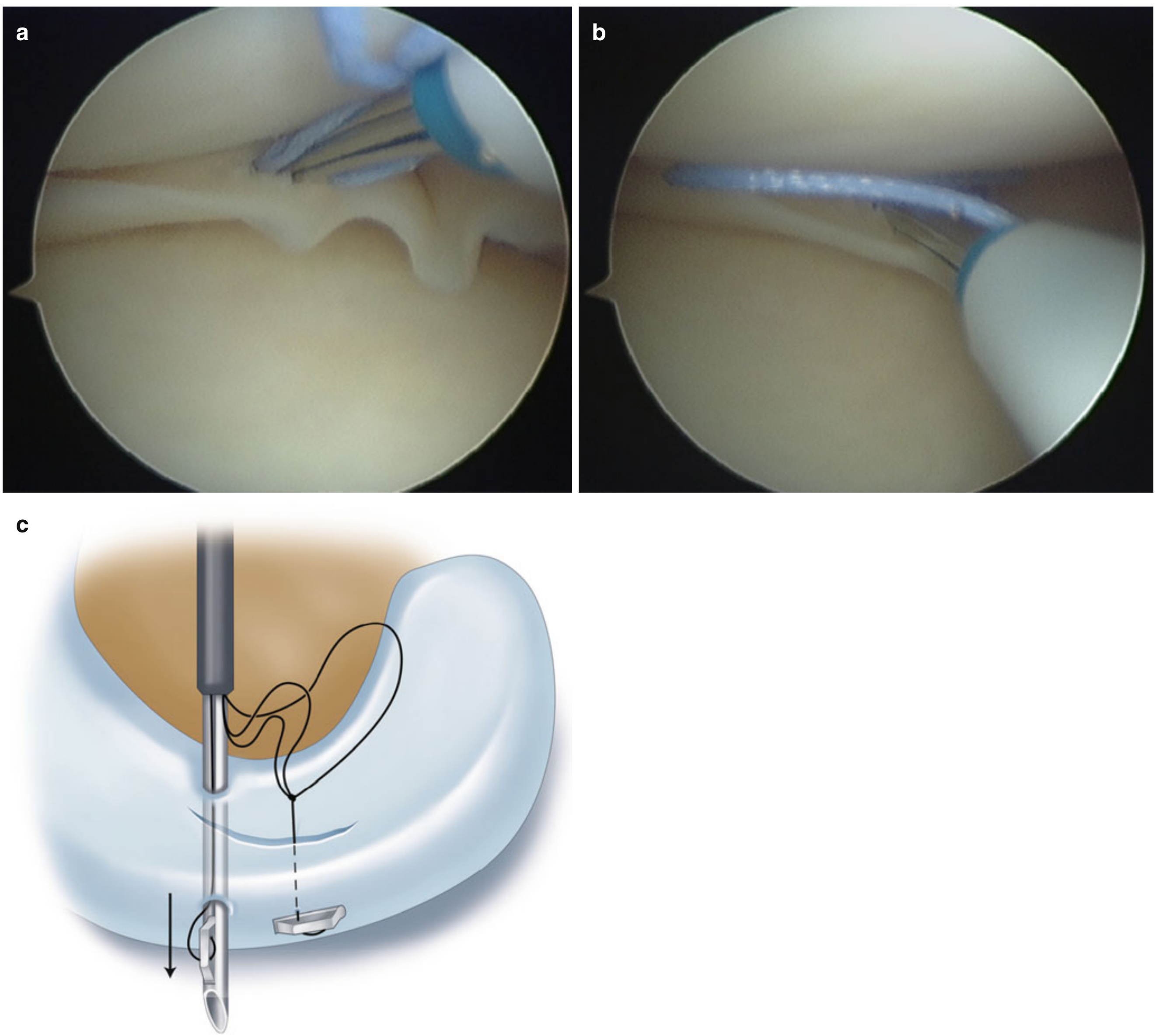


Fig. 4.5 (**a**–**c**) Implementation of the second implant

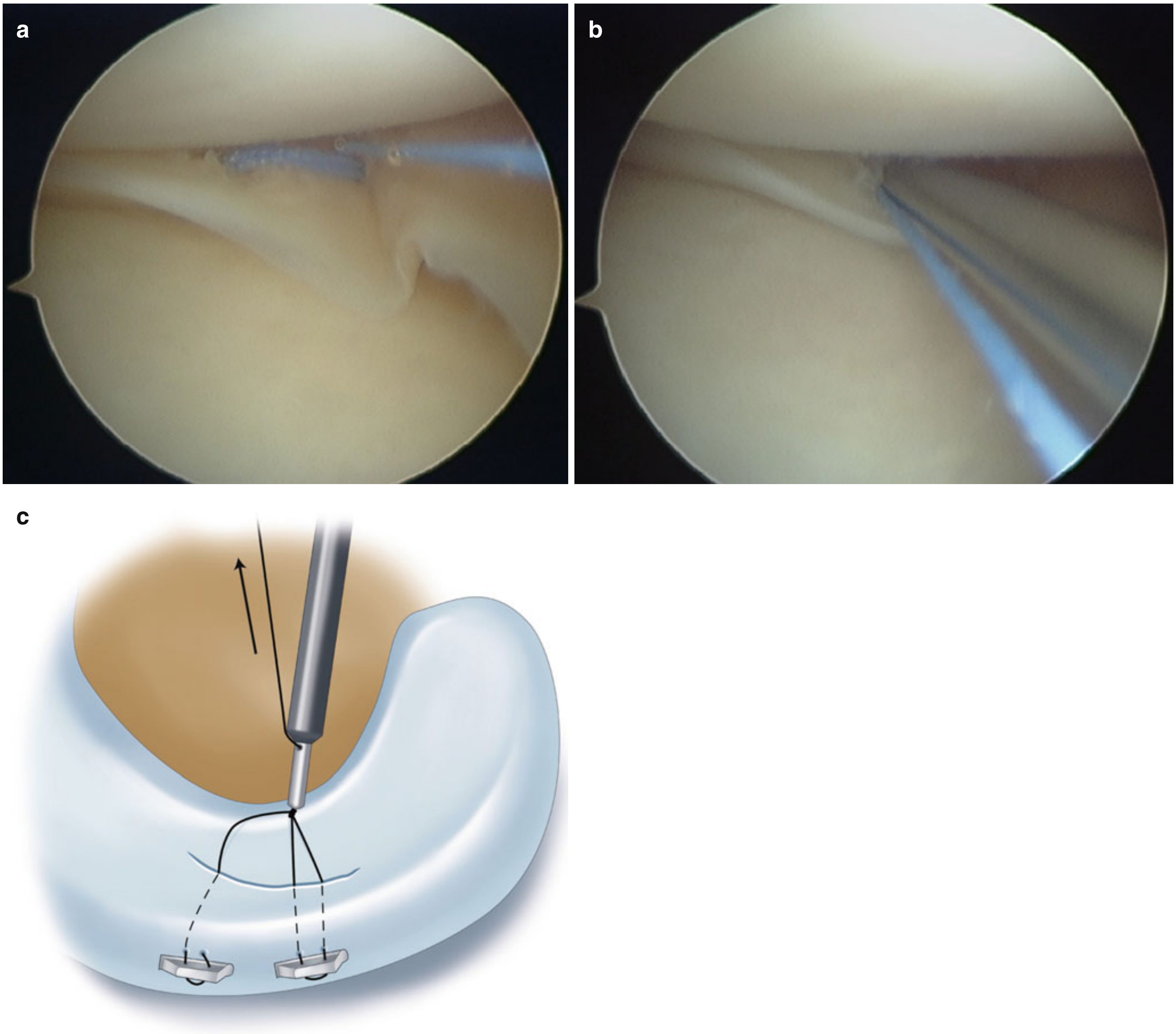


Fig. 4.6 (**a**–**c**) Tightening the knot by gentle traction and then with the knot-pusher

Inside-Out Technique Using Aiming Cannulas (Henning)

Similar to the previous technique, surgery begins with the identification of the lesion and debridement before repair. The aiming cannula (single or double) is introduced through the appropriate portal and is directed toward the lesion (Fig. 4.7). Two needles with nonabsorbable sutures are passed through the cannulas. They are retrieved through an open approach (knee flexed to 90°; medially, longitudinal incision posterior to the posterior edge of the medial collateral ligament, and laterally, posterior to the posterior edge of the lateral collateral ligament) (Fig. 4.8). Good reduction of the lesion is controlled arthroscopically while pulling on the sutures externally. The knot is tied over the capsule through the open approach.

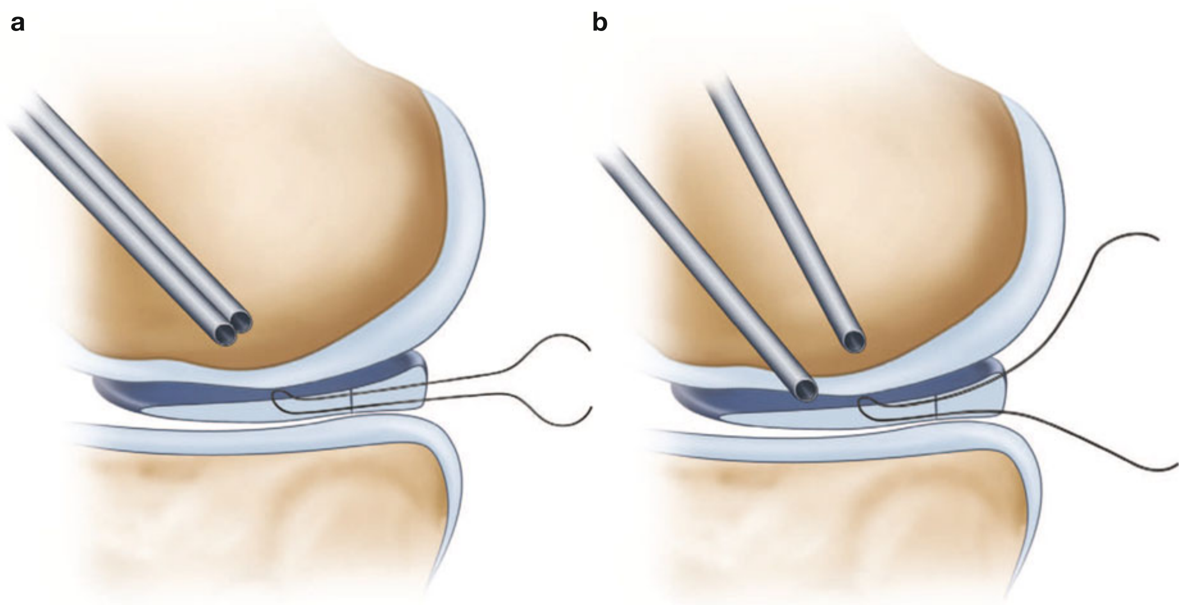


Fig. 4.7 Suture from inside out with double (**a**) or single (**b**) cannulas

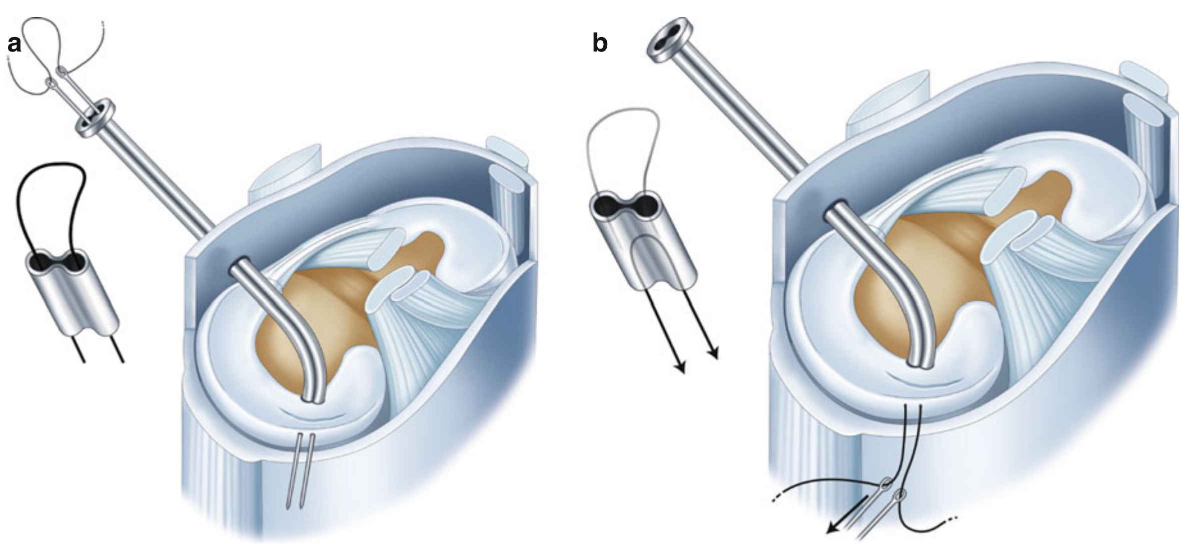


Fig. 4.8 Suture with double-cannula passage of the needles (**a**) and retrieval of the suture (**b**)

Outside-In Technique with a Loop (Warren)

A needle is inserted through the capsule and the meniscal tear. A loop is crafted with a stiff suture and passed into the joint (Fig. 4.9). A second needle is inserted and a second suture passing though the needle and through the loop in the first suture. Both needles are then removed, leaving the sutures in place. The looped suture is then pulled from the joint, bringing the second suture with it. Reduction is achieved by pulling on both strands. The knot is tied over the capsule through a small incision (Fig. 4.10). Rather than using a looped suture to retrieve the repair suture, we currently use Meniscus Mender® 2, an outside-in suture kit for the passage of suture through an intra-articular deployable loop.

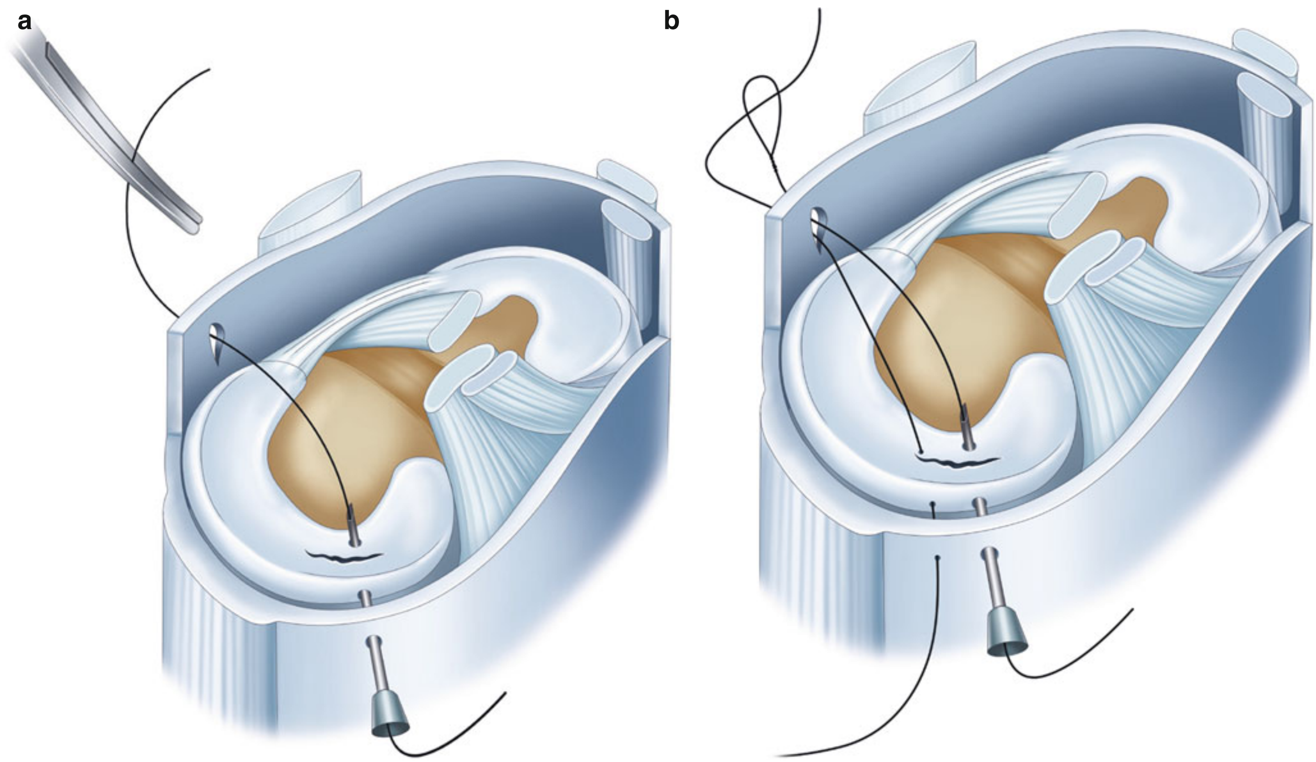


Fig. 4.9 Suture from outside to inside with needle. Both sutures are retrieved through the anterior approach (**a**). A loop is crafted to pull the second suture (**b**)

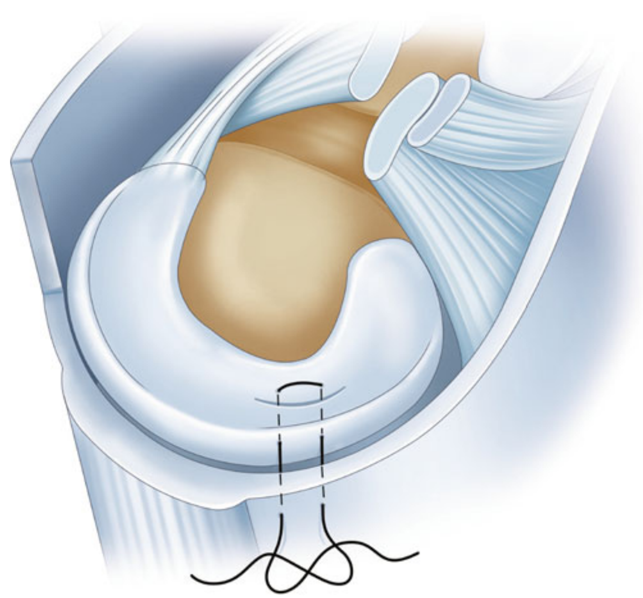


Fig. 4.10 The appearance of the tear before tightening the knot. Check the edges of the lesion confrontation by pulling on both strands

Postoperative Care

Meniscal repair is typically performed as an outpatient surgery. Knee range of motion is started on the first postoperative day. The aim is to have full extension, but hyperextension is prohibited. Flexion beyond 120° is delayed up to 6 weeks postoperatively. The configuration of the tear and stability of the repair can alter these restrictions. There is no agreement in the literature regarding weight bearing and range of motion restrictions. However, it seems logical to allow flexion and axial loading in cases of repair of longitudinal tears (the compression forces act to push the repaired meniscus together until hyperflexion is reached). This full weight bearing is permitted immediately in such patients. No weight bearing should be allowed following repair of radial tears.

Return to sport is not permitted until 4 months postoperatively at the earliest. Return to sports involving pivoting or contact is not permitted until 6 months postoperatively.

5 Anterior Cruciate Ligament Reconstruction: Surgical Technique

Robert A. Magnussen, M. Ozturk, and G. Demey

Introduction

Reconstruction of the anterior cruciate ligament is the method of choice for the treatment of chronic anterior laxity. Differences exist in surgical technique, graft choice, and how surgeons choose graft position.

We prefer to use a bone-patellar tendon-bone autograft for this reconstruction. This technique was initially described by Lambda in 1937 and popularized by Kenneth Jones. In the procedure described by Kenneth Jones, the patellar tendon-bone graft remained attached at its tibial insertion. Franke followed by Dejour and Clancy promoted of the use of a free graft. To guide our treatment strategy, we use the classification as proposed by the Henri Dejour school. This classification takes into account associated lesions and degree of anterior laxity.

Kenneth Jones Surgical Technique

Although we have modified the technique to utilize a free bone-patellar tendon-bone graft, we continue to call this operation a KJ procedure. Our technique was largely inspired by Pierre Chambat.

Setup and Clinical Examination

The setup we use to perform an ACL reconstruction is the same that we use for nearly all types of knee surgery (Fig. 5.1). After the patient is under anesthesia and the extremity sheet has been applied but prior to inflation of the tourniquet, the knee is once again tested for anterior laxity with the Lachman-Trillat test and the pivot-shift test.

Fig. 5.1 Setup

R.A. Magnussen, MD, MPH (✉)
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University, Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

M. Ozturk, MD
Manisa, Turkey
e-mail: sidarozturk@yahoo.com

G. Demey, MD
Department of Orthopaedic Surgery, Lyon Ortho Clinic, Clinique de la Sauvegarde, 29B avenue des Sources, 69009 Lyon, France
e-mail: demeyguillaume@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_5, © Springer-Verlag London 2014

Harvest of the Bone-Patellar Tendon-Bone Graft

We generally harvest the graft prior to arthroscopy in order to avoid swelling of the soft tissues. The skin incision starts at the inferior pole of the patella and continues 2 cm distal to the tibial tubercle (Fig. 5.2). In total, the paramedian skin incision is 6–8 cm in length and situated on the medial border of the patellar tendon. Dissection is performed down to the tenosynovium, which is vertically incised down the lateral aspect of the patellar tendon and carefully elevated from the anterior aspect of the tendon. The lateral and medial borders of the tendon are exposed as well as its insertion on the tibial tubercle and its origin on the distal pole of the patella.

Preparation of the Patellar Tendon Part

Harvest of the graft starts with the tendinous part. We use a specifically designed double-blade scalpel (Fig. 5.3). The graft width is 10–11 mm. The tendon is incised in the direction of its fibers (Fig. 5.4). The proximal and distal osteotendinous transition zones of the tendon are marked with a 23 blade. The bone blocks are marked by incising the periosteum with the blade.

Fig. 5.3 Double-blade scalpel

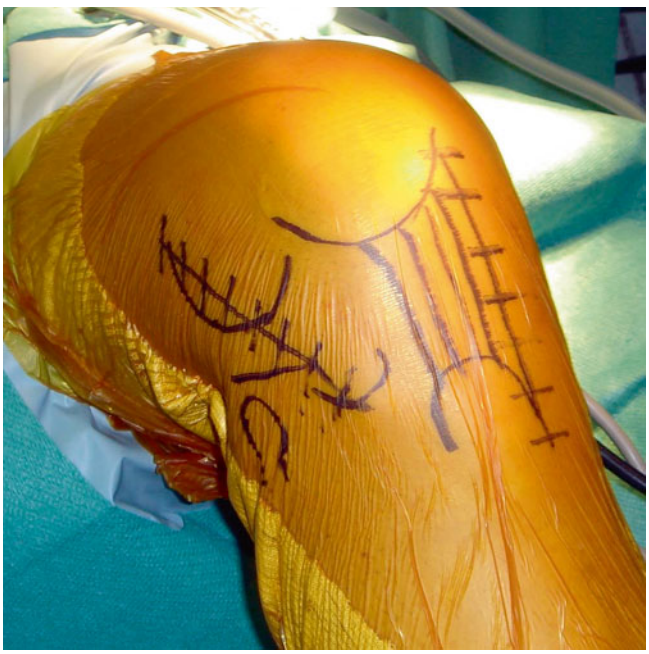


Fig. 5.2 Incision landmarks

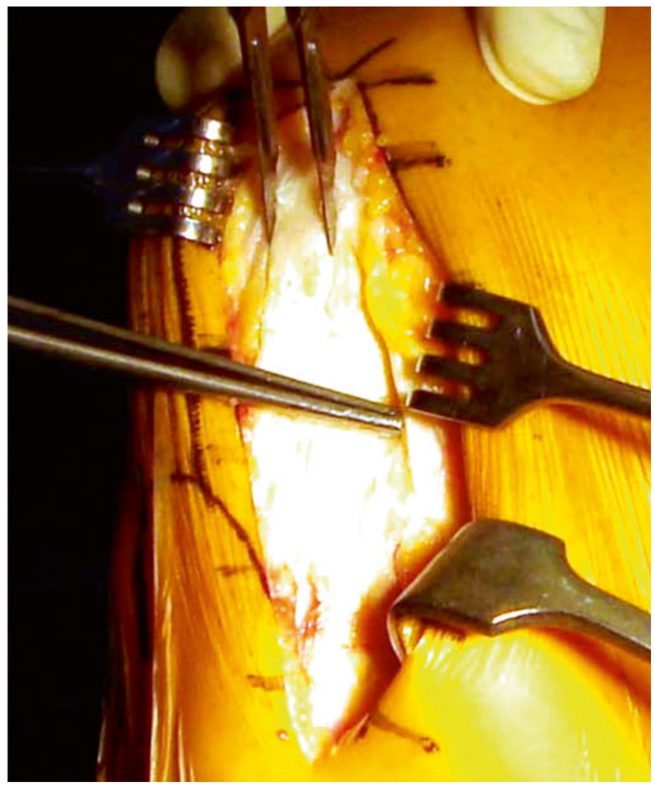


Fig. 5.4 Medial and lateral sides of the patellar tendon

Perforation of the Bone Blocks

Before the bone blocks are cut (Fig. 5.5) three holes are drilled with a 2 mm drill in the future bone blocks. Two holes are created proximally in the patella and one distally on the tibial tubercle. We find it easier to drill these holes prior to graft harvest rather than on the back table.

Harvest of the Bone Blocks

In order to facilitate the harvest of the bone blocks, the longitudinal incisions in the patellar tendon are opened up using a Farabeuf retractor (Fig. 5.6). A small-angled blade saw with a stop, to avoid cutting deeper than 10 mm, is used for the harvest.

Fig. 5.5 Bone blocks drilling

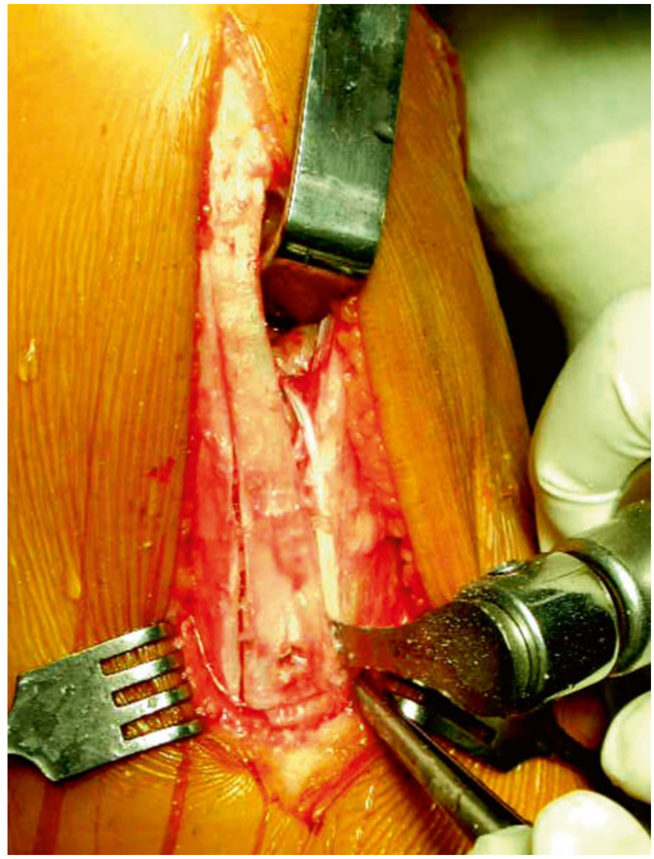


Fig. 5.6 Saw cutting (tibial side)

Tibial Bone Block

The tibial bone block is shaped in a specific way. It is trapezoidal in the shape of a champagne cork. The width is 10 mm proximally, widening gradually to 12 mm in the distal 10 mm of the block. The overall length of the tibial bone block is 25 mm and it is 10 mm thick (Fig. 5.9). The tibial bone block is then detached using a curve osteotome starting proximally.

Patellar Bone Block

The patellar bone block is prepared using a small blade saw. The dimensions of the patellar bone block are 10 mm in width and 15 mm in length. The tibial bone block and distal portion of the graft are lifted out of the harvest site and pulled proximally. The adhesions between tendon and Hoffa fat pad are dissected until the inferior pole of the patellar is clearly visible. A small osteotome of 10 mm in width is used to detach the patella bone block; its thickness should be between 5 and 8 mm. The osteotome should be introduced parallel to the anterior cortex of the patella (Fig. 5.7). One must take care not to fracture the patella when detaching the bone block. Any effort to detach it by prying with the osteotome must be avoided. The free graft is then prepared by the surgeon of the back table (Figs. 5.8 and 5.9).

The defect in the tendon is closed with interrupted resorbable stitches. The tenosynovium is carefully closed above the tendon and remaining periosteum closed over the bony defects (Fig. 5.10).

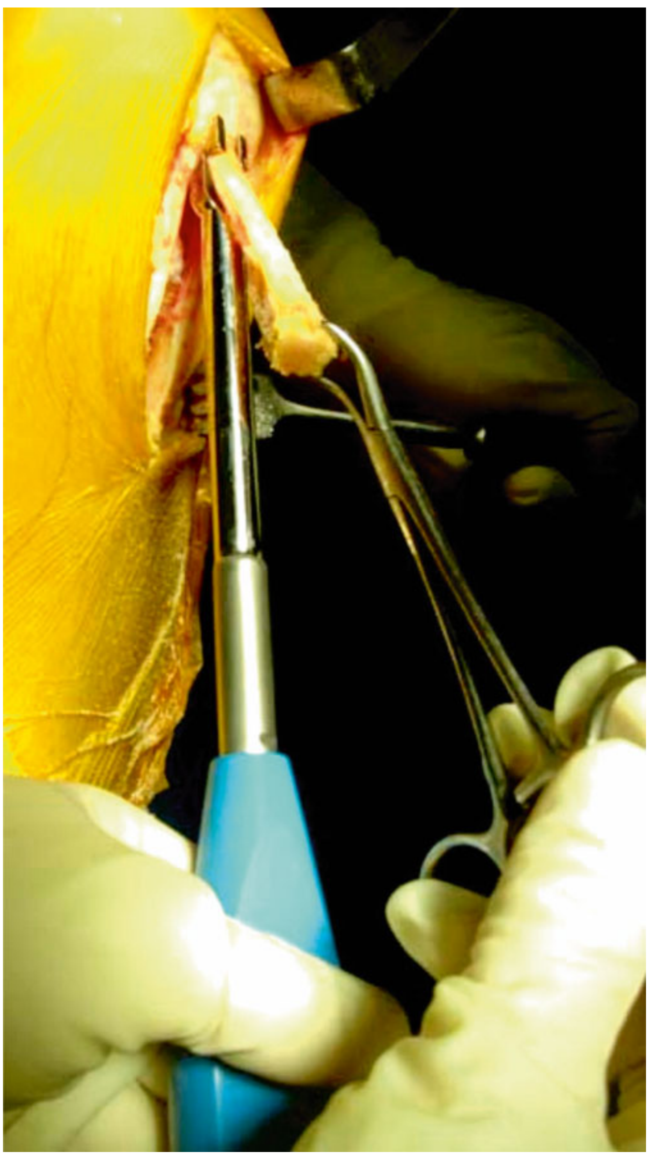


Fig. 5.7 Patellar bone block detachment

Fig. 5.8 Patellar tendon graft

Fig. 5.9 Transplant shape and size

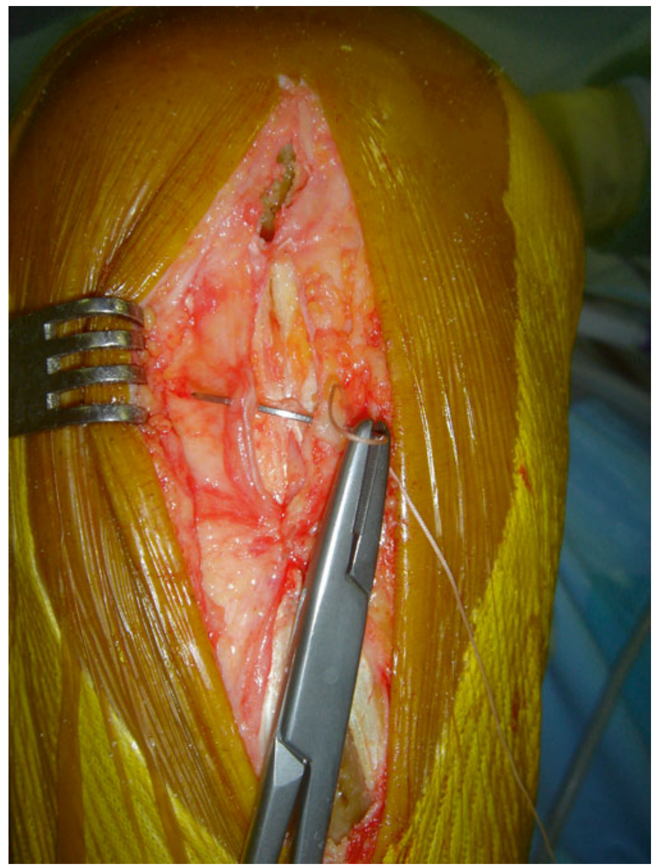


Fig. 5.10 Periosteum suture

Preparation of the Bone-Patellar Tendon-Bone Graft

This step of the procedure can be performed by an assistant while notch preparation and tunnel drilling continue. The first step in the preparation of the bone-patellar tendon-bone graft is the sizing of the bone blocks (Fig. 5.11). The edges and corners of the patellar bone block should be rounded using Liston scissors and cutting scissors. It should pass easily through the 9 mm hole of the graft-sizing block (Fig. 5.12). The proximal end of the tibial bone block should engage in the 10 mm hole of the graft-sizing block but should not completely pass. This illustrates the press fit that will be obtained on the femoral side. Pull sutures are introduced into the patellar bone block to aid in graft passage.

Through the two drill holes in the patellar bone block, a FiberWire suture is introduced in a figure of "8." This strong suture allows axial traction on the graft during passage. A number 5 resorbable suture is placed in the tibial bone block (Fig. 5.13). This suture will allow the retraction of the bone block in case of problems with the femoral fixation. The prepared graft is subsequently kept in a physiological solution. The graft should not be covered with gauze as it increases the risk of finding the graft in the trash together with the gauze.

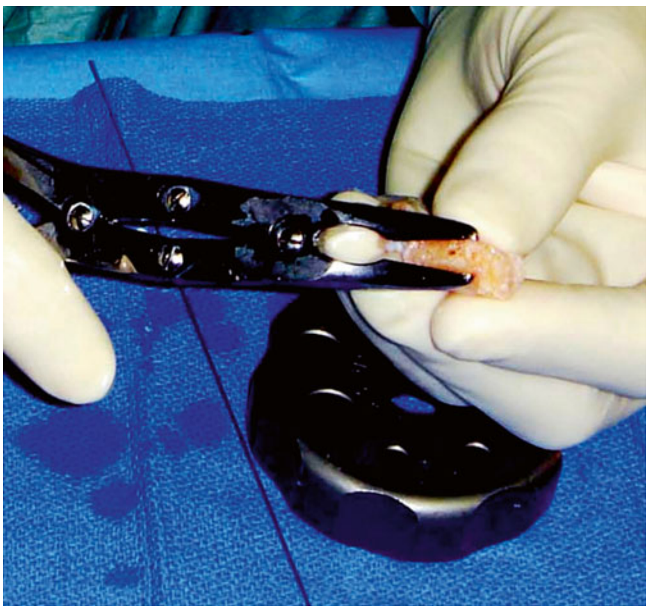


Fig. 5.11 Bone block calibration

Fig. 5.12 Graft-sizing block

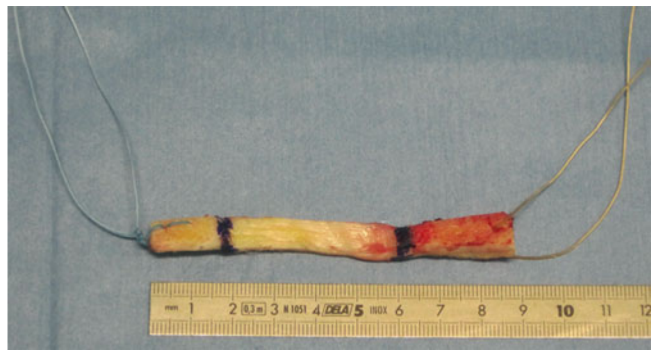


Fig. 5.13 Bone-patellar tendon-bone graft after preparation

Arthroscopy

Intercondylar Notch Preparation

The scope is introduced through the anterolateral portal. The instruments are introduced through the anteromedial portal (cf. chapter on arthroscopy) (Fig. 5.14). Possible meniscal lesions and cartilage lesions are evaluated and treated (Fig. 5.15). If a meniscal repair is considered necessary, the repair should be performed prior to the anterior cruciate ligament reconstruction (cf. chapter on arthroscopy). In case of any concern about a posterior meniscal lesion that is poorly visualized, a posterior compartment view must be obtained via either the Gillquist maneuver or the creation of a posteromedial portal to evaluate the posterior part of the meniscus.

First, the remnant of the anterior cruciate ligament is visualized as well as the morphology of the intercondylar notch. Preparation of the intercondylar notch is done in a systematic way. While in the past we removed the remaining fibers of the ACL, we now carefully analyze the remaining footprint to determine the insertions sites of the ACL and try to preserve the remaining fibers unless they obscure visualization. If there is any impingement of the old fibers on the anterior part of the notch once the graft is passed, these fibers are resected. Overzealous clearing of the wall of the notch limits the blood supply to the Healing graft. We generally prefer to do any resection with electrocautery as it preserves underlying osseous anatomy better than a shaver. In spite of the desire to preserve remnant tissue in the notch when possible, obtaining clear visualization is essential to avoid the most frequent error of malpositioning: a too anteriorly positioned femoral tunnel (Fig. 5.16).

Fig. 5.14 Arthroscopic exploration

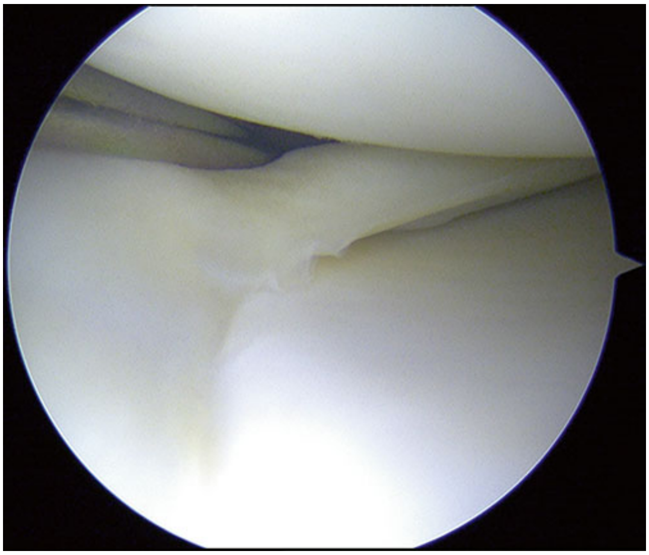


Fig. 5.15 Arthroscopic view of a medial meniscus tear

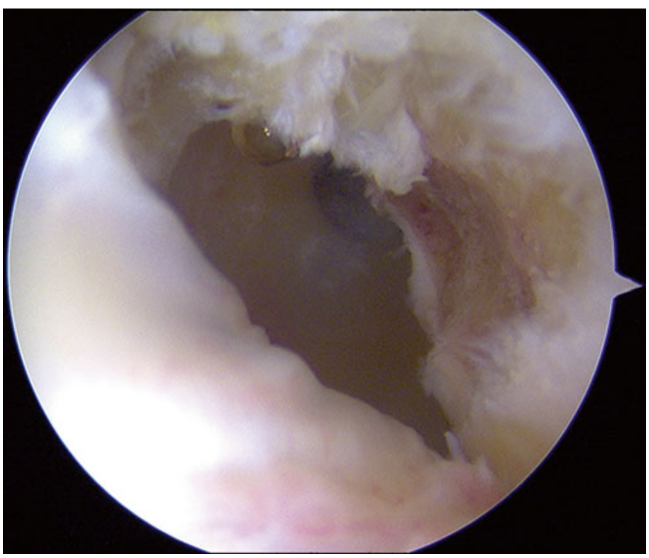


Fig. 5.16 Posterior edge of the intercondylar notch (arthroscopic view)

Notch Plasty

In our hand a notch plasty is rarely needed. We decide to perform a notch plasty when an impingement of the graft is observed in the intercondylar notch. This most frequently involves the superior part of the intercondylar notch and less frequently the lateral side.

To perform a notch plasty, the knee is placed in semi flexion. The zone of impingement is removed using a curve osteotome. This osteotome is positioned on the cartilage bone transition zone. By gently tapping it with a hammer, the osteotome easily removes the zone of impingement. The bony debris should be carefully removed and the remaining notch smoothed with a shaver or burr.

The Femoral Tunnel

Accurate femoral tunnel positioning is key to successful ACL reconstruction. The appropriate tunnel location is below and posterior to the lateral intercondylar (Resident's) ridge (Fig. 5.17). For single-bundle reconstructions, we prefer to place the tunnel in the area of the lateral bifurcate ridge (when visualized) and take care that it is below the resident's ridge. Once the appropriate tunnel position has been identified, the femoral drill guide (Fig. 5.18) is introduced through the anteromedial portal to the desired location. The bullet is subsequently introduced into the jig. This indicates the position of the lateral skin incision. The skin incision should be situated on the lateral surface of the lateral condyle anterior and proximal to the lateral collateral ligament. The incision must be sufficiently lateral to avoid opening the suprapatellar pouch.

The skin and the fascia lata are incised and the bullet is introduced through the guide until it is in contact with the bone. A guide pin is subsequently introduced into the bullet and driven across the lateral condyle and into the intercondylar notch. The guide is removed and the pin should be driven 4–5 mm into the notch (Fig. 5.19). At this point the position of the guide pin is checked while viewing through the medial portal. The surgeon now introduces a specially designed curette with a small hole in the middle. This curette is placed over the guide pin and is used to prevent inadvertent guide pin advancement during over-drilling. A femoral tunnel

6 mm in diameter is drilled over the guide pin (Fig. 5.20). The direction of the cannulated drill should be perfectly parallel to the guide pin. The progression of the cannulated drill should be progressive and smooth. If abnormal resistance is noted, the drill should be retracted immediately and its direction should be checked. In case of misdirection, metal debris is produced. Subsequently, a 10 mm cannulated drill is introduced over the guide pin and the femoral tunnel is enlarged. The guide pin is retracted and the debris from the tunnel are carefully removed (Figs. 5.21, 5.22, and 5.23). Preparation of the femoral tunnel in two steps has two advantages:

- Firstly, smooth progression of the drill without the need to use excessive force
- Secondly, the tunnel position can be adjusted by 2–3 mm if necessary. This correction is done by moving the guide pin with the curette. The direction of the 10 mm drill can thus be adjusted by 2–3 mm in the previously drilled 6 mm tunnel (Fig. 5.24a–c).

All debris should be removed from the tunnel (if one forgets to perform this step, one will be confronted with the presence of bony debris on the lateral side of the condyle visible on the post-op X-ray). Next, the tunnel is inspected with the scope to verify the circumferential presence of cancellous bone (Fig. 5.25). The corner of the femoral tunnel can be rounded with the curette to lower the risk of graft erosion. Finally, a plug is placed in the tunnel to avoid leakage of the irrigation fluid during tibial tunnel preparation.

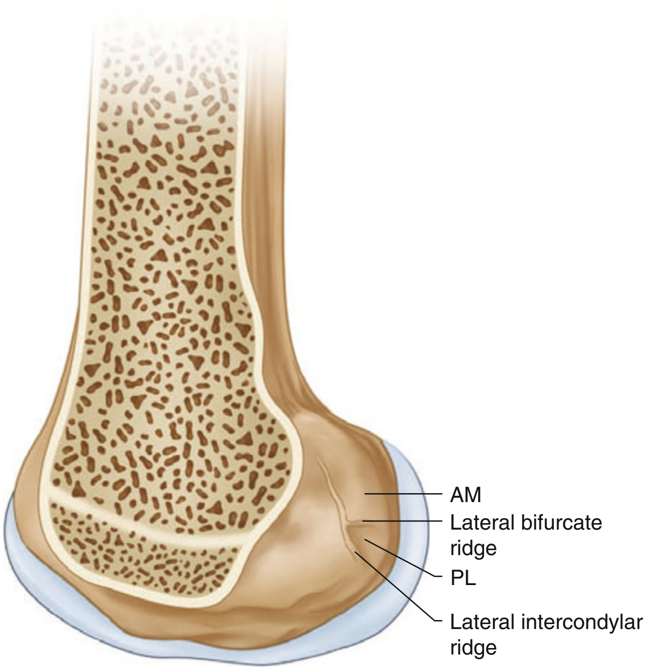


Fig. 5.17 Femoral insertion sites

Fig. 5.18 Femoral guide

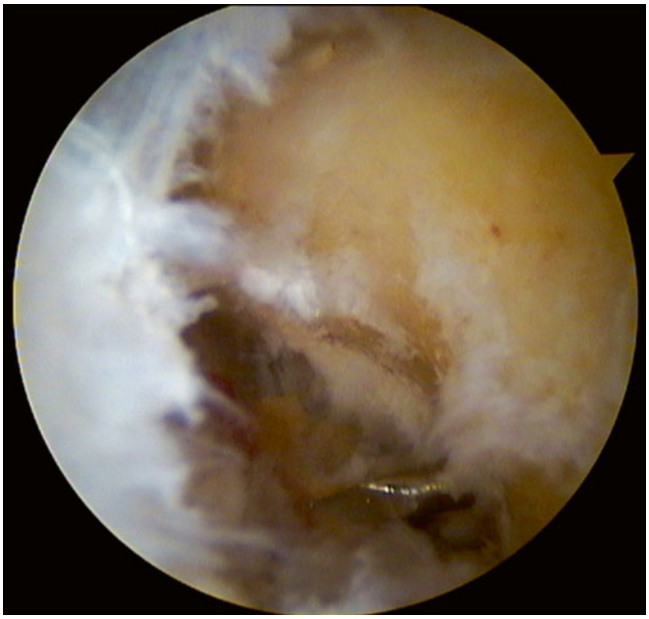


Fig. 5.19 Pin appearance

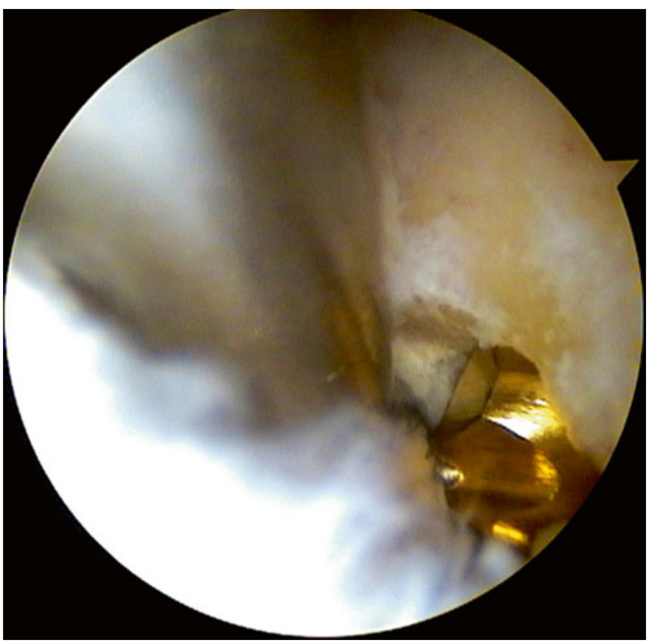


Fig. 5.20 Femoral tunnel drilling (6 mm drill first)

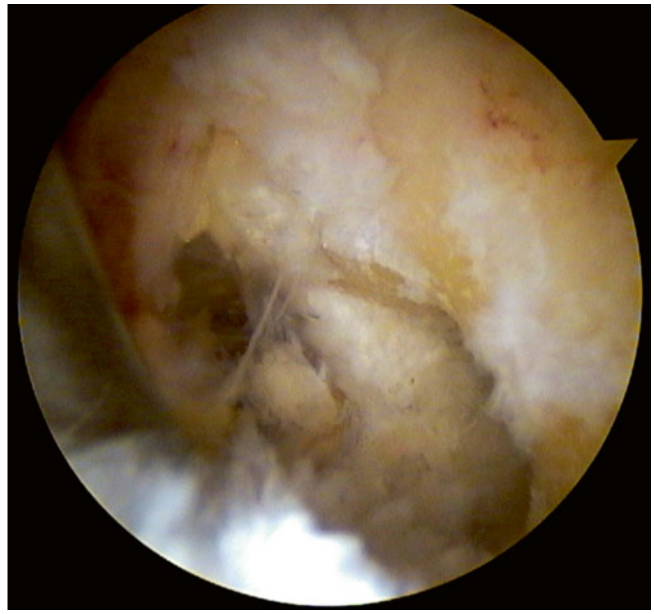


Fig. 5.21 Femoral tunnel (anterolateral portal view)

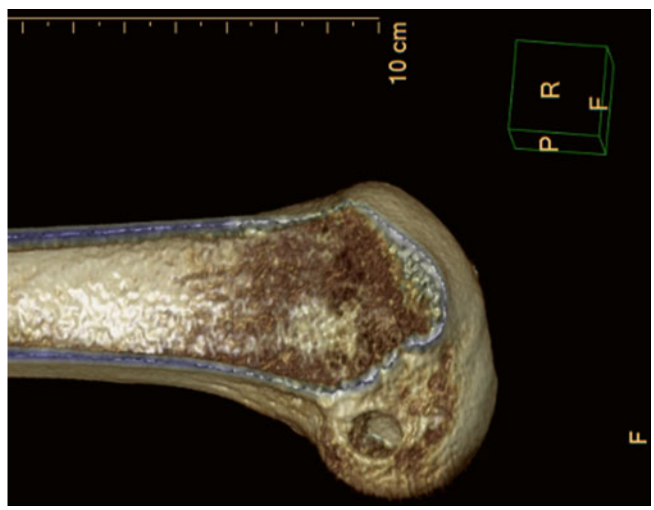


Fig. 5.22 Well-positioned femoral tunnel assessed on a 3D CT scan (AM bundle)

Fig. 5.23 Femoral tunnel (anteromedial portal view)

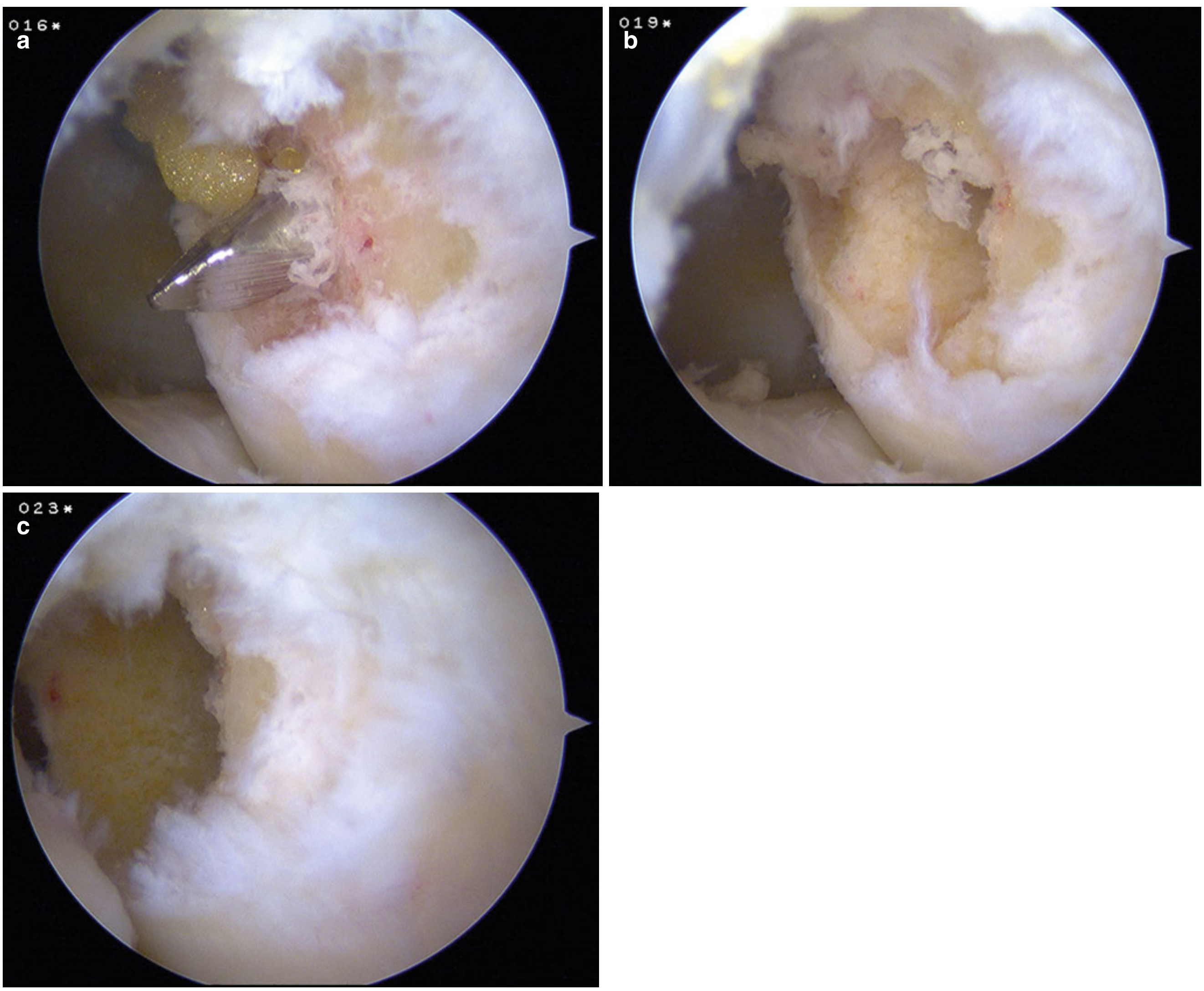


Fig. 5.24 **(a–c)** A precise positioning can be obtained with a progressive enlargement of the tunnel diameter (6 and 10 mm diameter)

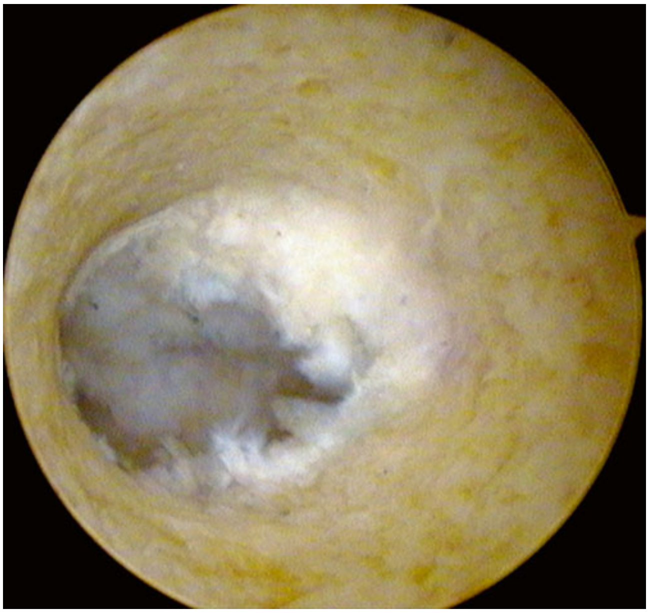


Fig. 5.25 Femoral tunnel inspection (outside view)

The Tibial Tunnel

The tibial drill guide (Fig. 5.26) is introduced through the anteromedial portal. The guide should be positioned in front of the posterior cruciate ligament just lateral of the cartilage of the medial tibial plateau, just behind the anterior horn of the medial meniscus, and medial to the anterior horn of the lateral meniscus (Fig. 5.27). This position is usually in alignment with the two femoral condyles in 90° of flexion. This point corresponds with the footprint of the original anterior cruciate ligament. The guide is set at 45° and the entry point on the tibial metaphysis is medial to the tibial tubercle. The bullet is subsequently introduced, the guide pin is driven into the knee, and its position is checked first in flexion (Fig. 5.28).

The knee is then extended and the position of the guide pin is checked to ensure that no impingement occurs between the notch and the guide pin. A 3 mm minimal distance should be present between the guide pin and the intercondylar notch in order to avoid any conflict between the notch and the graft. This concept is called graft clearance and was introduced by R. Jakob. Once the final position is checked, the curette is placed over the guide pin and the 6 and 9 mm cannulated drills are introduced over the guide pin (Fig. 5.29). It is very important to respect this sequence (first 6 followed by 9) because a 9 mm drill could induce a fracture of the tibial spine if used straight away. Moreover, as for the femoral tunnel, the position of the tibial tunnel can be adjusted by 2–3 mm if necessary when moving from the 6 mm drill to the 9 mm drill. Tunnel debris (Fig. 5.30) are aspirated and the entry hole of the tunnel is cleared from soft tissues which could block the entrance of the bone block. Because the graft will be passed from proximal to distal, this step is key to ensuring smooth graft passage.

Fig. 5.26 Tibial guide

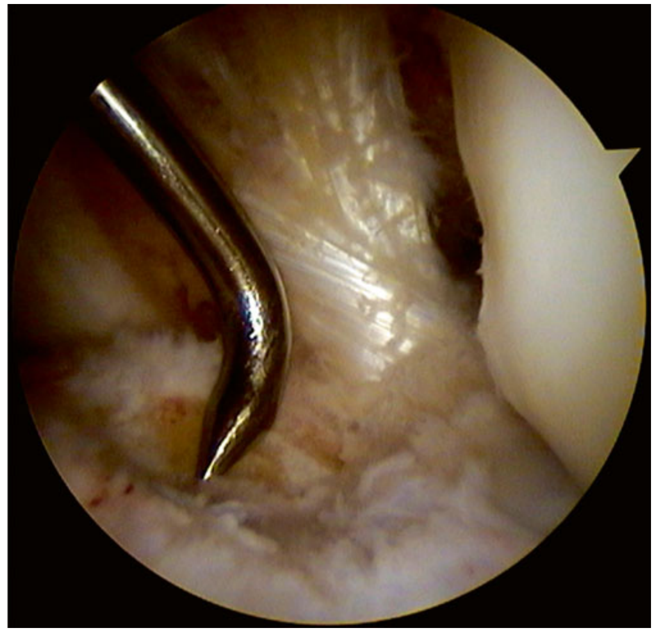


Fig. 5.27 Tibial guide positioning

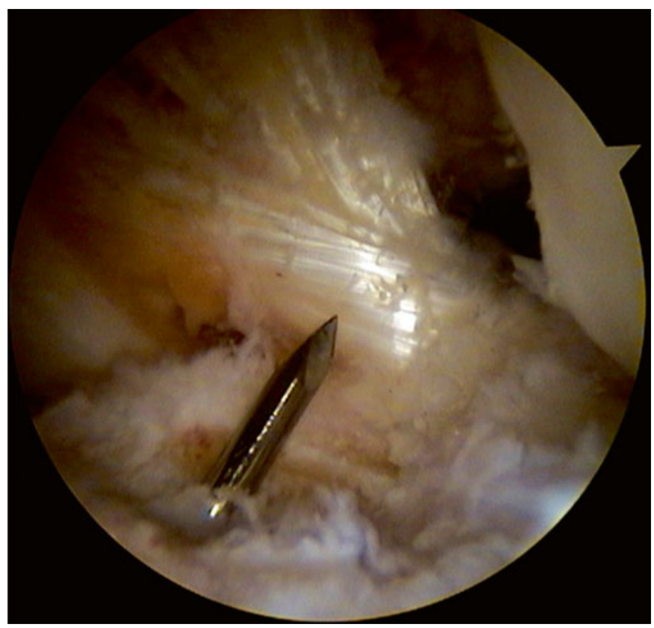


Fig. 5.28 Pin appearance

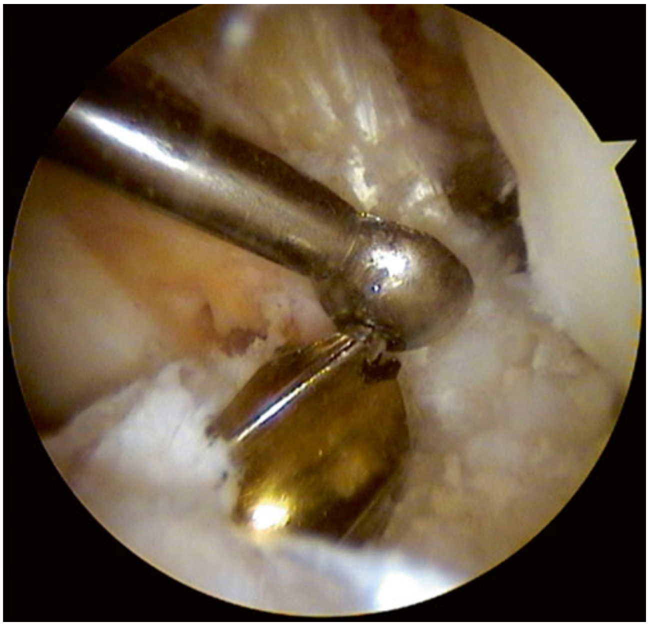


Fig. 5.29 Tibial tunnel drilling (6 mm drill fist)

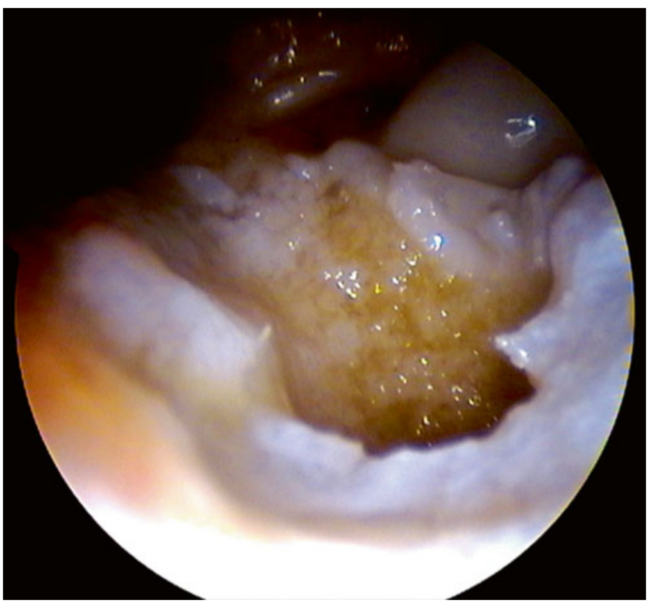


Fig. 5.30 Tibial tunnel (anterolateral portal view)

Introduction of the Bone-Patellar Tendon-Bone Graft

With the knee flexed to 30°, a pull suture is introduced through the tibial and femoral tunnel in a retrograde fashion with a suture guide. We verify arthroscopically that the suture guide does not perforate the posterior cruciate ligament. The pull suture is captured in the intercondylar notch with a grasper introduced through the femoral tunnel. The traction sutures from the graft are fixed to the pull suture (Figs. 5.31 and 5.32). This allows the introduction of the graft in an antegrade fashion first through the femoral condyle, into the intercondylar notch, and then through the tibial tunnel. It is sometimes possible that the passage of the patella bone block in the notch is difficult, particularly if the bone block is too long. In these cases, a Wolff grasper (Fig. 5.33) is introduced through the anteromedial portal to guide the bone block through the notch. Once the graft is introduced in the tibial tunnel, impaction of the bone block in the femoral tunnel can be initiated (Fig. 5.34). The orientation of the bone block in the femoral tunnel should be controlled. The tendon attachment site should be positioned posteriorly in the femoral tunnel. During impaction it is essential to exert some traction on the graft and to assure that the graft progresses into the tibial tunnel. The risk on the femoral side exists for invagination of the block into the tendinous portion of the graft like an accordion, resulting in a paradoxical situation: The more the bone block is impacted on the femoral side, the less the graft progresses into the joint (Figs. 5.35, 5.36, and 5.37).

The bone block on the femoral side is advanced with an impactor and mallet while the graft is kept under tension. The bone block on the femoral side should be well impacted and should not be palpable outside of the femoral condyle.

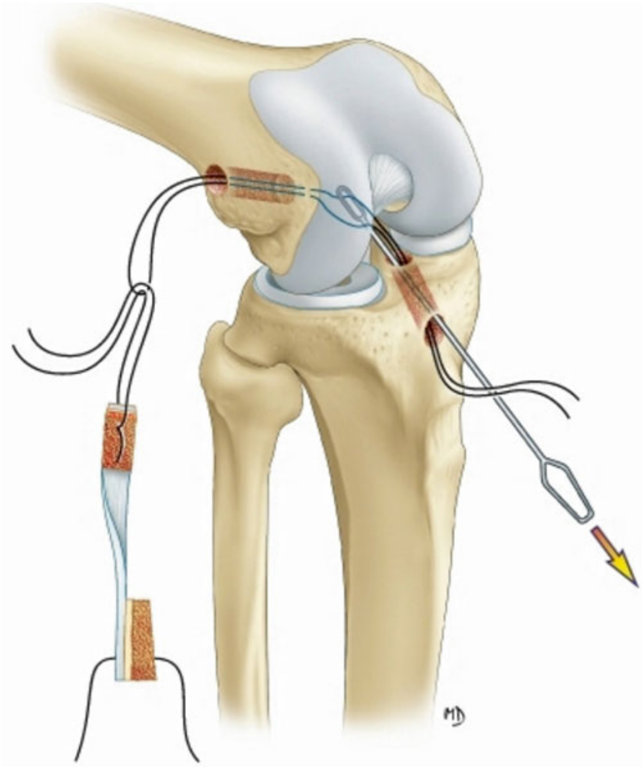


Fig. 5.31 Introduction of the bone-patellar tendon-bone graft (1)

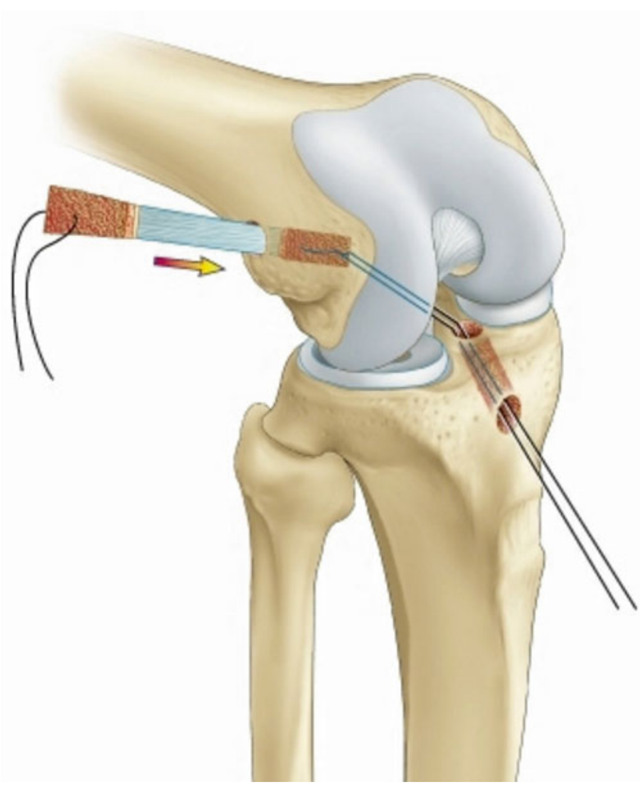


Fig. 5.32 Introduction of the graft (2)

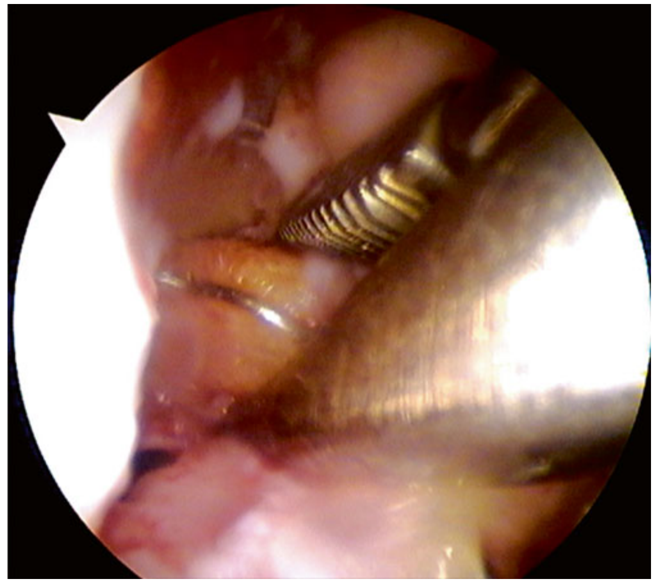


Fig. 5.33 A Wolff grasper is sometimes used to guide the bone block migration through the notch

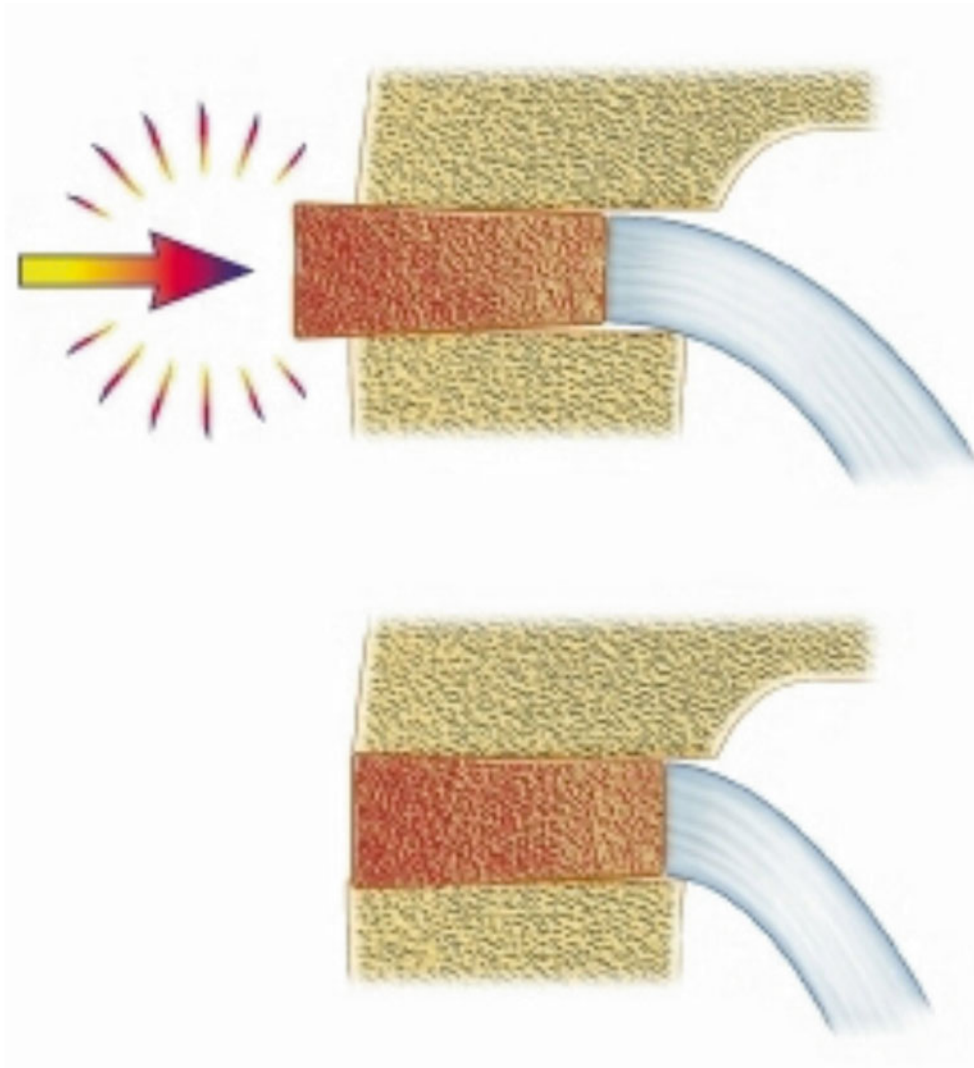
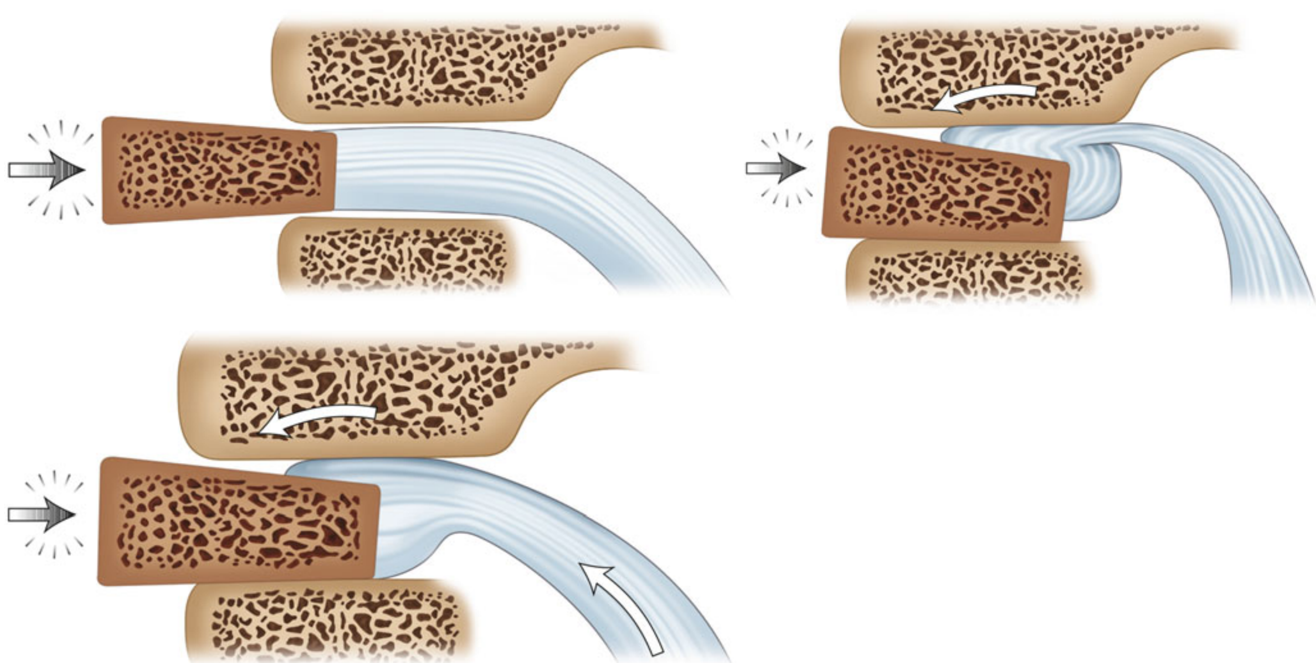


Fig. 5.34 Graft impaction



Figs. 5.35, 5.36, and 5.37 “Accordion” paradoxical situation

Graft Fixation

Prior to fixation the following should be checked:

- Isometry of the graft during flexion and extension between 5 and 90° (Fig. 5.38)
- Possible impingement of the graft with an intercondylar notch
- Engagement of the bone block in the tibial tunnel

On the anteromedial side of the tibia, a 2 mm drill hole is made through cortical bone connecting the tibial tunnel and the graft harvest site. The FiberWire loop from the graft is then tied over this bone bridge providing the first tibial fixation. A guide wire is then introduced through the tibial tunnel inside the knee. The guide wire should be on the anterolateral border of the bone block in the tibial tunnel. If necessary the position of this guide pin can be modified. Its position is secured inside the knee with a grasper. A resorbable interference screw (Habilis, Phusis), 25 mm in length and 9 mm in diameter, is introduced as additional fixation over the guide wire (Figs. 5.39 and 5.40). The interference screw is introduced under arthroscopic vision until it reaches the level of the joint line. In case of a long graft, contact between this interference screw and the bone block is preferred over screw tendon contact. This combination of the suture over the bone bridge (Figs. 5.41, 5.42, 5.43, and 5.44) and interference screw allows for double fixation on the tibial side. We recommend double fixation in all cases.

Prior to closure, four variables have to be checked:

(a) The position of the screw with respect to the bone block in the tibial tunnel.
(b) The tension of the fixation and the tension of the graft; the posterior fibers should be tensioned in extension while the anterior fibers are somewhat slack.
(c) Absence of impingement within the intercondylar notch.
(d) A stable Lachmann-Trillat test

At the end of the procedure, the tourniquet is deflated and hemostasis is performed. An intra-articular drain is introduced through the anteromedial portal. The subcutaneous tissues are closed with a 3.5 resorbable suture, and the skin is closed subcuticularly or by using skin staples. An additional compressive bandage is applied that will be removed 1 h postoperatively. The knee is put into a brace with 20° of flexion in order to prevent patella infera.

- Immediately postoperatively AP and lateral plain X-rays are performed.
- Low molecular weight heparins are prescribed for 10–15 days.
- Prophylactic antibiotics are administered during a 24 h period.
- Skin staples or skin sutures are removed between day 12 and day 15.

A clinical follow-up is planned on day 45, 90, 180, and 360. Telos stress radiographs are requested at 1-year postoperative. When a young surgeon starts his practice, it can be useful to check the tunnel position using a 3D CT scan. Very quickly this surgeon will become very confident and improve his tunnel placement.

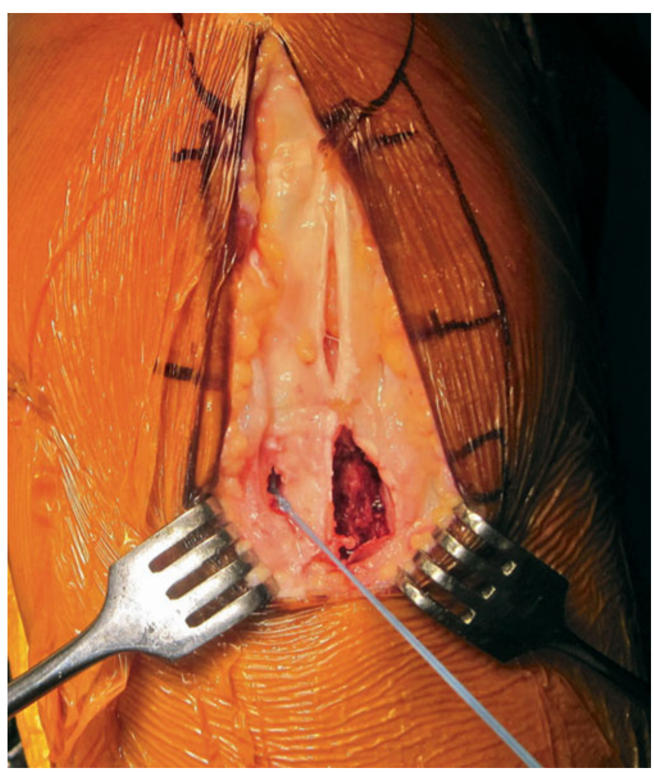


Fig. 5.38 Isometry of the graft is tested

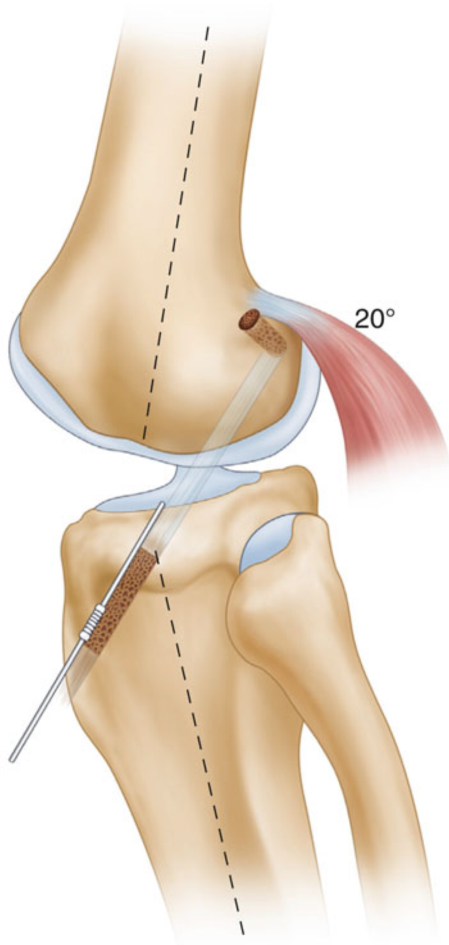


Fig. 5.39 Position of the graft and interference screw

Fig. 5.40 Position of the interference screw into the tibial tunnel

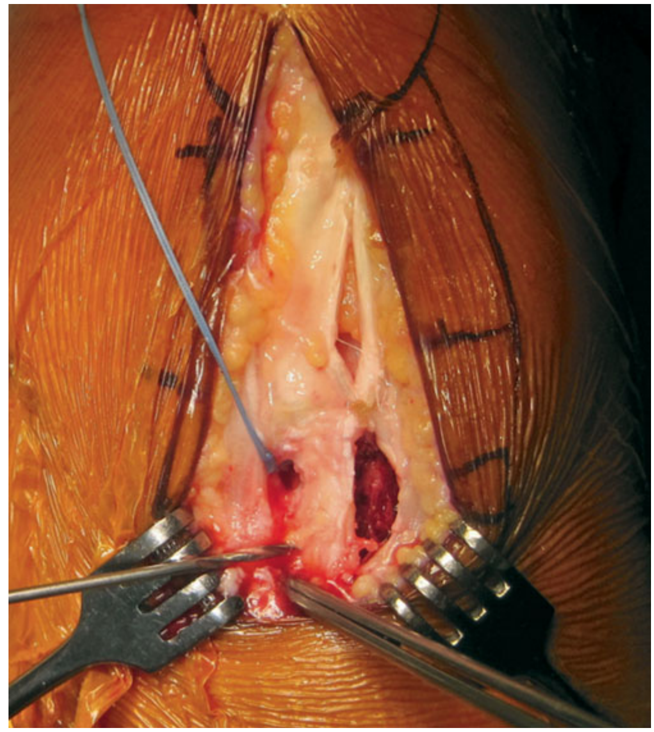
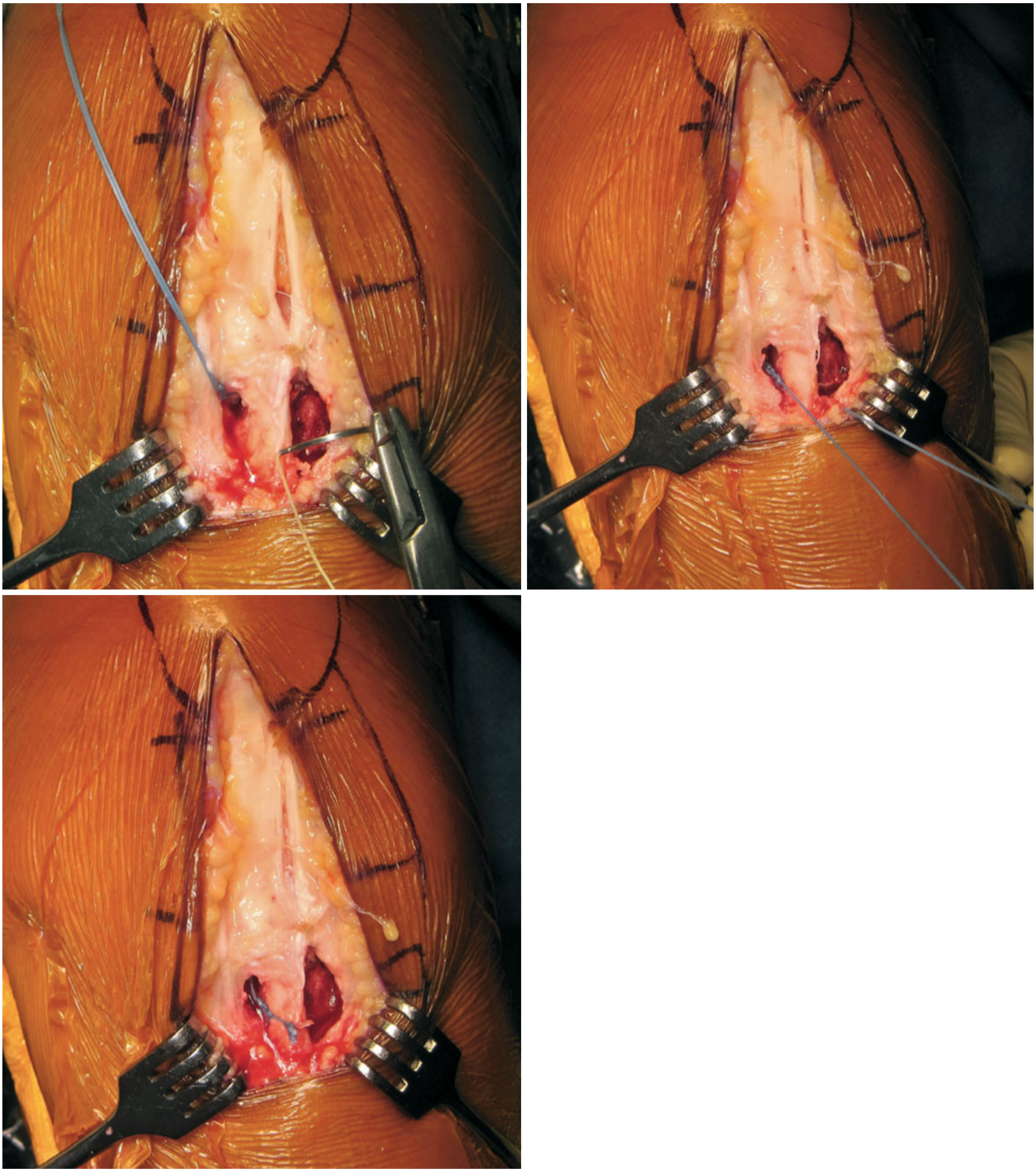


Fig. 5.41 Drilling of transosseous tunnel (additional tibial fixation)



Figs. 5.42, 5.43, and 5.44 The FiberWire is passed through the bony tunnel and sutured

The KJ Modification: The KJT

This surgical intervention combines both an intra-articular reconstruction using a bone-patellar tendon-bone graft and an extra-articular plasty with the gracilis or occasionally the semitendinosus tendon.

Harvest of the Bone-Patellar Tendon-Bone Graft

We start with the harvest of the bone-patellar tendon-bone graft as described above. The anteromedial skin incision, which is used for the harvest of the bone-patellar tendon-bone graft, is extended distally for about 2 cm.

Harvest of the Gracilis

For the extra-articular anterolateral plasty, either the semitendinosus or the gracilis tendon can be used. We prefer the semitendinosus. The pes anserinus is identified. The sartorius tendon is most superficial and covers the gracilis and semitendinosus tendons. Both can be seen and palpated under the sartorius fascia. The sartorius tendon is incised in the direction of the fibers proximally and then hockey-sticked at its insertion on the tibia. On its undersurface, the gracilis tendon can be identified proximally and the semitendinosus distally (Figs. 5.45 and 5.46). As the three tendons have a conjoint tendon insertion on the tibia, they can be more easily identified 4–5 cm proximally. The superficial fibers of the medial collateral ligament can be harmed during the dissection since they cross deep to the pes anserinus conjoint tendon. Once the gracilis tendon is identified, the tendon is isolated and a vessel loop is applied. If the semitendinosus is used, the vinculae of the semitendinosus (including one to the gastrocnemius aponeurosis) are dissected carefully. The distal part of the tendon is whip stitched using a no. 5 suture. Once this is done, the insertion of the tendon on the tibia is cut. Subsequently the tendon is harvested using a closed stripper (Fig. 5.47). The pulling sutures are passed through the eye of the closed stripper. The tendon is maintained under tension while the stripper is progressively pushed proximally with the knee in the figure of four position. Usually an increase in resistance is felt when the myotendinous junction is reached. The graft is usually at least 5 mm in diameter or at least 18 cm of its length.

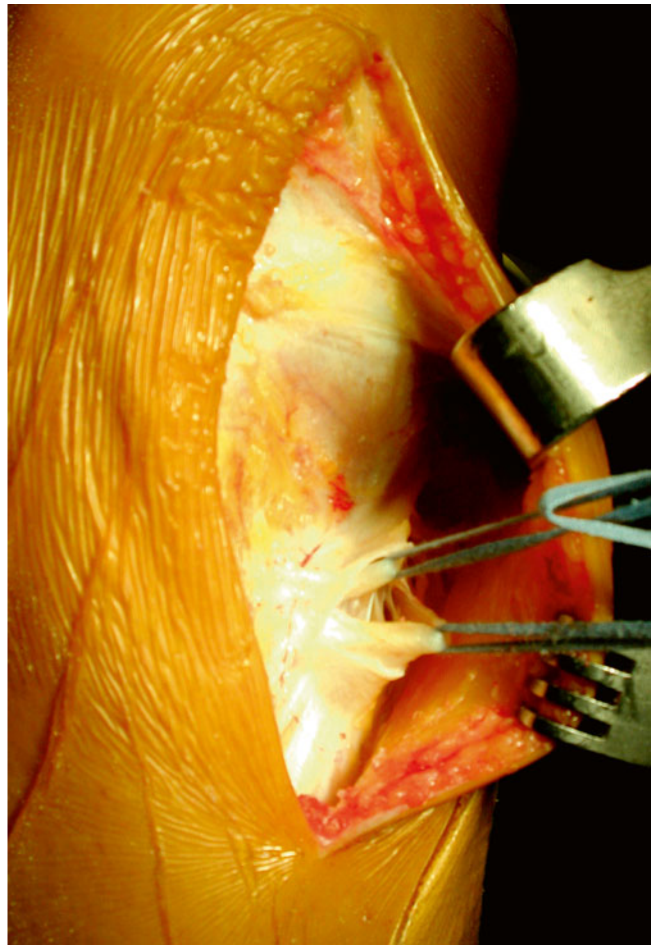


Fig. 5.45 Dissection of hamstring tendons (proximally, gracilis; distally, semitendinosus)

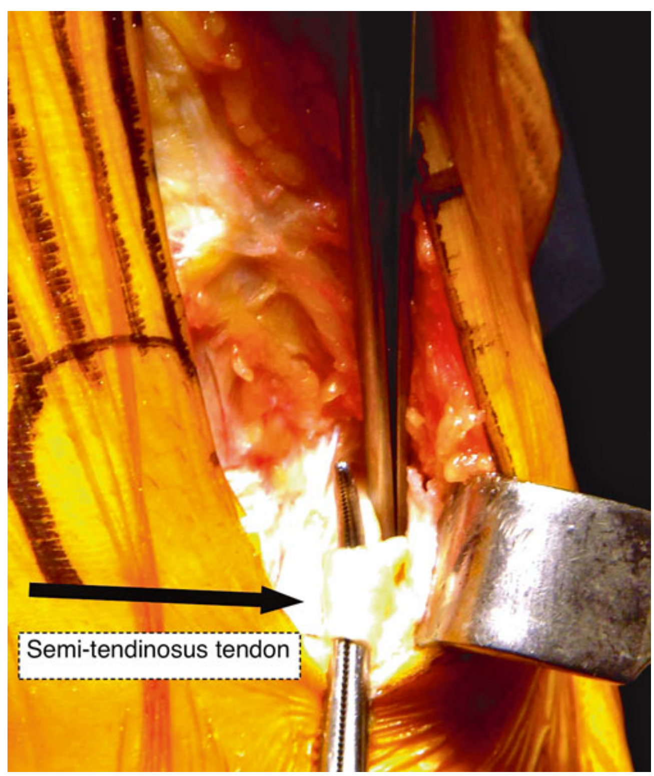


Fig. 5.46 Dissection of semitendinosus tendon in this case

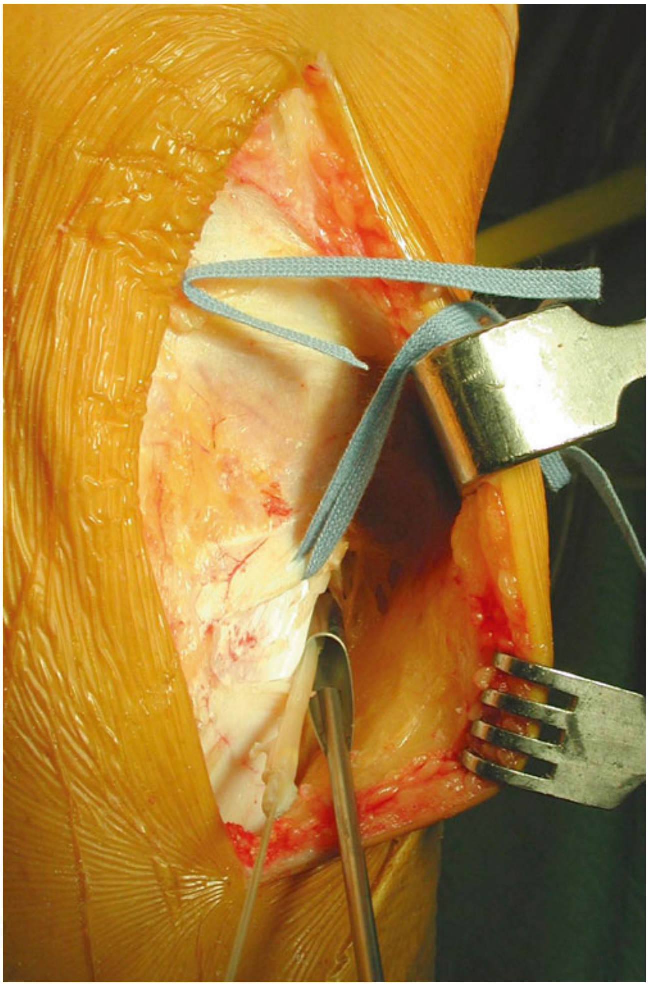


Fig. 5.47 Hamstrings harvesting using a closed stripper

Preparation of the Graft

The muscle fibers attached to the proximal end of the tendon are removed with the use of an osteotome or the back side of a blade. The proximal end of this tendon is usually wider and thinner as this is the muscle-tendon transition area. This side of the tendon is also whip stitched with a no. 5 suture. The tendon is then passed through the tibial bone block that was perforated with a 4.5 mm drill (Figs. 5.48 and 5.49). This construction allows for an intraosseous fixation of the extra-articular plasty when the bone block is impacted in the femoral tunnel.

Upon wound closure it is advisable to close the extensions of the sartorius tendon and to have an extra drain positioned in this area.

Fig. 5.48 Bone-patellar tendon-bone. A 4.5 mm diameter hole is drilled on the tibial bone block

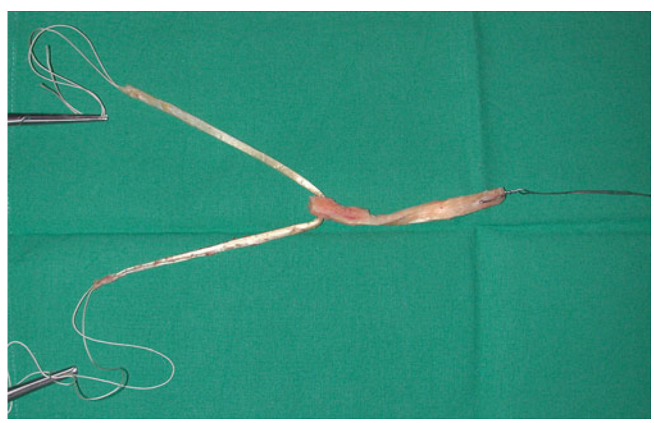


Fig. 5.49 Composite graft (patellar tendon and Hamstring tendon)

Surgical Approach for the Extra-Articular Tenodesis

After the patellar tendon and the hamstrings tendon harvest, the surgical approach for the lateral plasty is made. This approach is done prior to the arthroscopy. The anterolateral incision is 5–7 cm long (Fig. 5.50) and starts just proximal to the lateral epicondyle and ends at the level of Gerdy's tubercle. The iliotibial (IT) band is subsequently divided in the direction of its fibers (the distal part of the incision is somewhat more oblique) to the level of Gerdy's tubercle. Care has to be taken not to harm or transect the lateral collateral ligament since it crosses the undersurface of the IT band. The lateral collateral ligament is identified by palpating its anterior and posterior borders. Just posterior to the lateral collateral ligament, the lateral head of the gastrocnemius muscle can be palpated as well as the posterior lateral capsular structures. The posterolateral structures and the insertion of the lateral collateral ligament on the femur form a triangle. The undersurface of the lateral collateral ligament is dissected. However, one should stay extra-articular. We therefore prefer to do this last step of this procedure at the end of the intra-articular procedure in order to avoid leakage of arthroscopic irrigation fluid. The lateral entry point for the femoral tunnel is chosen just proximal to the insertion of the lateral collateral ligament on the femur. This entry point determines the biomechanics of the lateral extra-articular plasty. Therefore the direction of the femoral tunnel will be somewhat more horizontal than for the classic KJ (Fig. 5.51). Reconstruction of the intra-articular anterior cruciate ligament is as described in the previous chapter.

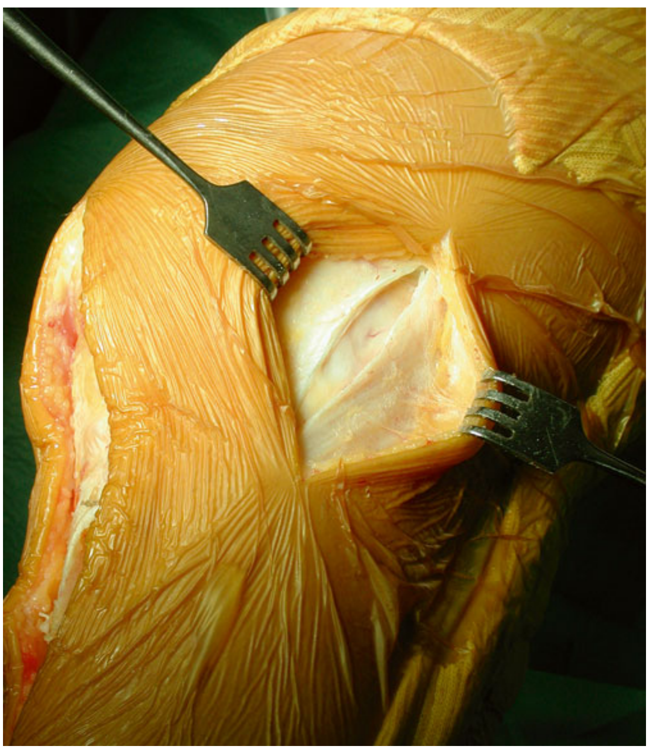


Fig. 5.50 Lateral approach

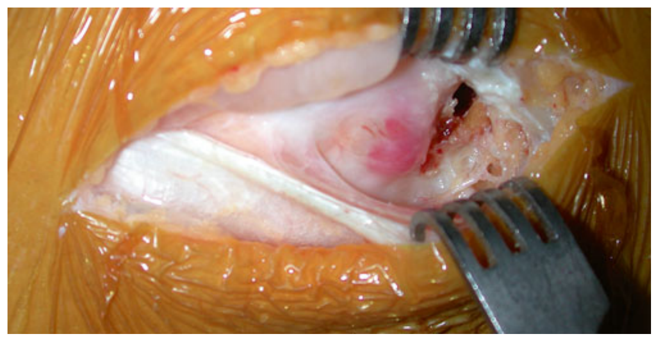


Fig. 5.51 Fascia lata incision

Fixation of the Lateral Plasty

Proximal graft fixation is obtained automatically when the bone block is impacted in the femoral tunnel (Fig. 5.52). The two free ends of the tendon are now passed under the lateral collateral ligament. Distal fixation of the tendon is achieved on Gerdy's tubercle. A bony tunnel is made at this location using an awl (Fig. 5.53). To achieve this, it can be useful to release a small amount of the origin of the tibialis anterior muscle on the lateral border of Gerdy's tubercle. The proximal, superior free end of the tendon is passed from superiorly to inferiorly across the tunnel. The inferior part is passed from inferiorly to superiorly in the same tunnel. To achieve this position, it must first be passed deep to the inferior part of the fascia lata (Figs. 5.54, 5.55, 5.56 and 5.57). The two ends of the tendon are sutured side to side, thus creating a solid fixation (Fig. 5.58). Tensioning of the extra-articular plasty is performed with the knee in 30° of flexion and neutral rotation after fixation of the intra-articular reconstruction.

Closure of the wound is done over a drain. The IT band is sutured with interrupted no. 5 sutures (Fig. 5.59).

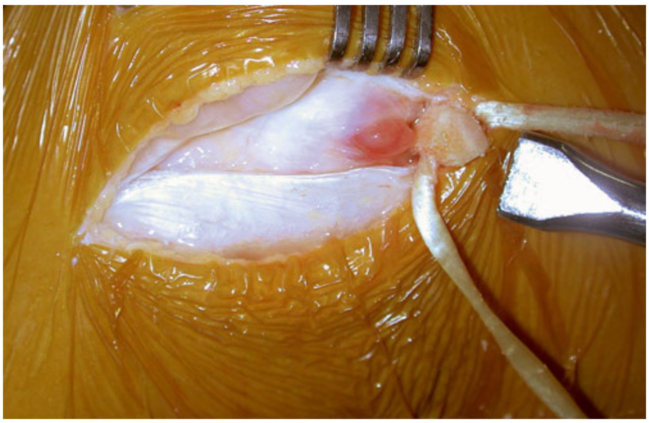


Fig. 5.52 Press-fit proximal fixation

Fig. 5.53 Bony tunnel on Gerdy's tubercle

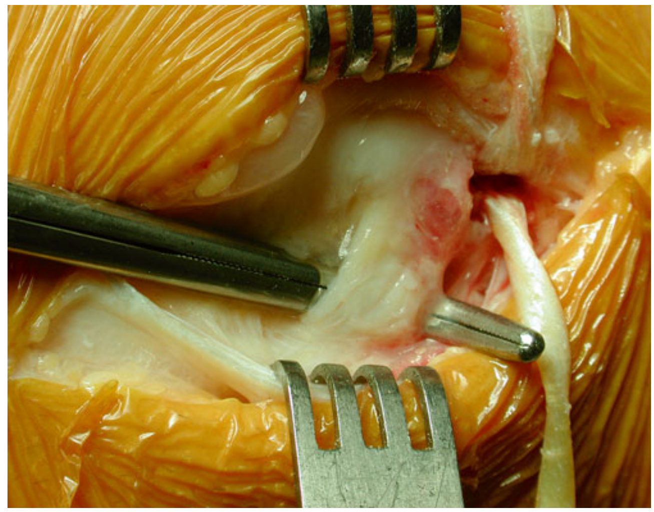
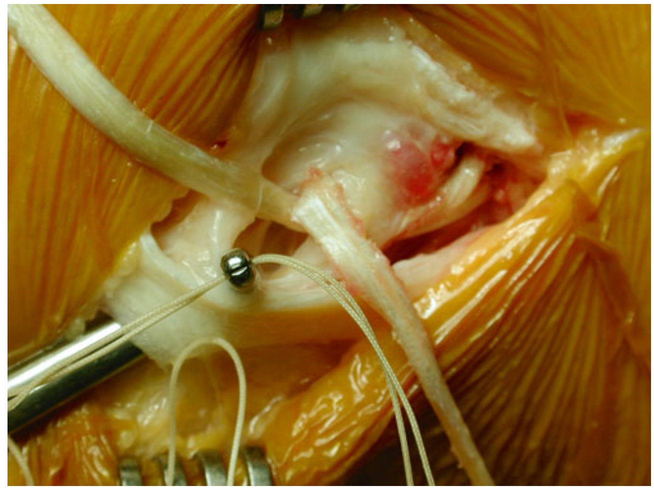
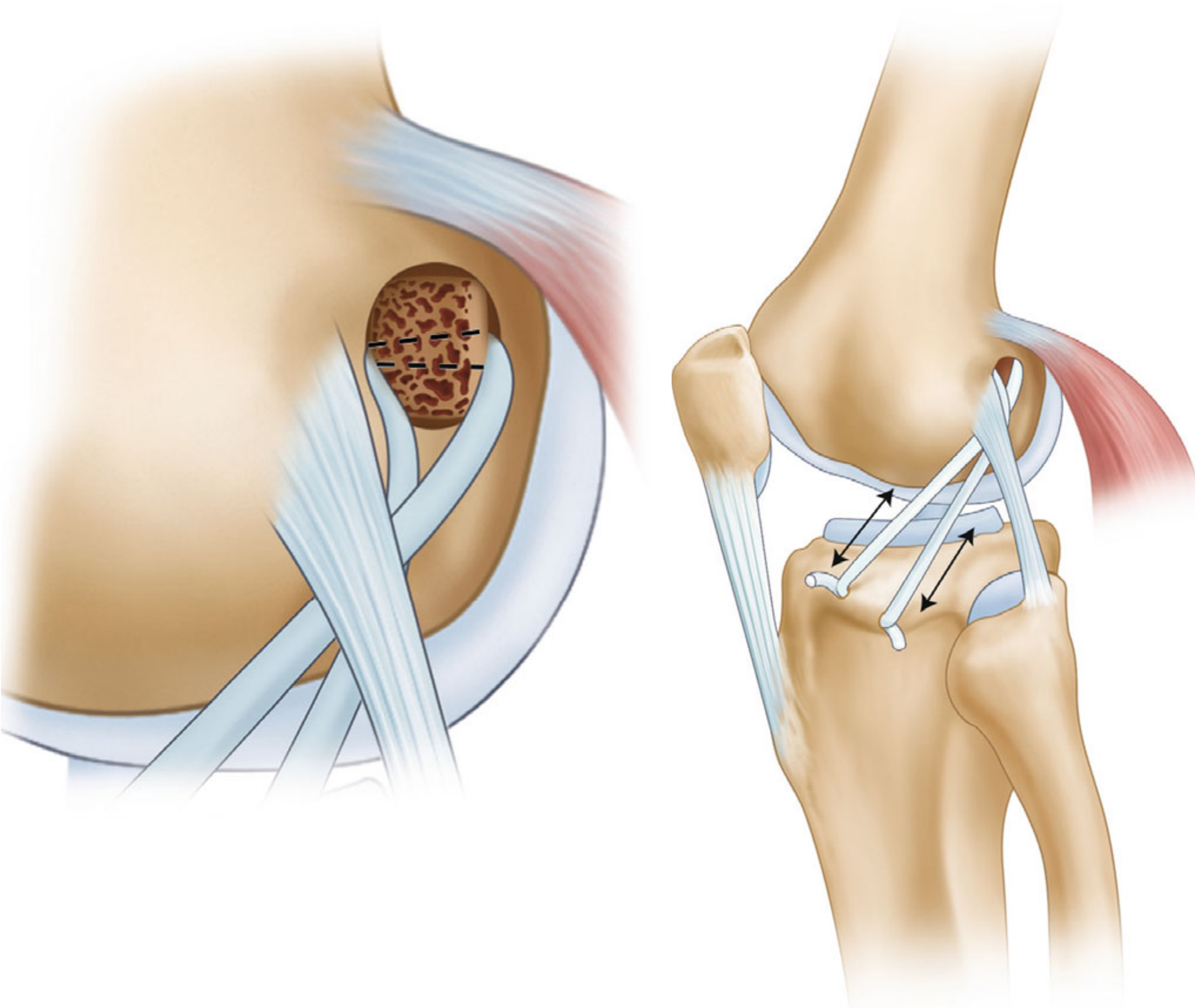


Fig. 5.54 The lateral tenodesis is first passed under the lateral collateral ligament

Fig. 5.55 The inferior bundle is passed under the fascia lata





Figs. 5.56 and 5.57 Lateral tenodesis

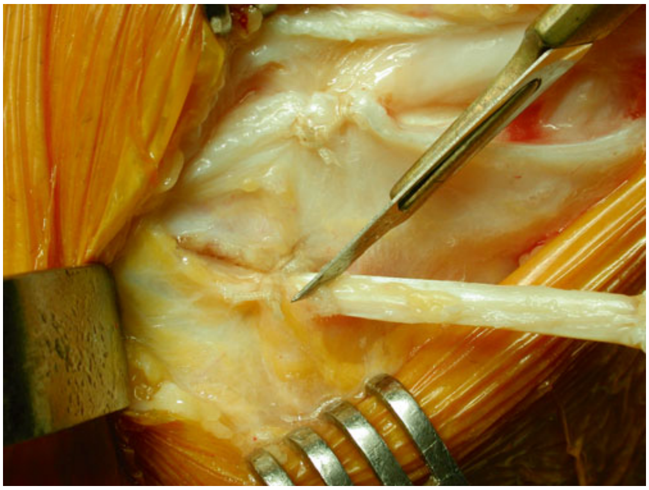


Fig. 5.58 Lateral tenodesis fixation

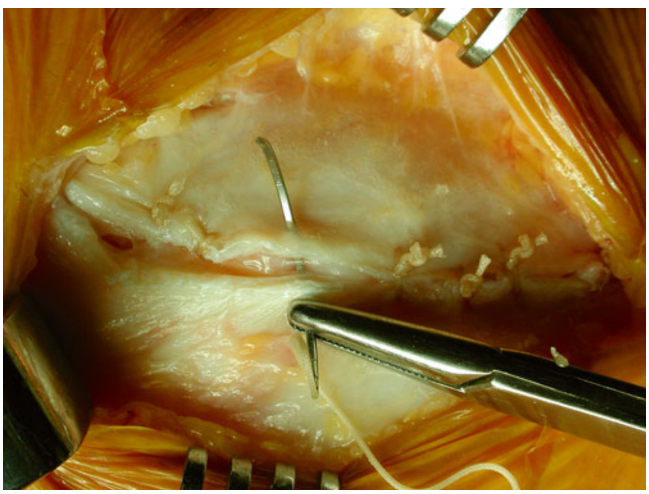


Fig. 5.59 Fascia lata suture

Anterior Cruciate Ligament Reconstruction with a High Tibial Osteotomy

The indication to combine a high tibial osteotomy with a reconstruction of the anterior cruciate ligament is prearthritis with varus alignment or associated with lateral side laxity. This surgical intervention combines two separate surgical interventions that are detailed in other chapters. In this chapter we will detail the sequence of the surgical steps. For over 10 years we have preferred the opening wedge osteotomy as it allows a precise correction to be obtained. Nevertheless, one should always be careful not to change the tibial slope.

The procedure starts with the harvest of the patellar tendon graft followed with the preparation of the femoral and tibial tunnel. Through the same anteromedial approach, the high tibial opening wedge osteotomy can be performed prior to the introduction of the tendon graft (Fig. 5.60). Once the osteotomy is performed (cf. chapter on osteotomies), one has to check (Fig. 5.61) the axis correction with the use of an image intensifier. The metal bar illustrates the mechanical lower limb axis (Fig. 5.62). Once an adequate correction is obtained, a cortical-cancellous iliac bone graft with the correct dimension is harvested. These grafts are introduced posterior to the medial collateral ligament in order to avoid an increase of the tibial slope. The osteotomy is fixed using 2–3 staples (Fig. 5.63). Once the osteotomy is checked and fixed, the bone-patellar tendon-bone graft is introduced into the femoral and tibial tunnels. The bone block in the tibial tunnel is fixed with a metal wire on a post (Fig. 5.64) or with FiberWire via a cortical bone bridge as described above. Isolated fixation on a post or over a bone bridge in combination with an opening wedge osteotomy is insufficient. Therefore we advise augmentation of the graft fixation with an interference screw.

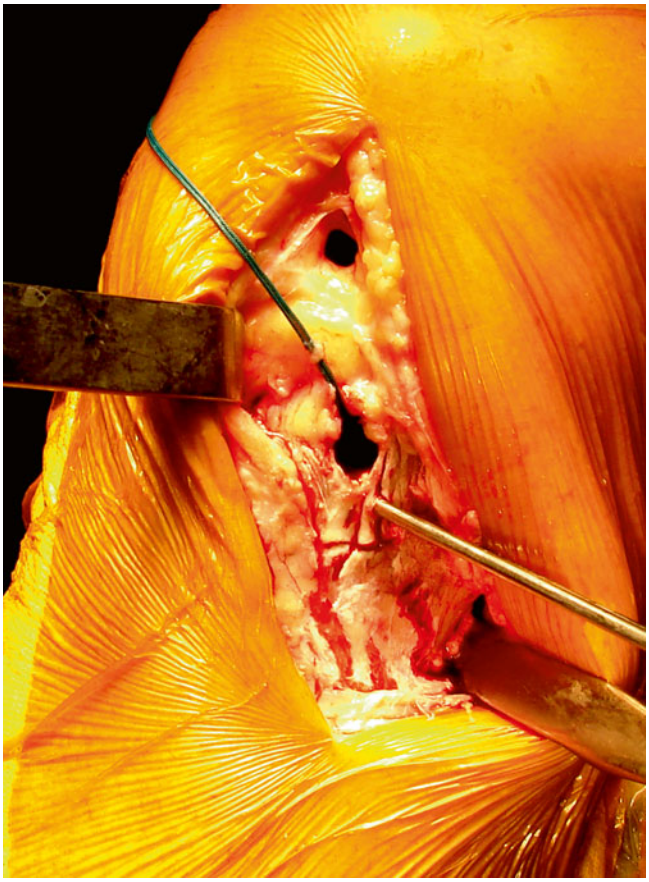


Fig. 5.60 Guide pin positioning

Fig. 5.61 Direction of the osteotomy controlled by fluoroscopy

Fig. 5.62 Lower limb axis assessed with fluoroscopy

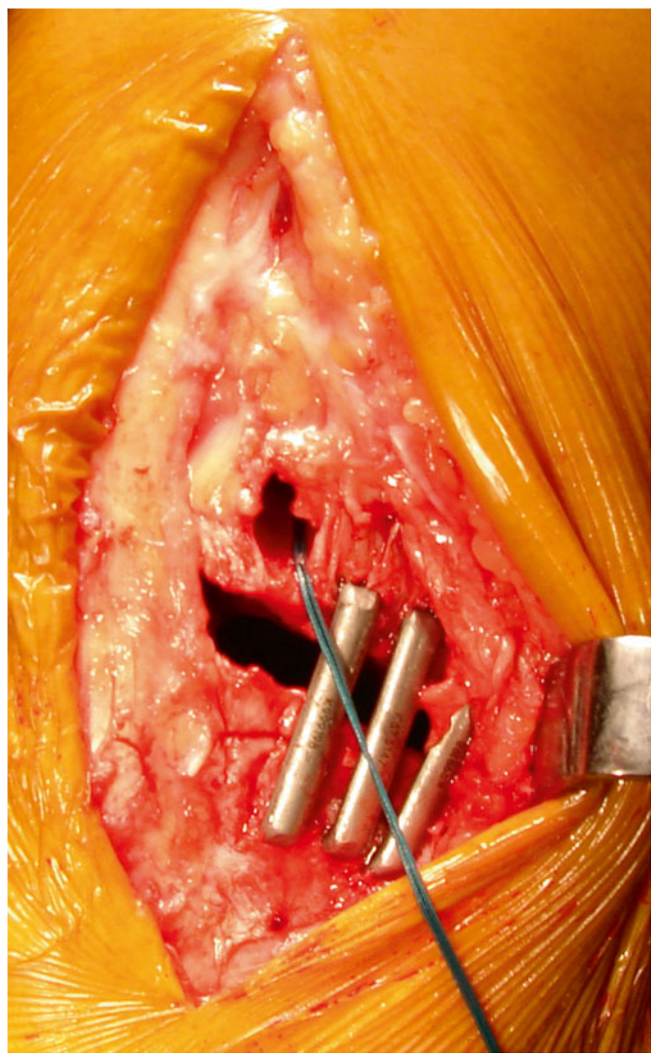


Fig. 5.63 Osteotomy fixation by staples

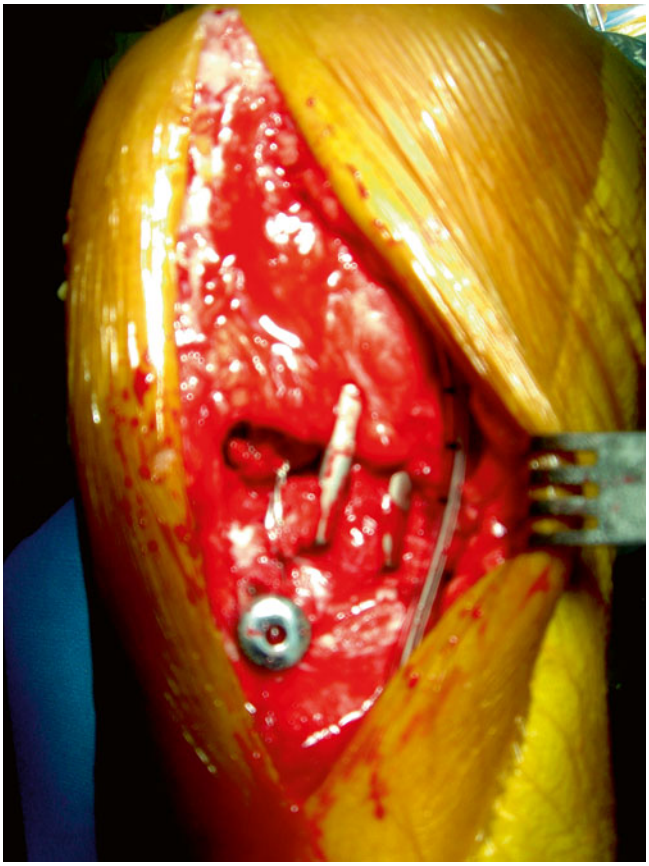


Fig. 5.64 Graft tibial fixation

Postoperative Care

Flexion is limited to 120° for 45–60 days and weight bearing is only allowed after 60 days. Range of motion exercises are allowed immediately in the postoperative setting. A brace in 20° of flexion is applied between the rehabilitation sessions.

Lemaire Extra-Articular Plasty

The extra-articular plasty using the fascia lata was described by Marcel Lemaire in 1967. This technique was modified in Lyon by Professor Dejour and has always been considered very useful in the treatment for rotational instability, specifically in the case of a clearly positive pivot-shift test. It does not control anterior tibial translation of the medial compartment.

Although usually used in addition to an anterior cruciate ligament reconstruction (KJT), this technique can be used on its own, although very infrequently. The indications include residual laxity of the lateral compartment after an isolated reconstruction of the anterior cruciate ligament and chronic anterior laxity in the older patient (55 years and up). The absence of the posterior horn of the medial meniscus is a theoretical contraindication to this procedure since the posterior horn of the medial meniscus serves at the central point of rotation in this procedure.

Positioning of the Patient

This procedure can be performed under general anesthesia or with regional anesthesia. The patient is placed in the supine position. A lateral vertical post is located high on the femur. The distal lateral post allows the knee to be flexed at 30°. The tourniquet is positioned high on the femur. A contralateral post can be applied and allows the surgical table to be inclined to the contralateral side (Fig. 5.65).

Approach

We use a lateral skin incision starting distally at the level of Gerdy's tubercle and continuing proximally 15 cm in the direction of the fibers of the IT band (Fig. 5.66).

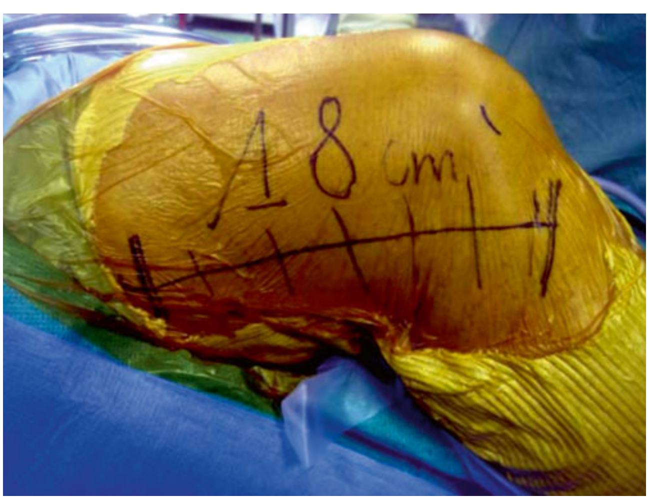


Fig. 5.65 Patient setup

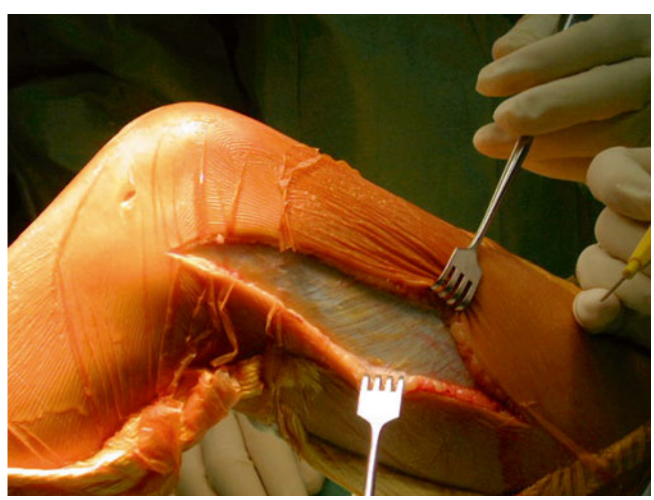


Fig. 5.66 Lateral approach according to Lemaire

Harvest and Preparation of the Fascia Lata Graft

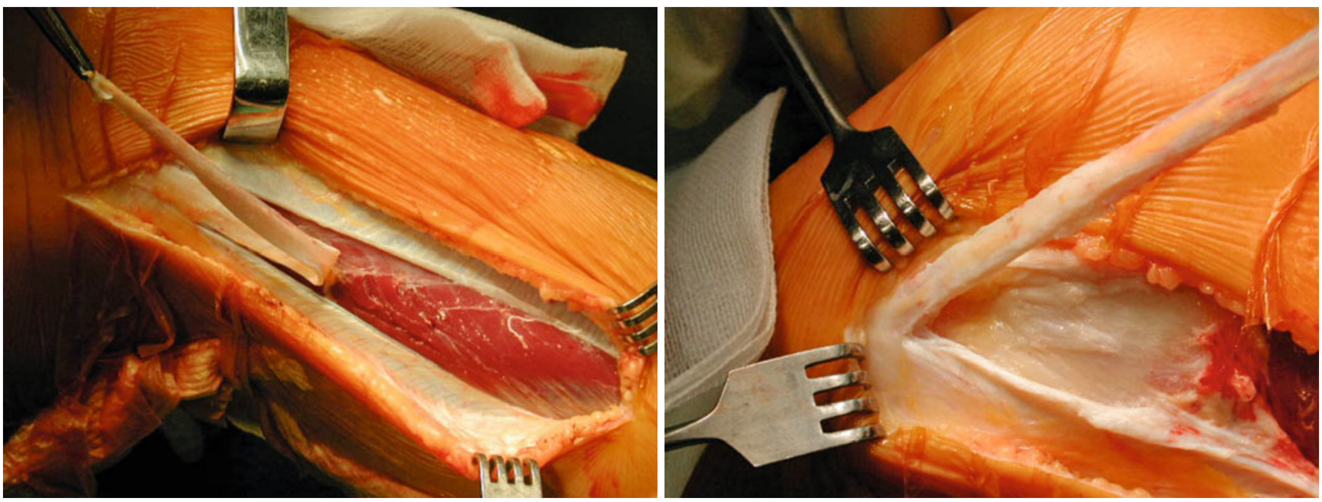
The fascia lata graft is 18 cm long and 1 cm in width and is harvested with the 23 blade (Figs. 5.67 and 5.68). Care is taken not to section or harm the lateral collateral ligament, which crosses the incision in distally. The dorsal border of the graft corresponds with the anterior border of the intermuscular septum. The graft remains in continuity distally with Gerdy's tubercle (Fig. 5.69).

The graft is then prepared by removing all fatty tissue. The proximal end is whip stitched over a minimum distance of 2 cm using n° 5 resorbable sutures (Fig. 5.70).

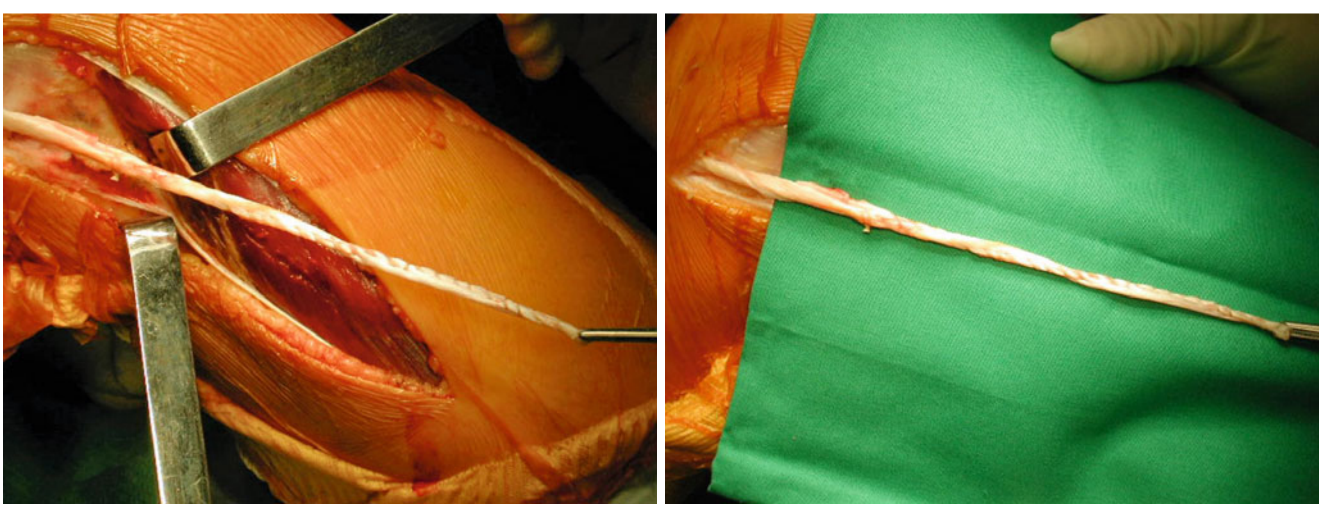
Preparation of the Femoral Tunnels

The entry points for the femoral tunnel are marked. On the femur, the anterior entry point is situated exactly at the end of the lateral intermuscular septum on the lateral condyle. This point is easily identified by following the septum from proximally to distally carefully lifting the vastus lateralis muscle and reflecting it anteriorly together with the suprapatellar pouch using a Farabeuf or Homan retractor.

Care must be taken to obtain hemostasis of the perforating and metaphyseal vessels. The knee is now flexed by hanging the foot over the edge of the operating table. This maneuver relaxes the posterior margin of the fascia lata. The posterior tunnel is located exactly at the top of the triangle formed anteriorly by the lateral collateral ligament and posteriorly by the lateral head of the gastrocnemius muscle. The



Figs. 5.67 and 5.68 ITB harvesting



Figs. 5.69 and 5.70 ITB preparation

LCL is identified easily just below the epicondyle (Fig. 5.71). If difficulty is encountered in finding the ligament in this location, it can be traced from the top of the fibula. Nevertheless, the best landmark for tunnel location is the anterior border of the lateral gastrocnemius muscle.

The connective tissue and fatty tissue covering the LCL are stripped from both sides of the ligament, providing clear visualization. The interval between the deep surface of the proximal two-thirds of the LCL and the underlying synovium is carefully opened with fine dissecting scissors. The popliteus tendon can be palpated deep to the LCL.

The two tunnels are now made using a straight awl. Using "O'Shaughnessy" arterial clamps, the size of the tunnels is progressively increased (Fig. 5.72). A curved suture guide is passed through the femoral tunnel from anteriorly to posteriorly to insert a passing suture to guide the graft through the tunnel.

Tibial Tunnel Preparation

The tibial tunnel passes under Gerdy's tubercle. A 1 cm incision in the tibialis anterior muscle is made at the inferior border of the tubercle where the exit of the posterior tibial tunnel will be located (Fig. 5.73).

The anterior tibial tunnel is located anterior to Gerdy's tubercle. Again the entry holes are opened up with an awl and enlarged with the "O'Shaughnessy" arterial clamp. The

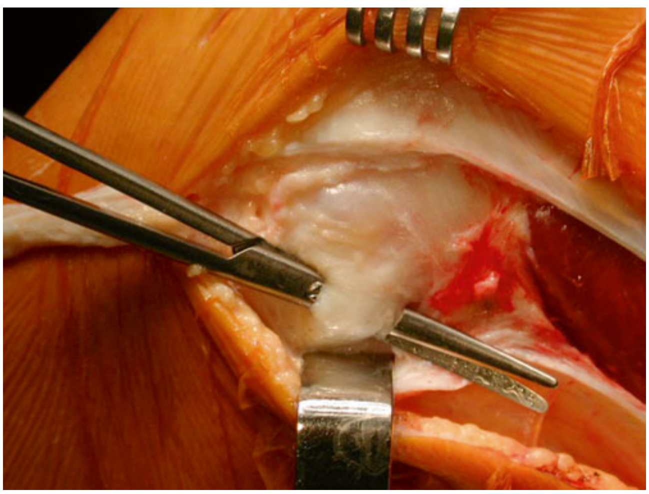


Fig. 5.71 LCL dissection

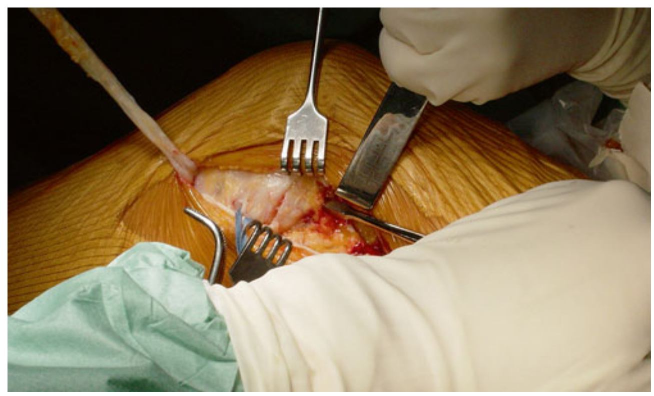


Fig. 5.72 Femoral tunnel preparation

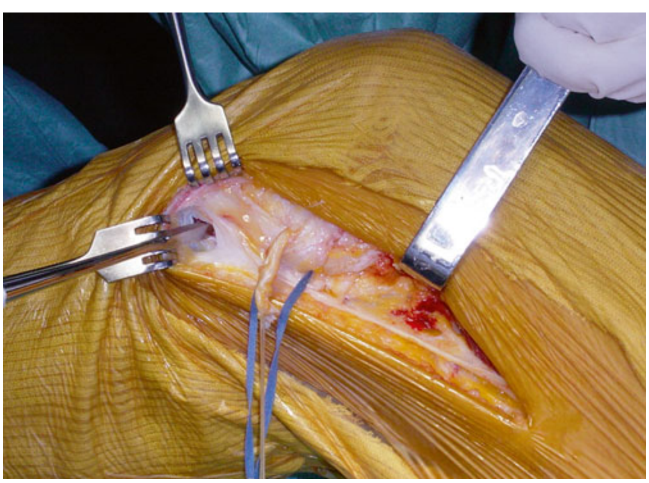


Fig. 5.73 Tibial tunnel

tibial passing suture is inserted from posteriorly to anteriorly using a curve suture passer.

Passage of the Graft

The graft is inserted using passing sutures (Fig. 5.74). It is first pulled underneath the lateral collateral ligament (Fig. 5.75) from distal to proximal taking care not to twist it. The graft should remain extra synovial when passing underneath the lateral collateral ligament but superficial to the popliteus tendon. It is then passed from posterior to anterior through the femoral tunnel (Figs. 5.76 and 5.77) using the previously placed passing suture. The graft is again passed from proximal to distal under the lateral collateral ligament (Fig. 5.78) and then through the tibial tunnel from anterior to posterior using the tibial tunnel passing suture (Figs. 5.79 and 5.80).

The knee is now positioned near extension and in neutral rotation, in contrast to the initial description by Lemaire where the foot was placed in external rotation.

Fixation of the Lateral Plasty

This graft is secured by suturing the ends together on either side of the tibial tunnel with two or three solid sutures using Ercedex no. 5 suture material (Fig. 5.81).

Distally, the two ends of the pull suture are passed through the edges of the IT band with a Reverdin needle to additionally secure the graft. The remaining IT band is closed with interrupted sutures to prevent herniation of the vastus lateralis muscle. The rest of the incision is closed as normal. A drain is inserted under the fascia lata.

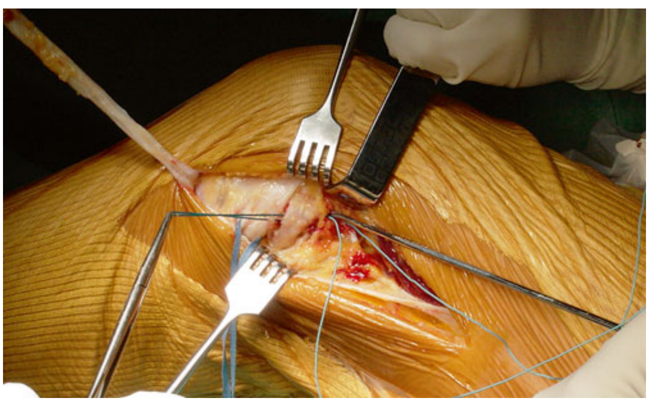


Fig. 5.74 Passing sutures

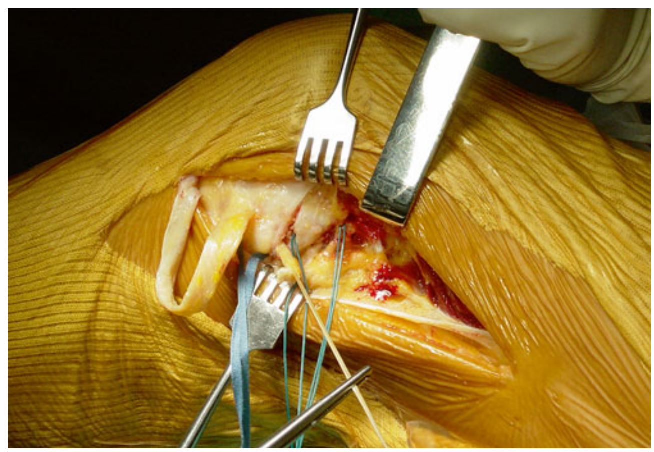
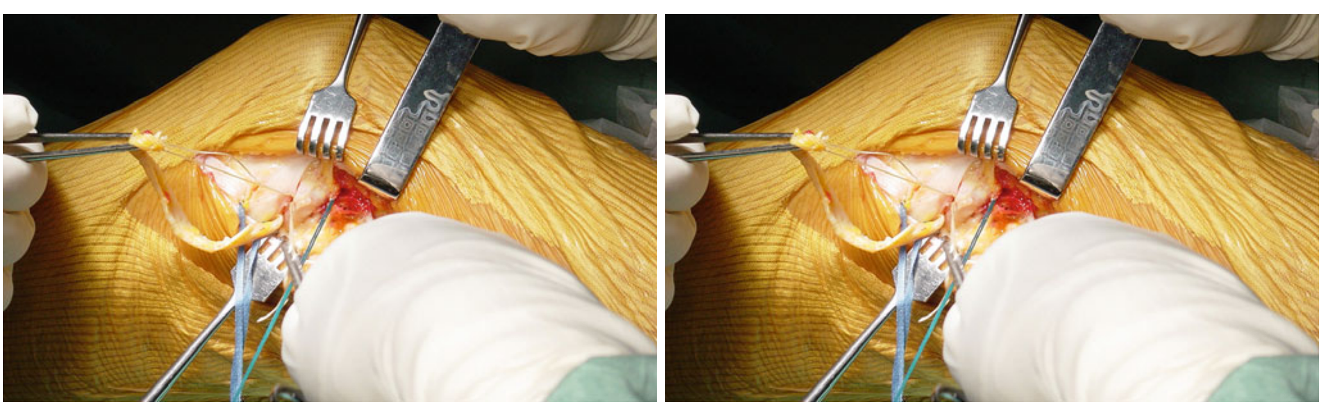


Fig. 5.75 The graft is pulled underneath the LCL 1



Figs. 5.76 and 5.77 The graft is passed through the tunnel femoral

Postoperative Guidelines

The patient is braced in 20° of flexion (full extension according to M. Lemaire). Range of motion exercises of the knee are commenced on the first postoperative day. Full weight bearing is allowed, but a heel of 1 cm should be worn for 2 weeks. This heel is shortened every 3 days by 1 mm. At the end of 45 days, the heel has been completely removed.

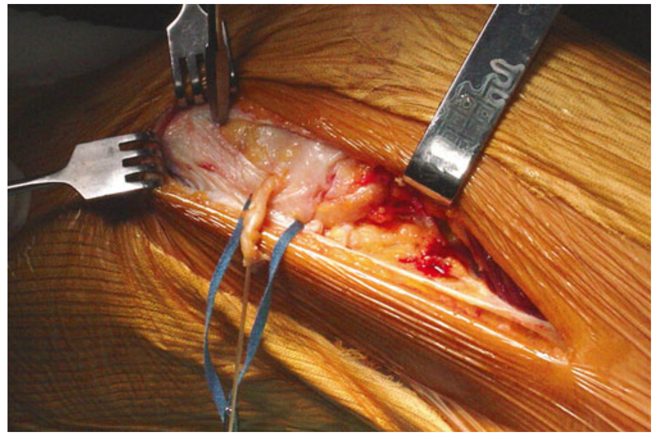
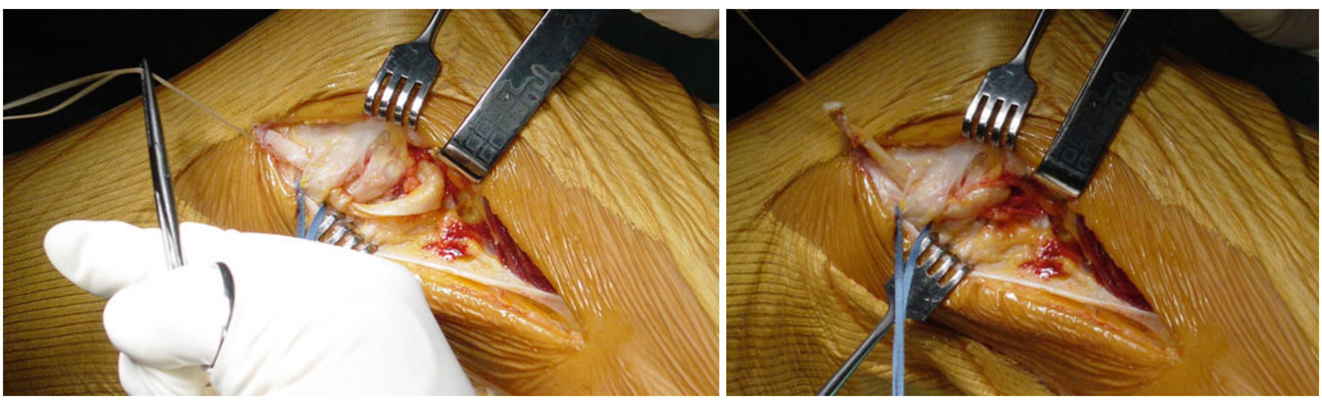


Fig. 5.78 The graft is pulled underneath the LCL 2



Figs. 5.79 and 5.80 The graft is passed through the tibial tunnel

Fig. 5.81 Lemaire extra-articular plasty fixation

6 Revision Anterior Cruciate Ligament Reconstruction

Robert A. Magnussen and G. Demey

Introduction

Revision anterior cruciate ligament (ACL) reconstruction is increasingly common. These procedures must be carefully planned and are often fraught with technical difficulties. The surgeon must address the following questions prior to surgery:

- How are the previous tunnels positioned?
- Which graft should be used?
- Is a one-stage or two-stage reconstruction required?
- What graft fixation will be utilized?

To answer the questions, the cause of failure of the prior ACL reconstruction should be identified. The answers to these critical questions will guide the revision surgery and ensure the avoidance of technical errors that could compromise results.

Causes of Failure

It is important to obtain a detailed clinical history, including the initial injury mechanism and information about the prior reconstruction such as graft type, surgical technique, and intraoperative findings including meniscal and articular cartilage status. One should also determine the postoperative rehabilitation protocol, the time to return to sport, and any subsequent surgical procedures such as the resection of the cyclops lesion or subsequent meniscal tear.

Technical Error

Technical error is the most common cause of recurrent instability following ACL reconstruction.

R.A. Magnussen, MD, MPH (✉)
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University, Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

G. Demey, MD
Lyon Ortho Clinic, Clinique de la Sauvegarde, 29B avenue des Sources, 69009 Lyon, France
e-mail: demeyguillaume@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_6, © Springer-Verlag London 2014

Incorrect Tunnel Position

This error is by far the most common. The positions of tibial and femoral tunnels can be evaluated on plain radiographs (see analysis of the causes of failure) and computed tomography (CT) scans. Our experience has been that three-dimensional CT reconstructions are quite useful in evaluating tunnel position.

Errors in femoral tunnel position are more common than those involving the tibia, but both can be present. On the femur, tunnels are often too anterior (Fig. 6.1), leading to impingement in the notch and a loss of extension. Placement of the femoral tunnel too far posterior can lead to graft laxity in flexion or excessive tension in extension. Vertical positioning in the notch is also common, leading to poorer control of tibial rotation.

In the tibia, the tunnel may be too far posterior, leading to a vertical graft that poorly controls anterior translation (Fig. 6.2), or too far anterior, leading to impingement of the graft in the notch with extension. Similarly, lateral tunnel placement can lead to impingement of the graft on the medial border of the lateral femoral condyle, possibly leading to abrasion and graft rupture.

Fig. 6.1 Lateral plain radiograph demonstrating anterior femoral tunnel malposition

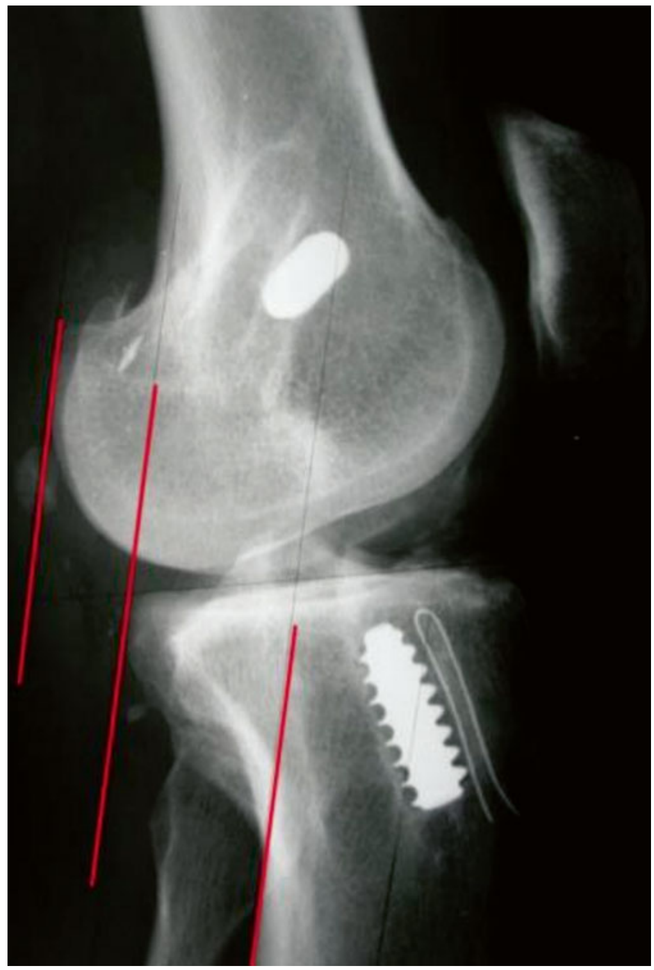


Fig. 6.2 Lateral stress radiograph demonstrating anterior tibial translation that is poorly controlled by a vertical graft with a too-posterior tibial tunnel

Poor Fixation

Graft fixation may be inadequate or insufficient. This problem can occur when there is inadequate contact between an interference screw and the bone block of a patellar tendon graft. Advancing the screw too far or not far enough can lead to this problem, as can divergence of the screw and graft. Additionally, poor bone quality may diminish the fixation strength of an appropriately placed screw. This problem commonly occurs in the cancellous bone of the tibia, which is why we prefer to utilize double fixation in the tibia.

Poor Graft Quality

Use of a graft that is too small or of poor quality can lead to early reconstruction failure. The quality of allograft tissue is variable and highly dependent on the sterilization process.

Associated Lesions

Lesions of the posteromedial or posterolateral corner that are not addressed at the time of ACL reconstruction frequently lead to persistent postoperative instability and failure. Of specific interest is whether a medial meniscectomy is required. Excision of significant portions of the medial meniscus can lead to increased stress on the graft and contribute to failure. Excessive posterior tibial slope ($\alpha > 13°$) can also contribute to increased graft stress and failure (Fig. 6.3).

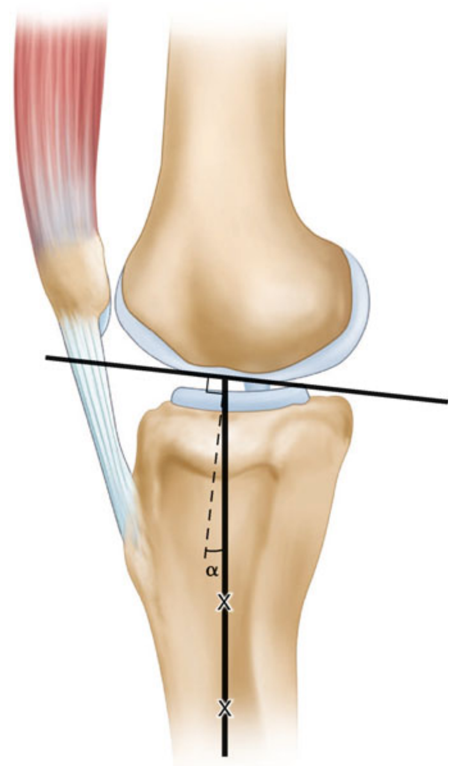


Fig. 6.3 Drawing of a lateral view of a proximal tibial demonstrating measurement of the posterior tibial slope based on the angle (α) between the long axis of the tibia and medial joint line

Re-traumatic Rupture

True traumatic graft ruptures are rare causes of failure and are ultimately a diagnosis of exclusion. To affirm this cause, we prefer to have a documented examination objectively describing control of the anterior laxity by the previous reconstruction and a significant traumatic reinjury. Reinjury is rarely caused by trivial injuries and is often accompanied by a "pop" and hemarthrosis. Patients often attribute failure of their prior reconstruction to a trivial trauma, and it is critical to rule out other etiologies of failure, so the mistakes of previous surgeries are not repeated at revision.

Biologic Failure

Biologic failure has been described as failure of the ACL graft tissue to revascularize and undergo ligamentization. The ligamentization process is significantly slower and often incomplete in allografts, making them more susceptible to this mode of failure. This etiology is again a diagnosis of exclusion.

Analysis of Failure Causes

The preoperative evaluation should be complete.

Clinical Examination

In addition to signs of anterior laxity, one should identify the scars from previous surgeries, palpate the patella and tibia to identify any bone loss if a prior patellar tendon graft was taken, search for any additional instability (especially posterolateral or posteromedial corner), and evaluate for excessive recurvatum, varus or valgus alignment, or diffuse ligamentous laxity.

Review of the Initial Operative Report

Critical information includes the type of graft and fixation that were used as well as any information regarding intraoperative complications or challenges.

Radiographic Examination

One should obtain:

- Anteroposterior and lateral radiographs of the knee at 30° of flexion in a single-leg stance.
  - These views allow for evaluation of tunnel position in both the coronal and sagittal planes. Additionally, they allow for assessment of tunnel enlargement.
- Objective radiographic measurements of anterior laxity (anterior tibial translation with differential Telos).
  - These views allow quantitative evaluation of anterior laxity and comparison to the contralateral side.
- Bilateral standing anteroposterior radiographs in 30° of flexion (Schuss view).
  - This view is the most sensitive for detection of tibiofemoral osteoarthritis.
- Axial patellar view in 30° of flexion.
  - This view detects patellofemoral arthritis and patellar maltracking.
- Long cassette views of the lower extremities if malalignment is suspected clinically.
  - This view determines the mechanical axis and can influence decision-making regarding the need for associated osteotomy.

CT with 3D Reconstructions

This study is essential. It not only gives precise information on the positioning of the tunnels but also quantifies bone defects that are often poorly assessed on plain radiographs. Analysis of the axial cuts is particularly useful in evaluating the relationship of the femoral tunnel with the notch (in terms of orientation, positioning, and filling). Ideal positioning is indicated when the femoral tunnel is visible on the cut in which the notch forms the shape of a Roman arch (Fig. 6.4). The axial cuts also allow evaluation of graft fixation, the position of the interference screw, and its resorption. A complete description of the femoral tunnel position requires information from both the axial and sagittal cuts, making its analysis difficult.

On the tibial side, the axial cuts allow analysis of the position of the tibial tunnel. Sagittal plane analysis details tunnel orientation and graft fixation. Again, evaluation of the exact point of entry of the tunnel into the joint is complex and requires the use of data from several cuts.

The diameters of the tunnels and any other bony defects can be easily assessed with CT images. Bone loss near the entry site of the tunnel into the joint is especially important (Fig. 6.5). In the case of a bony defect greater than 15 mm, there is a risk of a windshield-wiper effect and subsequent graft loosening. Bone graft fillers may be utilized in these cases (see surgical technique below). In case of revision following failed double-bundle surgery, this type of tunnel enlargement is frequently seen.

The 3D reconstruction allows one to integrate information from numerous planes into a single image and is the single most important aid in understanding tunnel position. While quantitative analysis is difficult, the general graft position and tunnel orientation can be qualitatively assessed (Fig. 6.6). These views provide an accurate preview of the

Fig. 6.4 Axial CT image demonstrating ideal positioning of ACL femoral tunnel in this plane. Note the tunnel centered on the cut in which the notch resembles a Roman arch

Fig. 6.5 A 3D CT reconstruction of part of a distal left femur viewed from proximally. One can visualize the prior femoral tunnel and note its improper vertical position in the femoral notch

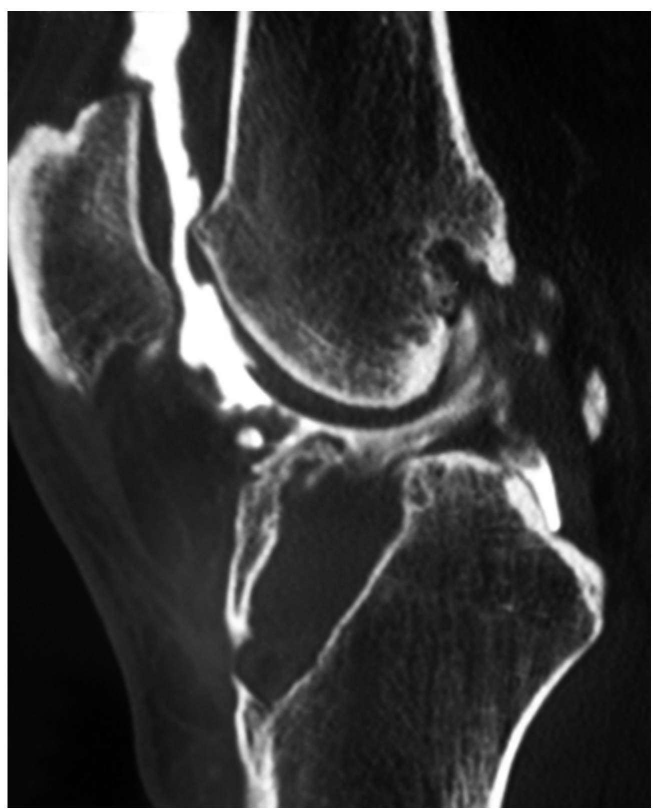


Fig. 6.6 A sagittal CT image of a knee demonstrating enlargement of the ACL tibial tunnel

view of the notch that will be encountered intraoperatively and are indispensable planning tools.

MRI

It allows the evaluation of the appearance of the prior graft and determination of the status of the menisci and articular cartilage. It is quite useful in the diagnosis of graft failure and other predictors of outcome but is less useful than CT for preoperative planning.

Surgical Technique

General

Our preferred technique for revision ACL is nearly identical to that for primary ACL reconstruction (see Chap. 5). The primary difference occurs when repeat harvest of the ipsilateral patellar tendon is not possible, requiring contralateral harvest. Other considerations include the impact of previous tunnels and bone loss on placement of the tunnels for the revision surgery.

An image intensifier can be quite useful in case of removal of retained hardware or if an associated osteotomy is performed.

Physical examination is repeated under anesthesia to assess the degree of anterior laxity and detect any associated instability.

Choice of Graft

Patellar tendon autograft is our preferred graft for revision ACL reconstruction in order to attain bone-to-bone fixation. In addition, bone blocks can help fill an expanded tunnel if tunnels from the prior surgery are to be reused. We consider re-harvest of an ipsilateral patellar tendon to be possible 18 months after prior harvest. When re-harvesting, the scar frequently must be enlarged.

However, any pathology related to the prior harvest (short tendon, dehiscence on the prior tendon harvest site, or significant bone loss at either the patella or tibia) is an indication to harvest the contralateral patellar tendon. This decision must be made preoperatively in order to inform the patient and to drape appropriately.

When ipsilateral re-harvest or contralateral harvest is impossible, we prefer a quadriceps tendon autograft. It provides a broad, thick tendon with a bone block.

Joint Exploration

Anterolateral and anteromedial portals are made. A systematic assessment of the joint should be performed evaluating all articular cartilage surfaces and the menisci. The shaver is used to clear fat and scar tissue and achieve a clear view of the notch (Fig. 6.7). A limited notch plasty with a small osteotome may be helpful to aid in visualization. It is imperative to fully visualize the posterior part of the lateral wall of the notch in order to ensure appropriate femoral tunnel placement (Fig. 6.8).

Fat pad resection is generally minimized, but some resection is required to allow accurate tibial tunnel placement (Fig. 6.9).

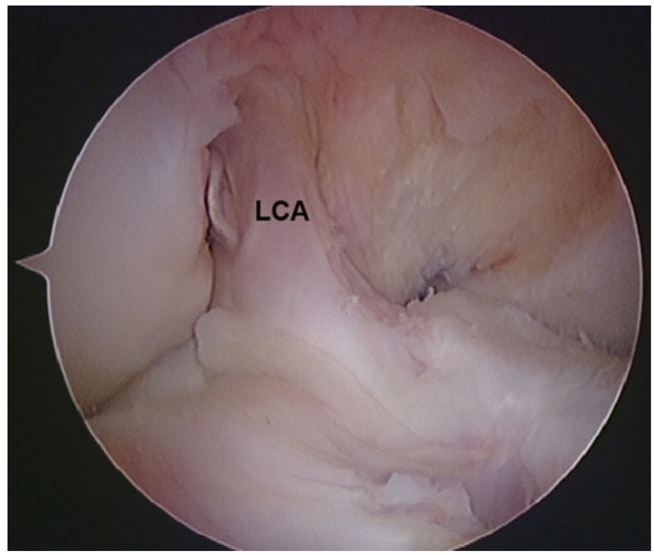


Fig. 6.7 An arthroscopic view of the notch in a right knee demonstrates a vertical ACL graft with the tibial tunnel placed too far posterior

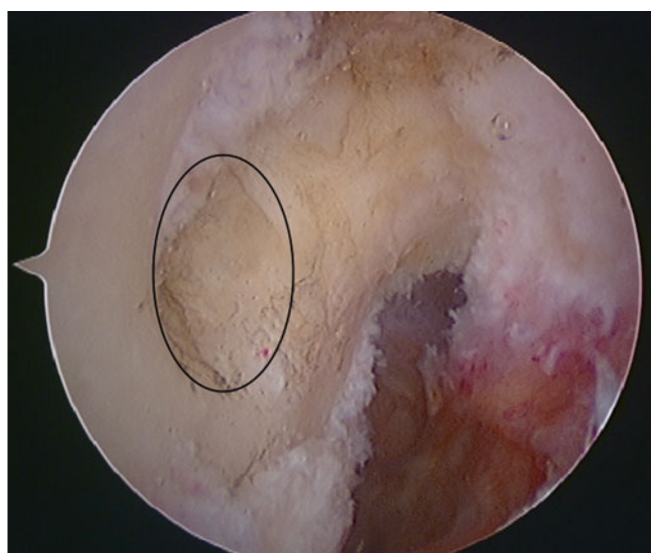


Fig. 6.8 An arthroscopic view of the lateral wall of the notch in a right knee with clear visualization of the posterior portion of the lateral femoral condyle. The prior femoral tunnel is clearly visible in a too-anterior position (*circle*)

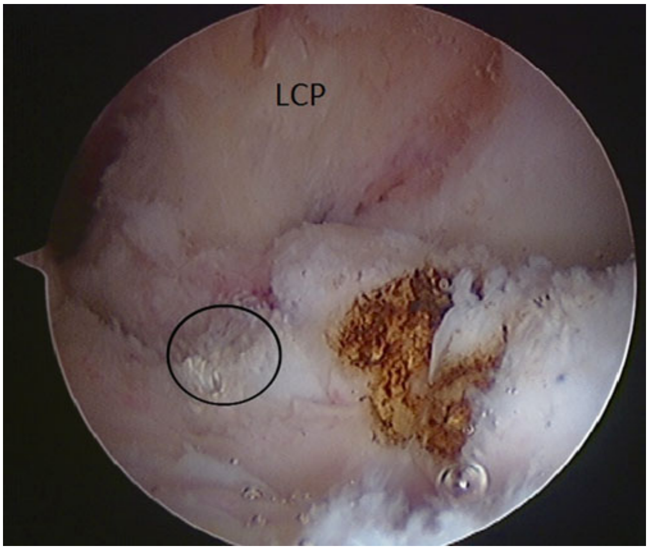


Fig. 6.9 Arthroscopic view of the tibial surface following resection of fat and scar. Note the too-posterior tibial attachment point of the prior graft (*circle*)

Tunnel Placement

There are two scenarios: the tunnels from the initial reconstruction are correctly positioned or there is an error in the position of one or both.

Previous Tunnels Are Correctly Positioned

- Removal of hardware

  When the original position of the tunnels is correct, the previous hardware is often an obstacle to tunnel preparation and placement of the new graft. If the original hardware was metal and intraosseous (such as a metal interference screw), it must be removed. It is therefore important to have the appropriate screwdriver available. This information should be gleaned from the original operative report.

  In the tibia, we find it useful to remove all hardware, including any cortical fixation (staples or screws) in addition to intraosseous hardware. On the femoral side especially, fluoroscopy can be useful in identifying and extracting hardware that has become overgrown by bone.

- Drilling of the tunnels

  If the original tunnels are well placed, they are frequently reusable. It is often sufficient to drill a second time through the same tunnel at the desired diameter, especially in the tibia.

  The tibial tunnel is created as in the prior ACL reconstruction by first placing a guide wire through the old tunnel then over-drilling with a drill, the diameter of which is equal to the desired tunnel size (usually 9 mm) (Fig. 6.10). Care must then be taken to clean the tunnel with a curette and/or shaver to remove any residual material (absorbable fixation, etc.) still in the tunnel (Fig. 6.11).

  If tunnel expansion is demonstrated in the preoperative workup, this finding may affect graft choice. The size of the bone block can be enlarged to a point to deal with this problem. Tunnel enlargement near the joint surface may potentially affect the graft position, which must be carefully monitored. However, the enlargement usually affects only cancellous bone, making achieving solid fixation the primary difficulty.

  Backup fixation is routinely used on the anterior tibia. The cortical fixation ensures appropriate graft tension and minimizes stress on the primary fixation. The cortical fixation is performed with a FiberWire loop passed through the bone block graft and tied over a bone bridge on the tibial tuberosity. Primary fixation is generally achieved with an interference screw 9 or 11 mm in diameter. If significant tunnel expansion has occurred, this fixation may not be sufficient. In this case, a useful trick is to place a second interference screw to augment the first. This second screw will both aid in fixation and help fill the area of osteolysis.

  The femoral tunnel is generally performed using an "outside-in" technique with a standard drill guide and guide pin. Often the prior femoral tunnel was made by the "all-inside" technique and cannot be easily recreated using our preferred "outside-in" technique. In this case, the tunnel is drilled in the standard outside-in manner and may intersect the previous tunnel near the notch. As fixation is achieved on the tibial cortex using a press-fit technique as with a primary reconstruction, this intersection has no effect on fixation.

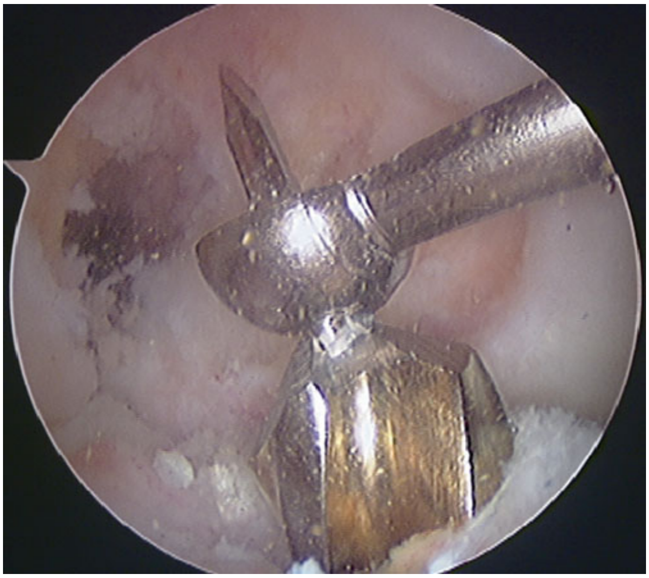


Fig. 6.10 Arthroscopic view demonstrating over-drilling of the guide pin with a 9 mm drill. Note the use of a curette to prevent guide pin advancement during drilling

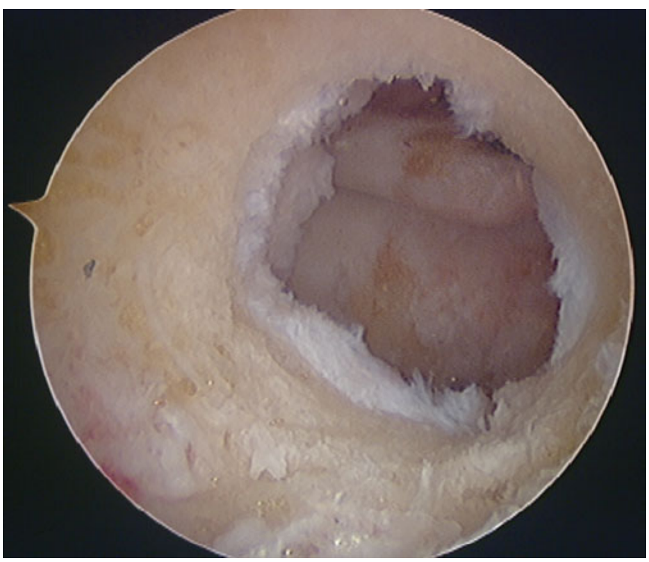


Fig. 6.11 View with the arthroscope through the tibial tunnel demonstrating its clean appearance after drilling and removal of scar tissue

Incorrect Prior Tunnel Position

- Hardware

  As above, hardware must be removed if it will interfere with creation of the new tunnels. However, it may be difficult to remove the hardware in the femur. In the case of poor positioning of the femoral tunnel, it may be possible to leave the old hardware in place. Unnecessary removal of hardware may weaken the bone or lead to enlargement of bony defects and should be avoided.
- Tunnels

  Malposition of the tibial tunnel

  It is easy to drill a new tunnel in anatomic position if the initial tibial tunnel is very poorly positioned. Prior hardware can be ignored and the new tunnel can then be drilled in the usual manner.

  In contrast, if the previous tunnel was only slightly offset from the ideal position, particularly if the previous tunnel was too posterior, independent tunnel entry into the joint cannot be achieved. The resulting tunnel is then very large, complicating both accurate graft positioning and fixation. One can compromise tibial tunnel position a bit without affecting outcome, but this solution has its limits. In case of excessive enlargement of an already malpositioned tibial tunnel, consideration should be given to a two-stage reconstruction (see below).

  In practice, it seems much easier to correct a tibial tunnel that is placed far too anterior and much harder to deal with a tunnel placed too far posterior. Too far lateral tibial tunnels can also be observed, although this malpositioning is generally small and correctable by placing the interference screw on the lateral side of the new graft.

  If the original hardware proves impossible to remove, or removal of the initial hardware will lead to a very large tunnel opening, it may be best to leave it in place. The new tunnel can then be drilled next to the old hardware in an anatomic position.

  Malposition of the femoral tunnel

  If the femoral tunnel is poorly positioned (commonly noted to be vertical in the notch), it is quite easy to drill a new tunnel in the correct position on the lateral wall using the "outside-in" technique (Fig. 6.12a, b). This type of tunnel placement generally completely avoids any intersection with the old tunnel (Fig. 6.13). Because the femoral bone block is fixed in the lateral cortex and the lateral part of the condyle, fixation will be solid even if the aperture is enlarged.

  When tunnels are only slightly malpositioned, it is easier to correct a femoral tunnel placed too far posterior and harder to correct a femoral tunnel placed too far anterior. The drilling of a second femoral tunnel in these cases may lead to increased risk for femoral fracture. A two-stage reconstruction may be indicated (see below).

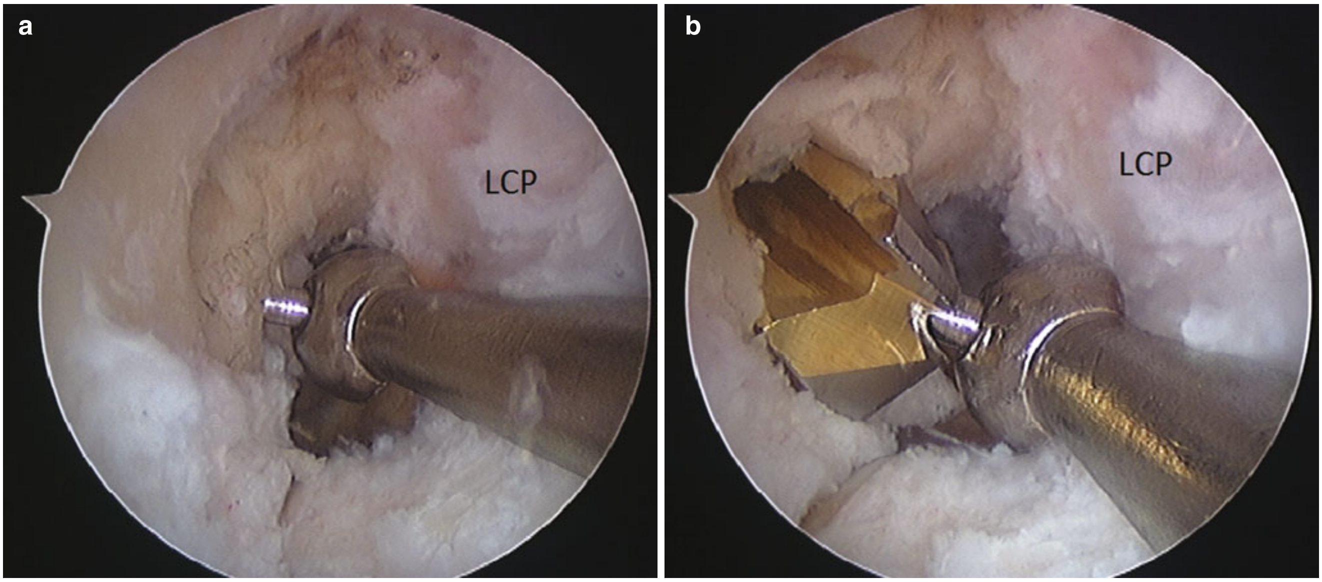


Fig. 6.12 (**a**, **b**) Arthroscopic view of a new femoral tunnel being drilled. The prior femoral tunnel can be visualized superiorly in the notch in Fig. 6.12

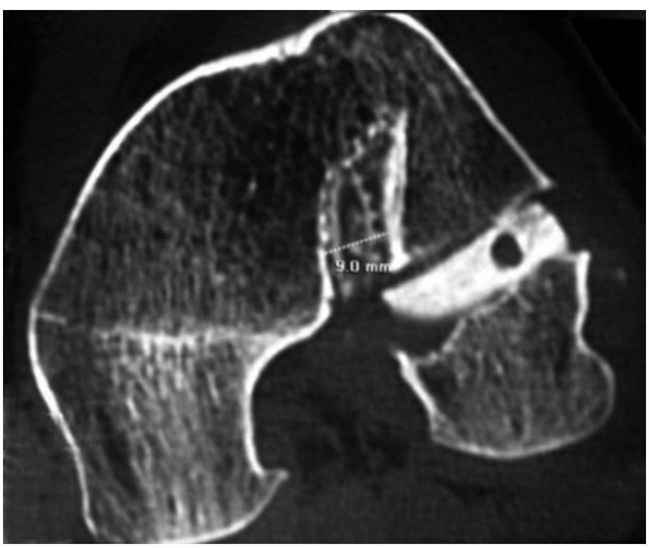


Fig. 6.13 Axial CT cut of the distal femur of a left knee. The previous vertical femoral socket is seen as in the new femoral tunnel drilled with the "outside-in" technique

Fixation

When the prior tunnels are used, the fixation of a new graft can also be performed in the usual way by interference screws and a cortical backup on the tibia.

In the case of a bone defect or poor bone quality, we recommend the use of two screws in the same tunnel associated with cortical backup. This can be achieved with a FiberWire® loop through bone tunnels on the anterior tibia or use of a wire through the bone block around a screw with a washer (Fig. 6.14).

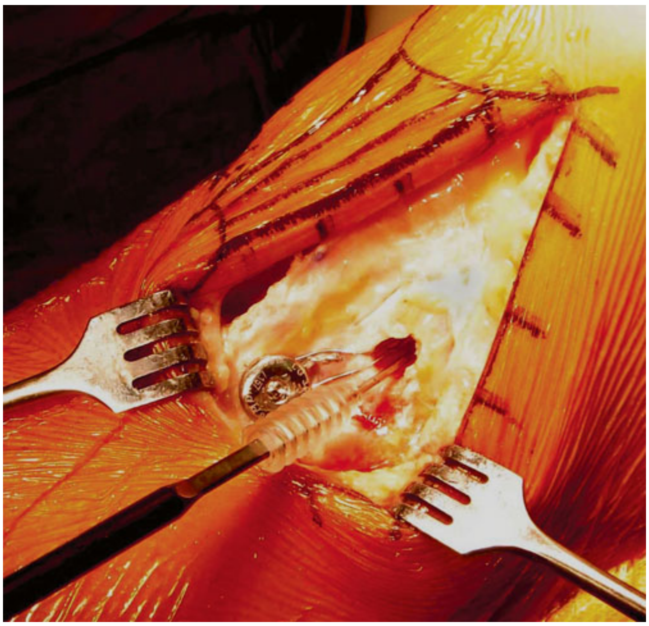


Fig. 6.14 Intraoperative view of double tibial fixation achieved with a wire through the bone block fixed with a screw and washer as well and an interference screw

Two-Stage Reconstruction

When there is significant bone loss that may compromise fixation and positioning of the new graft, a two-stage reconstruction is indicated. The first stage includes removal of the prior graft and hardware followed by bone grafting of the tunnels. The iliac crest should be prepped into the operative field. The previous graft is then completely excised using a shaver and/or basket. The tunnels are cleaned, fibrosis excised and the previous hardware removed. Fluoroscopy may be useful for locating intraosseous hardware. The cleaned tunnels can be grafted with cancellous bone from the anterior iliac crest. ACL reconstruction is then performed 3–6 months later.

This procedure is rarely performed in our practice and should be considered in extreme cases including severe tunnel enlargement or failed double-bundle reconstruction in which the two tunnels have eroded into one large defect (Fig. 6.15a–f). The exception is the case of slightly posterior tibial tunnel or slightly anterior femoral tunnel. In these cases, attempts to correct the tunnel position will likely lead to an enlarged entry site into the joint and placement of the graft in the same position as in the prior reconstruction. In these cases, we recommend a two-stage reconstruction even in the absence of tunnel enlargement.

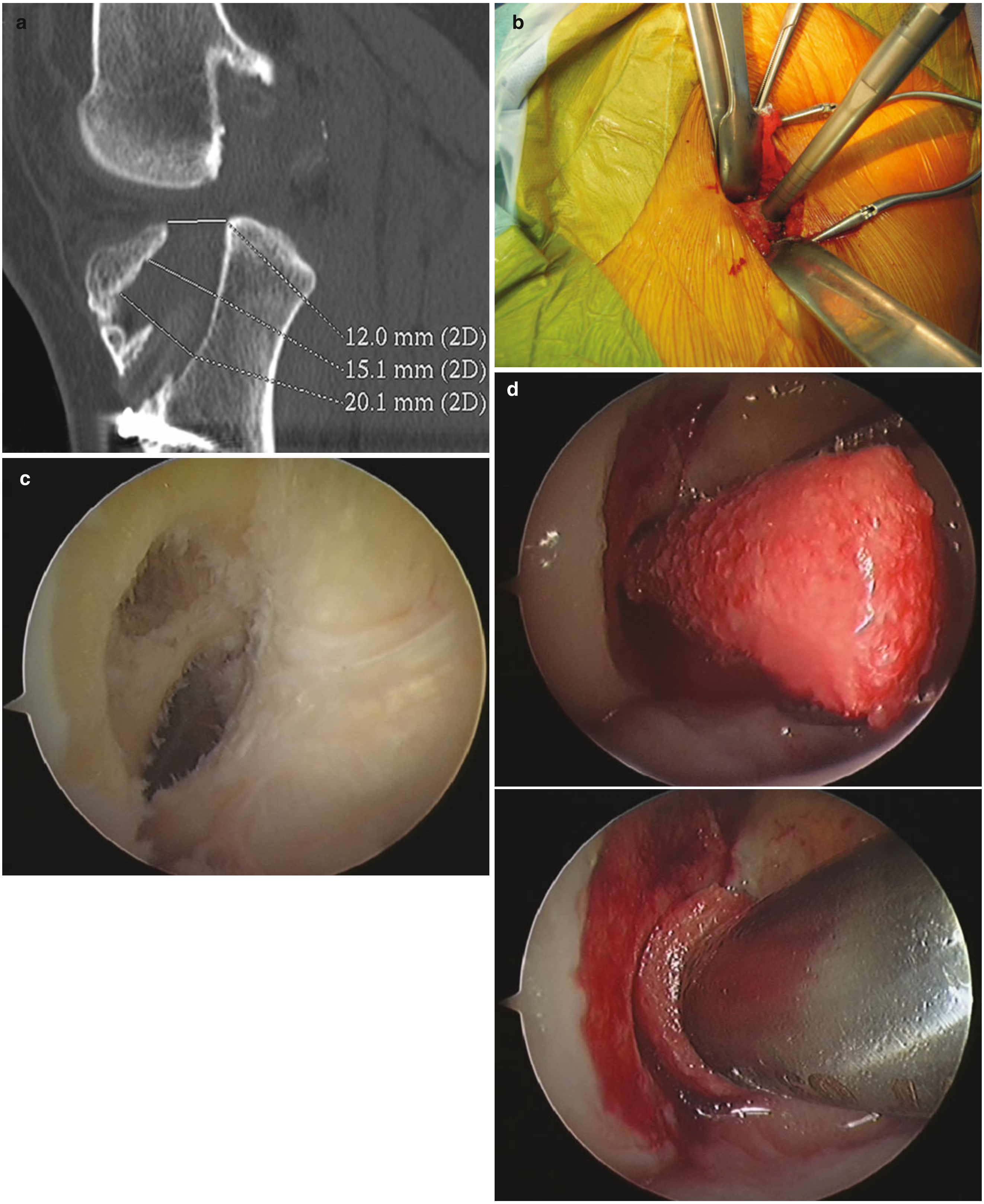


Fig. 6.15 (**a**) Sagittal CT image demonstrating tunnel enlargement and coalescence following a double-bundle reconstruction. A two-stage reconstruction is indicated. (**b**) Iliac crest bone harvest. (**c**) Debridement of the femoral tunnel. (**d1**, **d2**) Femoral tunnel grafting with cancellous bone. (**e**) Tibial tunnel grafting with cancellous bone. (**f**) Postoperative radiographs

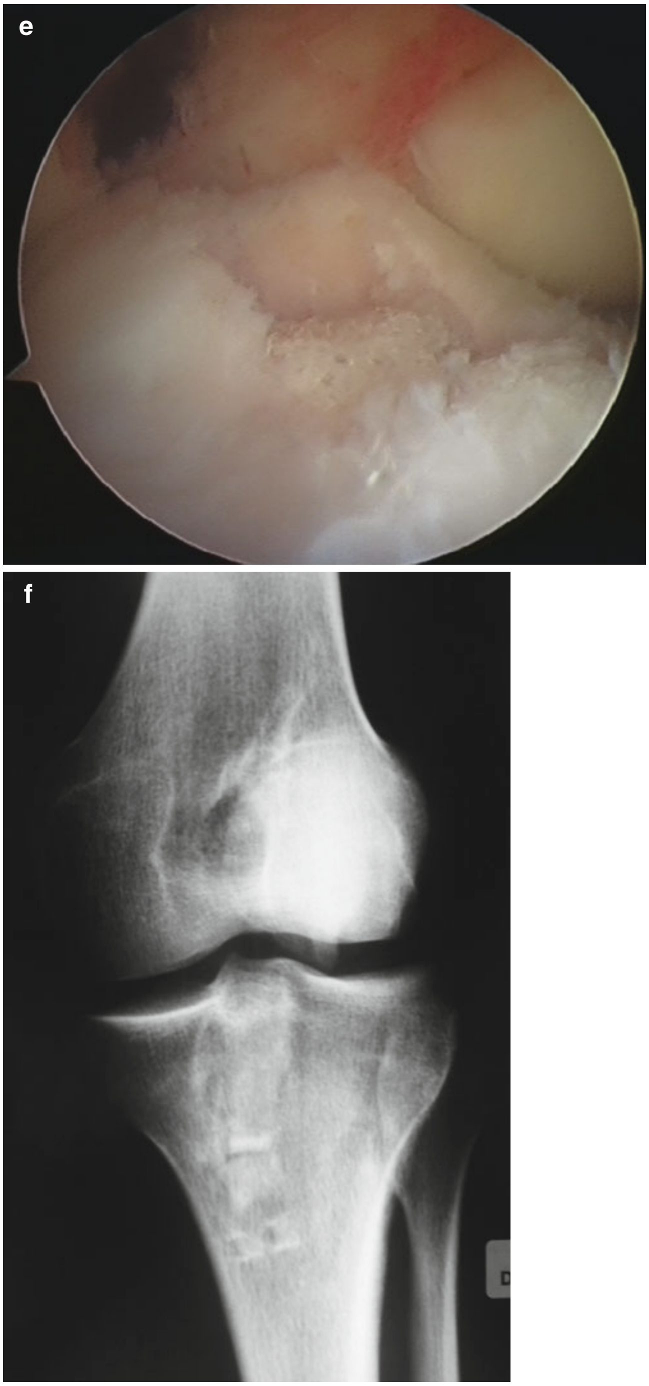


Fig. 6.15 (continued)

Combined Procedures

In specific clinical situations, revision ACL reconstruction can be combined with additional procedures to improve the odds of successful outcome or address associated pathology.

ACL Reconstruction and Valgus-Producing High Tibial Osteotomy

The addition of a valgus-producing high tibial osteotomy is indicated in the presence of early medial tibiofemoral arthritis or in cases with significant genu varum, especially associated with a lesion of the posterolateral corner ligament complex. In case of significant isolated genu varum (tibial in most cases), the osteotomy is designed to protect the graft as increased stress in the medial compartment likely contributed to the failure of the initial graft. We consider genu varum to be significant when the hip-knee-ankle angle exceeds 6° of varus. In cases of an associated injury to the posterolateral corner, the osteotomy will serve to protect both the ACL reconstruction and repair of the posterolateral corner injury (Fig. 6.16a, b).

A detailed description of the performance of the osteotomy is found in Chap. 16 and will not be repeated here.

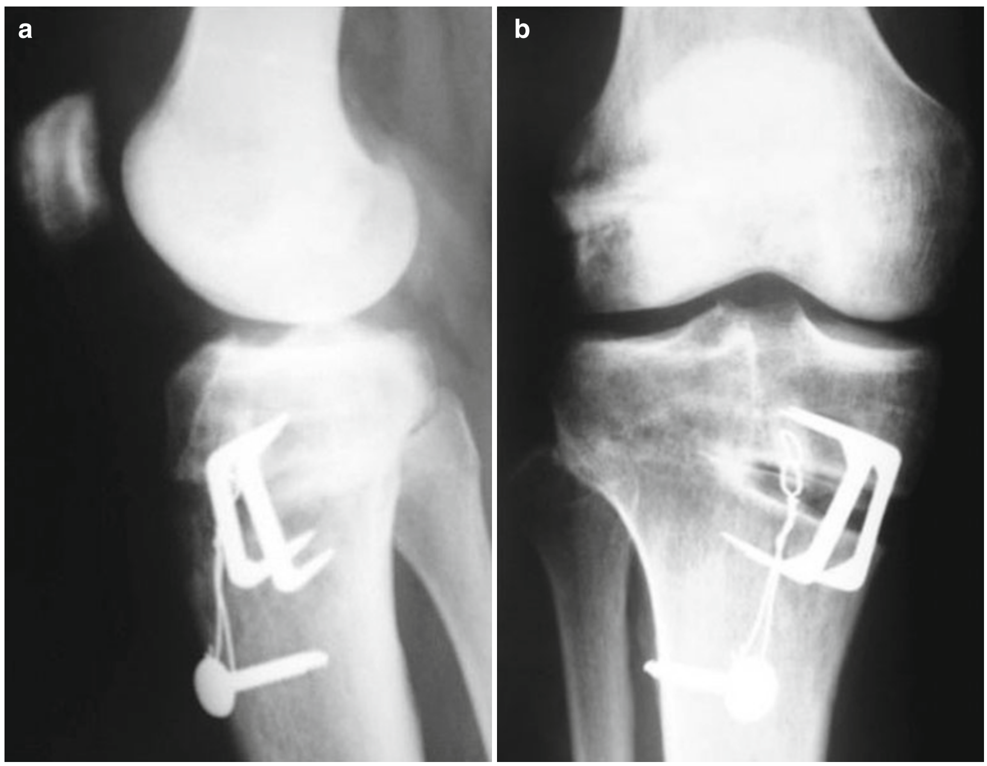


Fig. 6.16 Anteroposterior (**a**) and lateral plain (**b**) radiographs demonstrating the postoperative appearance of a right knee following revision ACL reconstruction and associated opening-wedge high tibial osteotomy

ACL Reconstruction and Anterior Tibial Closing Osteotomy

This procedure is rarely indicated; however, it must be considered in patients with a failed ACL reconstruction combined with a tibial slope greater than 14° (Fig. 6.17). The osteotomy is performed to reduce anterior tibial translation induced by excessive posterior tibial slope. This technique does not alter the position of the anterior tibial tuberosity. Preservation of the anterior tibial cortex in this region helps can limit postoperative hyperextension.

The surgical approach is identical to the valgus-producing high tibial osteotomy. The graft is harvested and the femoral and tibial tunnels are created prior to performance of the osteotomy. The anterior closing-wedge osteotomy is performed by preserving a posterior hinge centered at the junction of the PCL facet of the tibia with the posterior tibial cortex, just distal to the PCL insertion (Fig. 6.18). An anteroposterior guide pin is placed on both sides of the patellar tendon just proximal to the anterior tibial tuberosity about 4 cm below the joint line. The pins are placed with an upward trajectory and should meet the posterior tibial cortex near its junction with the PCL facet. The anterior portion of the superficial MCL medially and the proximal portion of the tibialis anterior origin laterally will need to be elevated to provide complete visualization (Fig. 6.19a). The positioning of the pins is controlled by fluoroscopy (Fig. 6.19b).

The osteotomy is performed with an oscillating saw below the pins on both sides of the patellar tendon. A second osteotomy is then created. When planning the degree of correction, the calculation must take into account the measured bone abnormality, but also the clinical abnormality. A patient with significant recurvatum will tolerate a larger correction. We generally aim to reduce the tibial slope by about 5°. As about 1 mm of anterior closure allows for a correction of about 2°, the second osteotomy should begin between 2 and 3 mm proximal to the first and converge posteriorly. The posterior hinge should be retained and the posterior cortex is fenestrated with a 3.2 mm drill bit in order to aid in closure (Fig. 6.20). The bone wedge is removed and the osteotomy is closed. A new radiograph is obtained and if correction is appropriate, the osteotomy is secured by a staple on both sides of the patellar tendon (Fig. 6.21). The tibial tunnel is then over-drilled using the same diameter drill used to create the tunnel. The graft is passed. Double fixation with wire around a screw as well as an absorbable interference screw is preferred (Figs. 6.22 and 6.23).

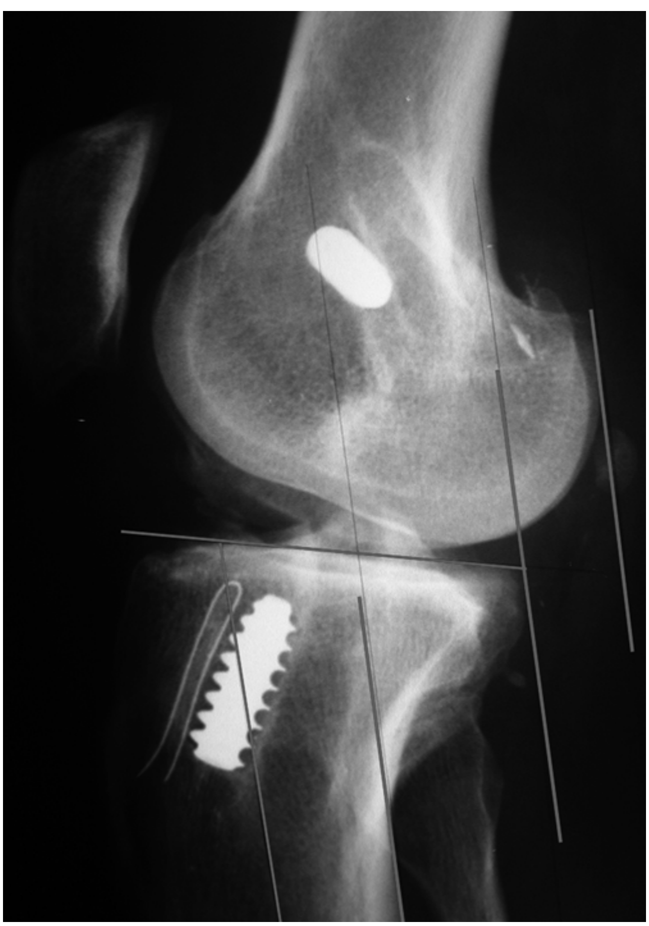


Fig. 6.17 Lateral stress radiograph of a knee demonstrating a failed ACL reconstruction (increased anterior tibial translation noted) associated with a tibial slope greater than 14°

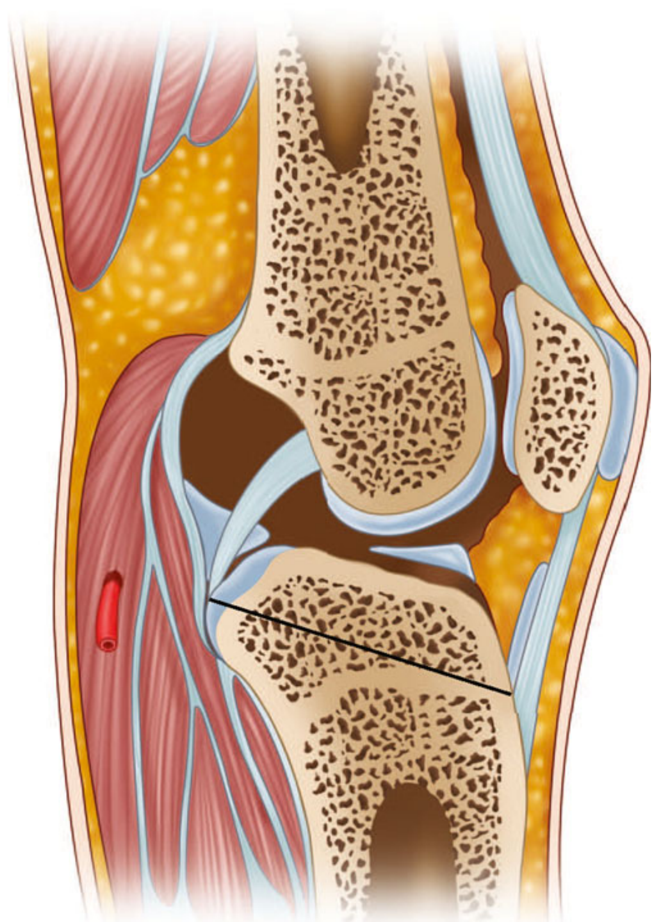


Fig. 6.18 Drawing of a sagittal section though the proximal tibia demonstrating the path of the anterior closing osteotomy. Anteriorly, the cut is just proximal to the anterior tibial tuberosity. The posterior hinge is centered at the junction of the PCL facet and posterior tibial cortex just distal to the PCL insertion

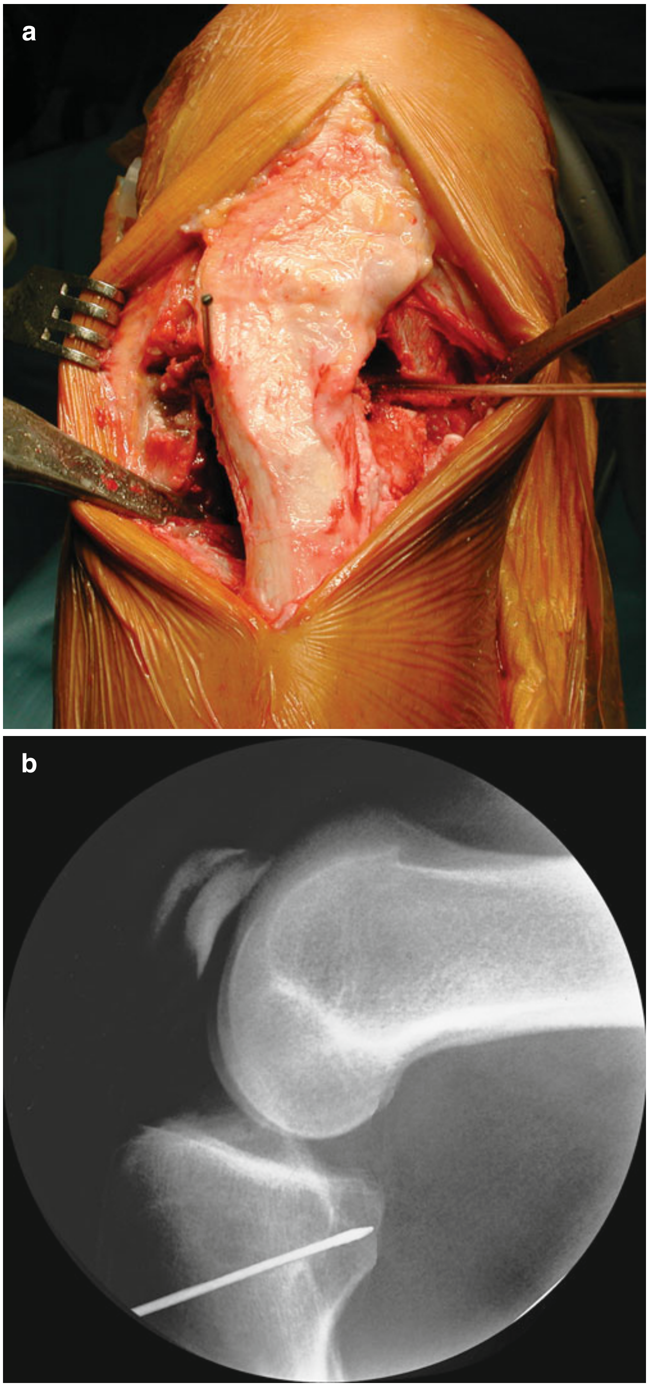


Fig. 6.19 (**a**) Intraoperative photo demonstrating the insertion of two guide pins into the anterior cortex of a right knee. The pins are placed just above the tibial tuberosity. Note the elevation of the superficial MCL medially and tibialis anterior muscle laterally to provide complete visualization. (**b**) Intraoperative fluoroscopic image of a proximal tibia demonstrating placement of the two guide pins prior performance of the anterior closing-wedge osteotomy. Note the pins track proximally toward the junction of the PCL facet and posterior tibial cortex

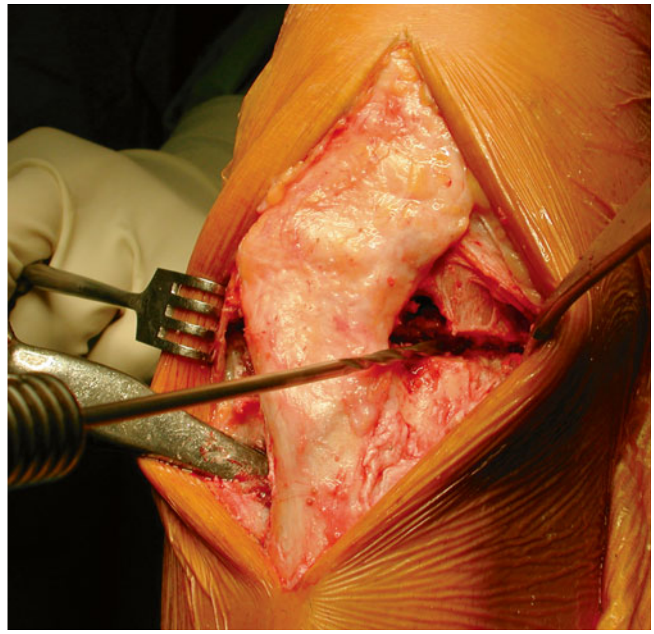


Fig. 6.20 Intraoperative photograph demonstrating fenestration of the posterior tibial cortex with a 3.2 mm drill

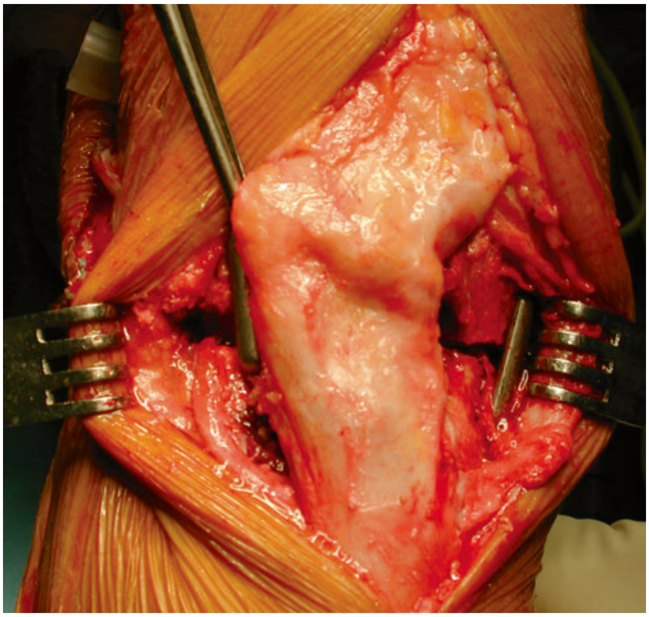


Fig. 6.21 Intraoperative photo demonstrating staples placed on either side of the patellar tendon to achieve secure fixation of the closed osteotomy

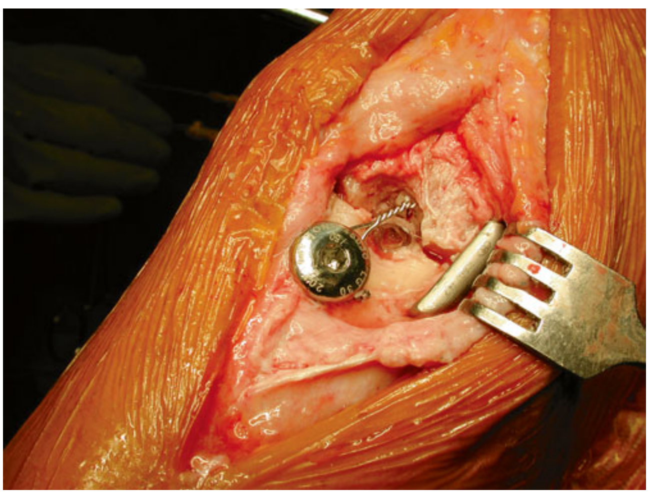


Fig. 6.22 Intraoperative photo demonstrating double tibial fixation

Fig. 6.23 Postoperative plain lateral radiograph demonstrating double tibial fixation. Note correction of the excess posterior tibial slope as well as the anterior tibial translation

Reefing of Posteromedial Soft Tissues

Reefing of the posteromedial soft tissues is usually sufficient to control any hyperextension secondary to the anterior deflection osteotomy. Rarely, posterolateral reefing is also required.

Reefing is performed by placing a retention suture in the superficial medial collateral ligament and oblique popliteal ligament and advancing the semimembranosus. This procedure is useful for control of anterior tibial translation in single-leg stance and control of recurvatum. Rehabilitation will include bracing to block full extension for 45 days.

Lateral Extra-Articular Tenodesis

A lateral extra-articular tenodesis is performed to protect the new ACL graft and allow better control of the pivot shift. We prefer to utilize the semitendinosus to achieve extra-articular tenodesis. The specifics of the technique are described in Chap. 5 and will not be detailed here (Fig. 6.24).

The lateral tenodesis is justified for several reasons in revision cases. The presence of prior tunnels potentially alters tunnel position and may compromise control of the laxity. The addition of an extra-articular tenodesis may better control the laxity and associated pivot shift. Additionally, failure of the prior graft demonstrates that this patient is prone to repeat instability and everything should be done to potentially increase stability. Neither the surgeon nor the patient wants to face another failure.

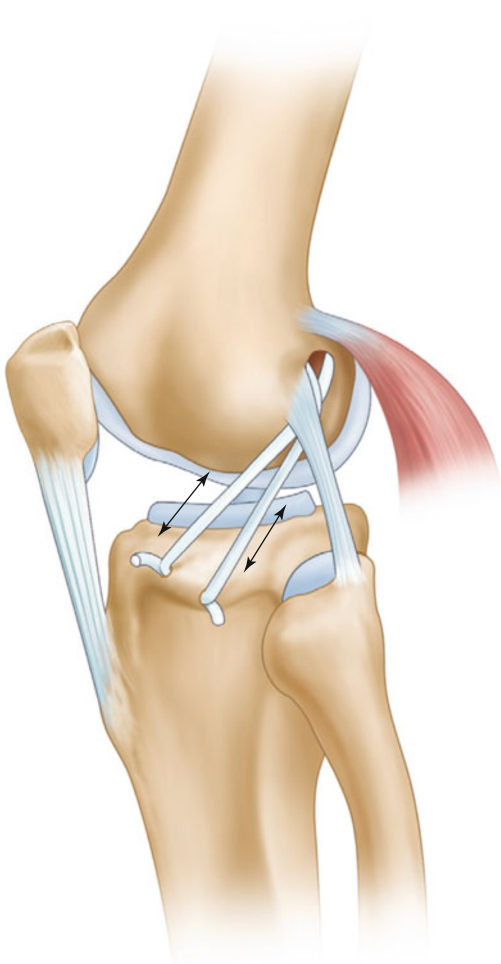


Fig. 6.24 Diagram demonstrating the completed lateral extra-articular tenodesis

Conclusion

Successful revision ACL reconstruction requires a detailed analysis of the reason for failure of the prior reconstruction. The etiology of prior failure, prior graft choice, prior surgical technique, and previous tunnel placement influence the revision surgical technique. A two-stage surgery is discussed but is rare in our practice. The technique of "outside-in" drilling combined with cortical fixation solves most technical challenges. Associated injuries and anatomical factors must be taken into account and be treated either by bony procedures (valgus-producing or anterior closing tibial osteotomies) or by soft tissue procedures (lateral extra-articular tenodesis or repair of associated ligamentous injuries).

7 Surgical Technique for the Arthroscopic Reconstruction of the Posterior Cruciate Ligament

E. Servien, G. Demey, and Robert A. Magnussen

Introduction

This chapter describes our technique for arthroscopic single-bundle reconstruction of the posterior cruciate ligament (PCL) with quadriceps tendon autograft. This technique can be adjusted to achieve a double-bundle reconstruction.

Indications

At our institution the majority of isolated PCL ruptures are treated conservatively. Our indications for surgical treatment are:

- Acute PCL ruptures associated with significant laxity (posterior drawer differential >10 mm) (Fig. 7.1)
- Persistent functional instability in chronic ruptures
- Multiligament knee injuries

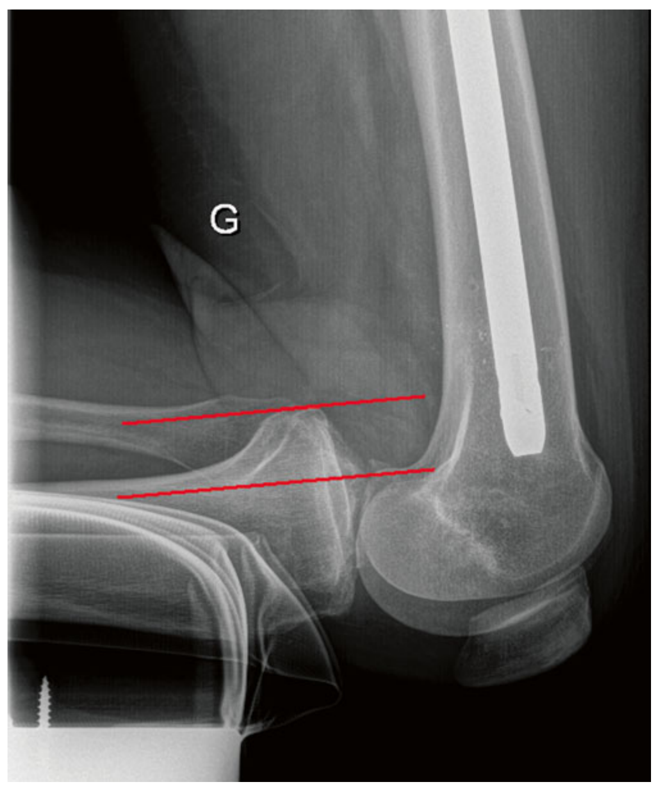


Fig. 7.1 Lateral radiograph in a 90° flexed position in posterior drawer (Bartlett view) showing a posterior drawer of 22 mm

E. Servien, MD, PhD (✉)
Department of Orthopaedic Surgery, Albert Trillat Center, Croix Rousse Hospital, 69004 Lyon, France
e-mail: elvire.servien@chu-lyon.fr

G. Demey, MD
Lyon Ortho Clinic, Clinique de la Sauvegarde, 29B avenue des Sources, 69009 Lyon, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University, Suite 3100 2050 Kenny road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_7, © Springer-Verlag London 2014

Surgical Technique

Patient Positioning and Initial Setup

The patient is positioned on the operating table in the supine position. A horizontal post is positioned distally on the table to hold the knee in a 90° flexed position. A lateral support holds the knee in this position, the thigh resting on the support with slight external rotation of the hip. Fluoroscopy is used routinely to control the correct positioning of the tibial tunnel. The image intensifier is positioned prior to the establishment of the sterile field; the arch is positioned over the table to allow lateral images to be obtained when the knee is placed in 90° of flexion (Fig. 7.2).

So that the image intensifier does not interfere during the rest of the procedure, it is moved in this position on its base up to the level of the patient's head. Prior to prepping the surgical limb, the grade of the posterior drawer test is performed (Figs. 7.3a, b and 7.4a, b).

Fig. 7.2 Preoperative positioning of the image intensifier

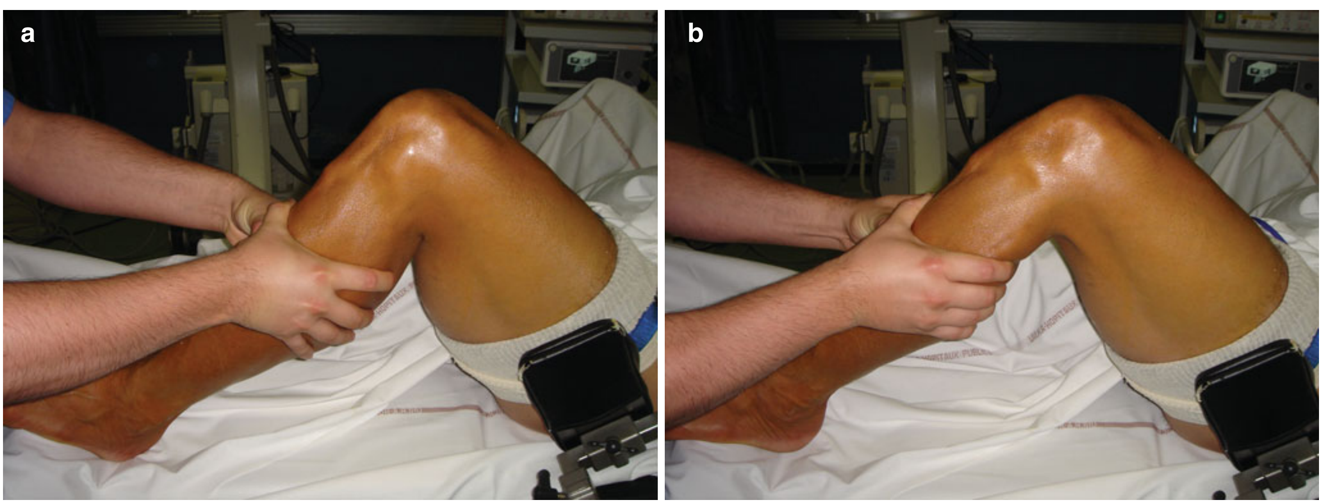


Fig. 7.3 (**a**, **b**) Examination under anesthesia

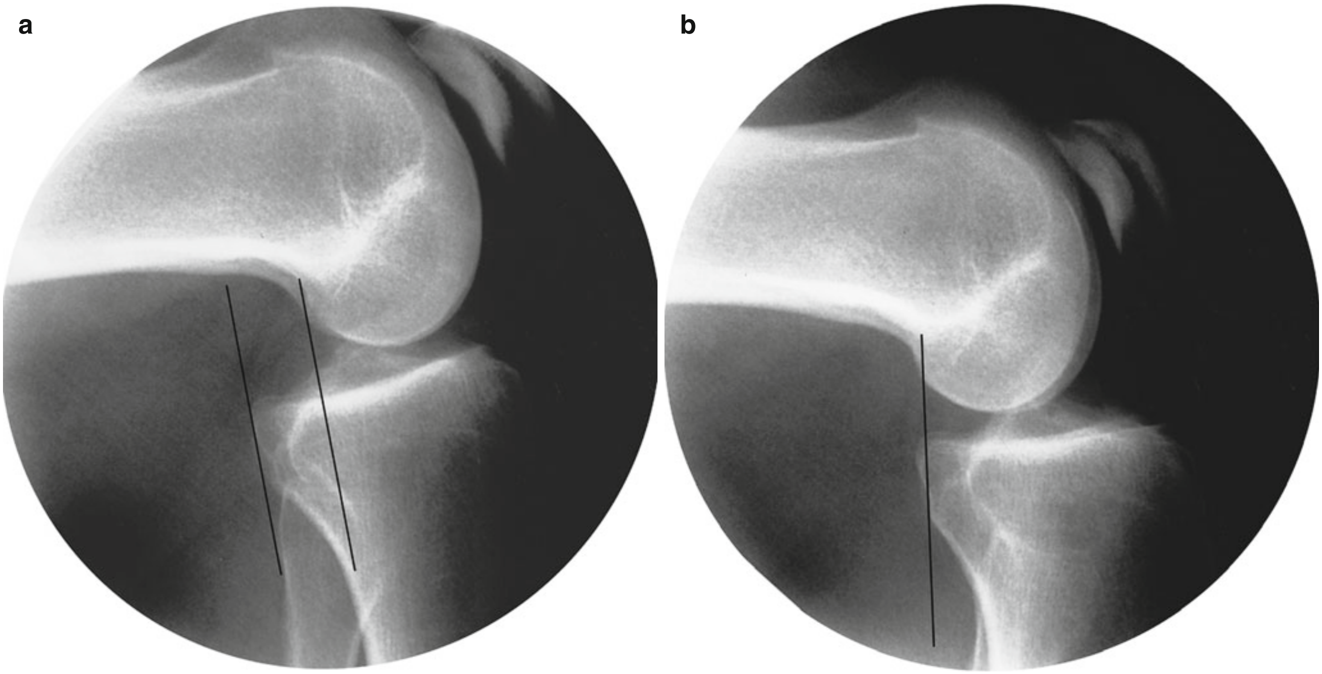


Fig. 7.4 (**a**, **b**) Posterior tibial translation under fluoroscopy

Harvesting of the Quadriceps Tendon

The quadriceps tendon graft is harvested through an antero-medial skin incision beginning at the superior pole of the patella and extending 6–8 cm proximally. Following exposure of the tendon, it is sometimes necessary to elevate some of the distal fibers of the rectus femoris muscle to achieve a sufficient graft length. The incision of the tendon is in line with its fibers. The width of the graft must be 10 mm for a length of 10 cm. In order not to breach the capsule, which causes leakage of arthroscopy fluid during the procedure, we try to only take the two most superficial layers of the quadriceps tendon. The dimensions of the patellar bone block are 10 mm wide by 20 mm long. This is outlined in the periosteum using a 23 scalpel blade. Two holes are then drilled into the bone block using a 2.7 mm drill. These holes are used to pass the metal wire that is used for traction when positioning the graft.

The anterior cortex is then cut with an oscillating saw along the periosteal incision. A 10 mm Lambotte osteotome is used to elevate the bone plug to a thickness of 8 mm. Once the graft has been harvested, it is taken to a side table to be prepared for implantation by the assistant surgeon. The edges of the quadriceps tendon are closed with a No. 2 braided absorbable suture.

Graft Preparation

After stripping any remaining muscle from the tendon graft, the end of the graft is tubularized with a whipstitch for a length of 5 cm with nonabsorbable suture, typically FiberWire®. The bone plug and graft are then trimmed with a rongeur so that it can pass easily through a 10 mm sizing tube (Fig. 7.5). Through the two drill holes in the patellar bone block, a metal wire of diameter 0.5 mm is introduced in a figure of "8". The free wire ends should be sufficiently long (20 cm) for later fixation. Allograft can also be used if necessary. Its preparation is identical (Fig. 7.6).

Fig. 7.5 Prepared quadriceps tendon autograft

Fig. 7.6 Prepared quadriceps tendon allograft

Arthroscopy

An anterolateral portal is used for the arthroscope and an anteromedial portal for the instruments. Although not routinely used in our practice, an accessory posteromedial portal can be useful to fully visualize and clean the tissue off the posterior aspect of the tibia at the outlet of the tibial tunnel. A thorough diagnostic arthroscopy is performed to assess the cruciate ligaments and assess for chondral and meniscal pathology. We believe that notch clearance and the debridement of the PCL should be minimized in order to enhance the biological integration of the graft. We also try to preserve the meniscofemoral ligaments (Fig. 7.7a, b).

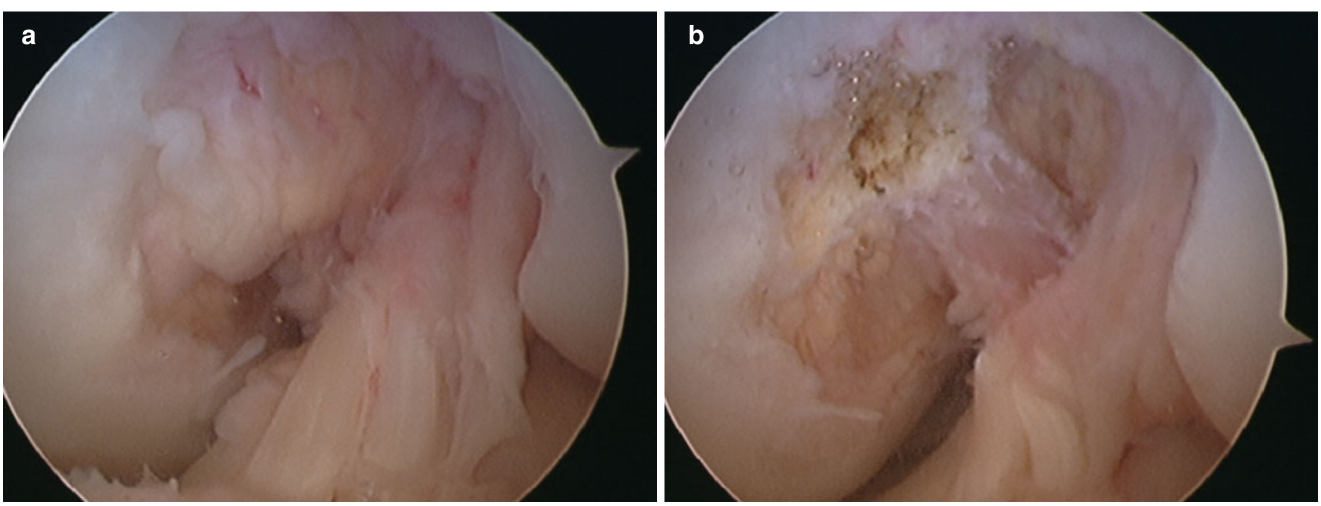


Fig. 7.7 (**a**, **b**) Arthroscopic view of the notch following shaving of the synovium. This highlights the residual fibers of the PCL that are preserved in order to optimize biological integration of the graft

Tibial Tunnel Preparation

The preparation of the tibial tunnel is performed with the knee flexed to 90°. This helps to protect the popliteal neurovascular structures. We use a specific tibial drill guide, Phusis® (Fig. 7.8a, b). The arm of the guide is inserted into the knee via the anteromedial portal and through the notch and positioned in the PCL fossa on the posterior tibia. The tip of the guide is positioned under fluoroscopy to control the ideal location for the tibial tunnel: the recommended landmark for placement of this guide is approximately 1.5 cm distal to the articular edge of the posterior plateau, which corresponds to the junction of the middle and distal one third of the posterior tibial facet (Fig. 7.9). The bullet portion of the drill guide is placed on the anterior medial aspect of the proximal tibia. A vertical incision is made approximately 3 cm medial to the tibial tuberosity and the guide is applied to the bone. The guide is then secured to the tibia with two short pins (Fig. 7.10a, b). The guide wire is drilled under fluoroscopic control to prevent injury to the popliteal vessels (Fig. 7.11). In the sagittal plane, the guide wire forms an angle of 55° (first setting of the guide) with the tibial diaphysis. The bullet is then removed, keeping the guide on the posterior aspect of the tibia in place to protect the vessels. The tibial tunnel is made using cannulated reamers over the guide wire, under fluoroscopic control. The tunnel diameter is gradually increased from 6 to 9 mm and then to the definitive 11 mm (Fig. 7.12a–c). The guide wire is then removed. The arthroscope is introduced into the tibial tunnel and the shaver is used to debride the remnants of the ligament (Fig. 7.13a, b). This stage is critical in order to allow easy passage of the graft. Although not routinely used, a posteromedial portal can be made if sufficient debridement cannot be achieved. In this case, the arthroscope is placed via the anterolateral portal and the shaver can be used via the posteromedial portal.

Fig. 7.9 The correct positioning of the tibial guide in the sagittal plane is ensured with fluoroscopy

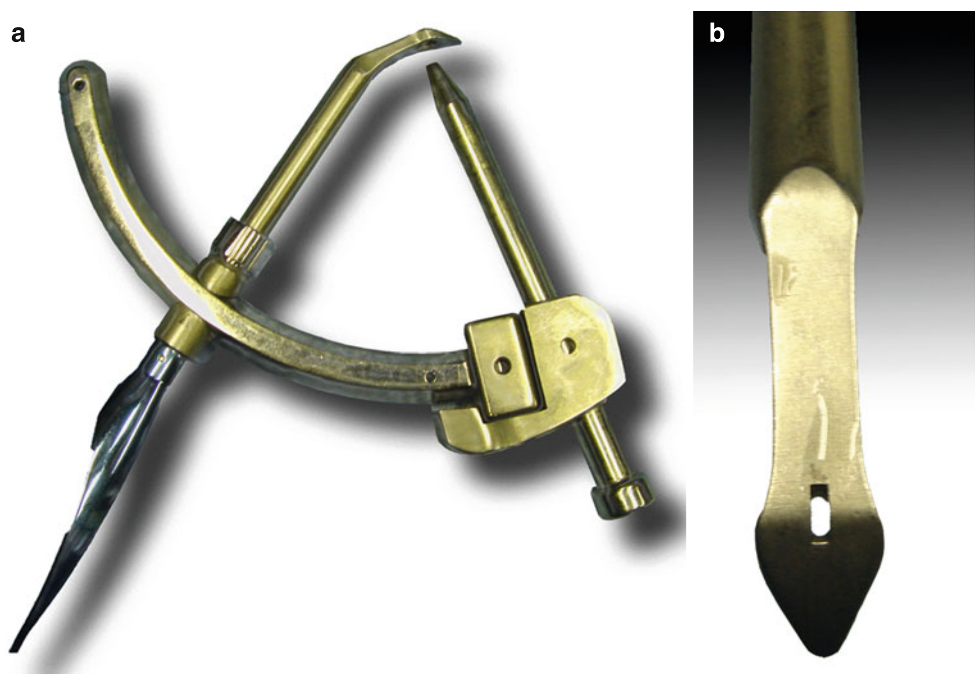


Fig. 7.8 (**a**, **b**) Specific PCL tibial drill guide set at an angle of 45°

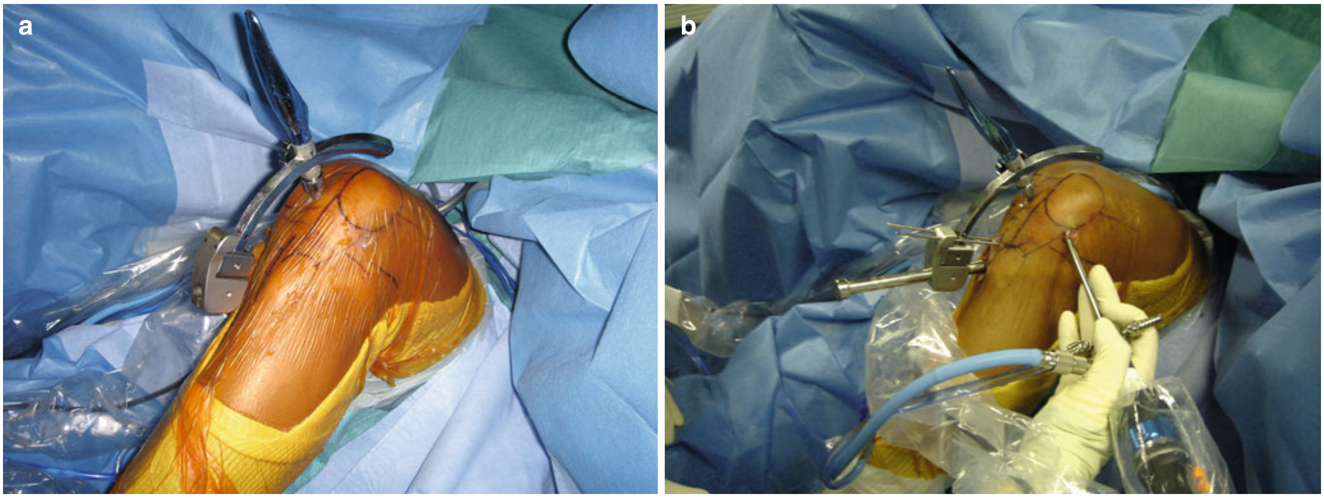


Fig. 7.10 (**a**) Placement of the tibial guide through the anteromedial portal. (**b**) Arthroscopic control for the correct positioning of the guide and pinning of the guide

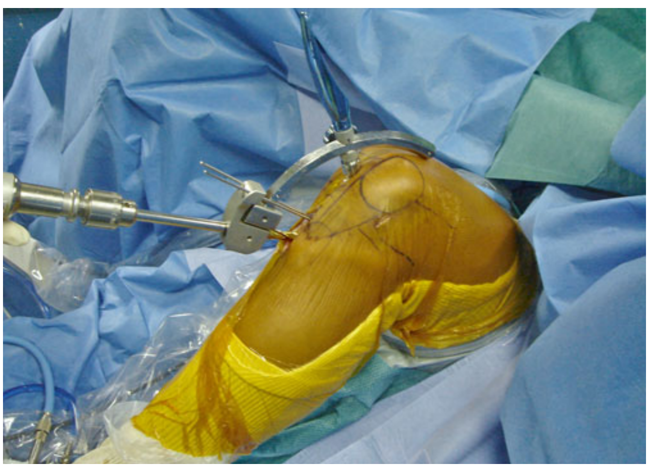


Fig. 7.11 Placement of the guide wire under fluoroscopic control

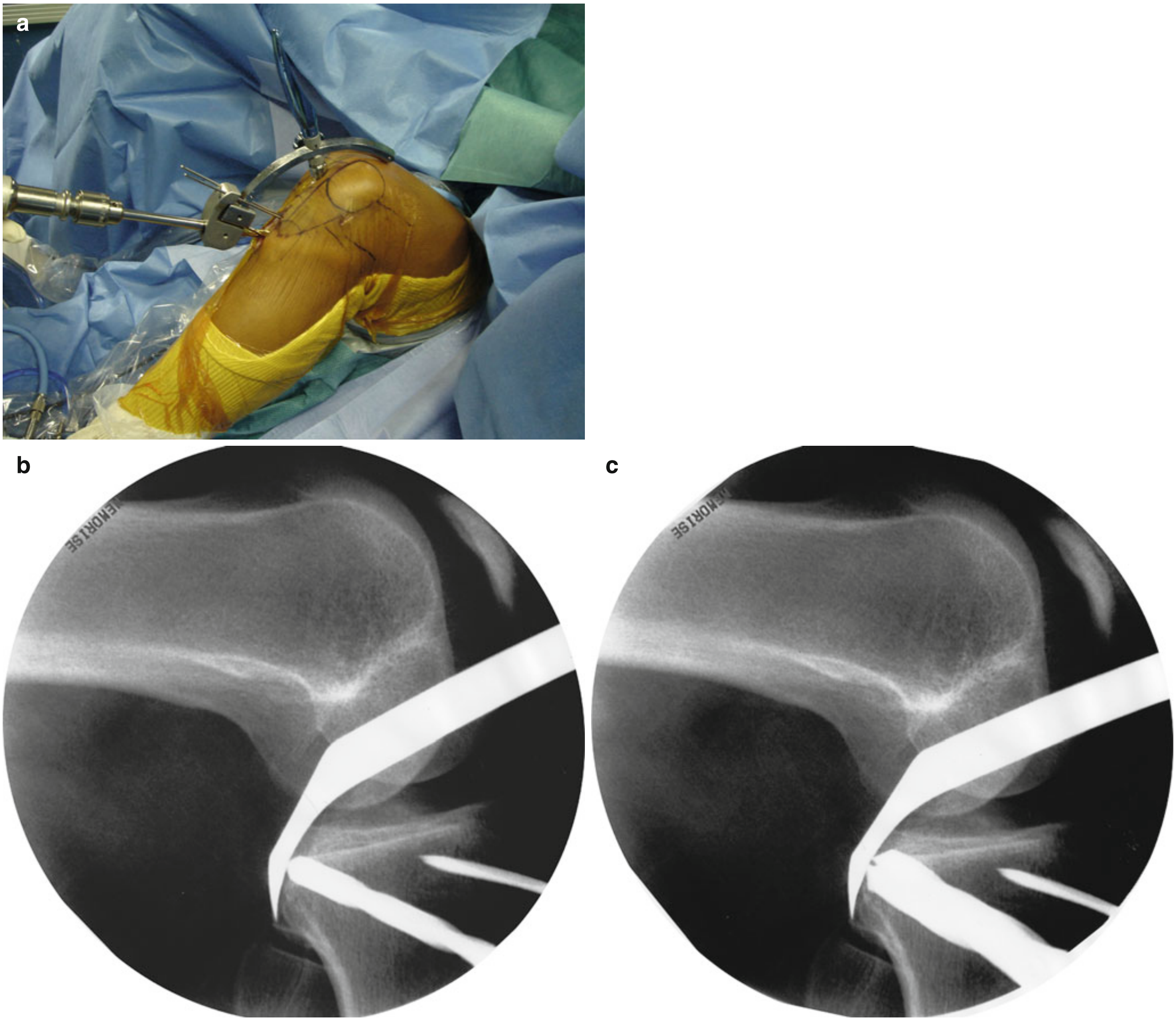


Fig. 7.12 (**a**–**c**) Reaming the tibial tunnel (6 mm diameter drill bit, then 9 and 11 mm)

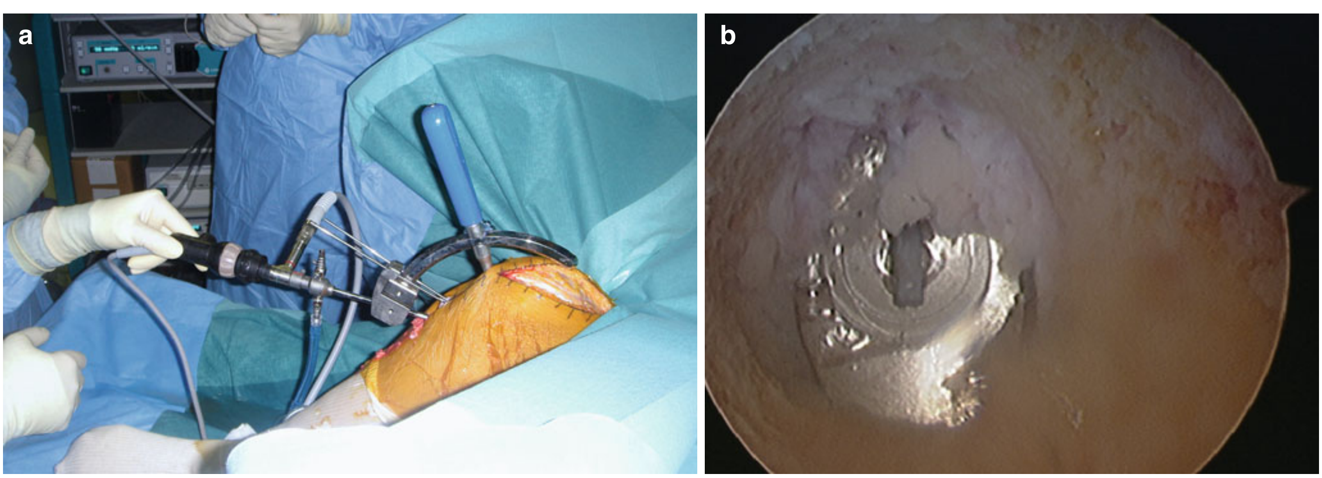


Fig. 7.13 (**a**, **b**) Debridement of the remnants of the PCL and debris at the exit of the tibial tunnel

Drilling the Femoral Tunnel

The single-bundle technique that we describe aims to reconstruct the anterolateral bundle of the PCL. We use an outside-in femoral tunnel guide. The arm of the guide is introduced through the anteromedial portal. The tip of the guide is placed such that the guide wire will exit through the center of femoral insertion of the anterolateral bundle of the PCL. This goal is achieved with the knee at 90° of flexion. In this position the intra-articular position of the tunnel opening in the axial plane is at 1 o'clock in a right knee and 11 o'clock in a left knee. The anterior border of the tunnel lies between the condylar wall and roof of the notch.

A 2 cm incision is made over the anteromedial aspect of the medial femoral condyle. The inner edge of the vastus medialis is identified and retracted upward to avoid injury to the muscle belly (Fig. 7.14a, b). The bullet of the outside-in femoral guide is advanced to bone. A guide wire is then passed through the condyle under arthroscopic control. The bullet and guide are removed and the end of the guide wire is held in a curette (Fig. 7.15a, b). The femoral tunnel is drilled using a cannulated reamer. Like the tibial tunnel, an initial tunnel of 6 mm in diameter is drilled and then enlarged using a reamer of 10 mm in diameter. The intra-articular opening of the tunnel is then debrided by successively introducing the arthroscopic shaver through the anteromedial portal and the femoral tunnel.

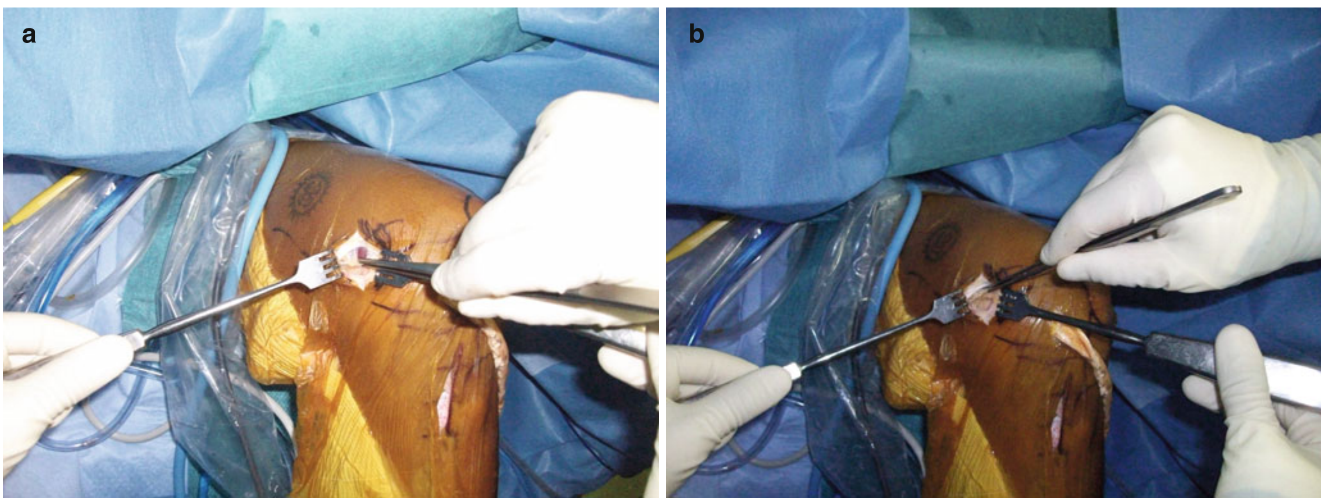


Fig. 7.14 (**a**, **b**) Incision for viewing and elevating vastus medialis to allow placement of femoral tunnel and prevent injury to the muscle

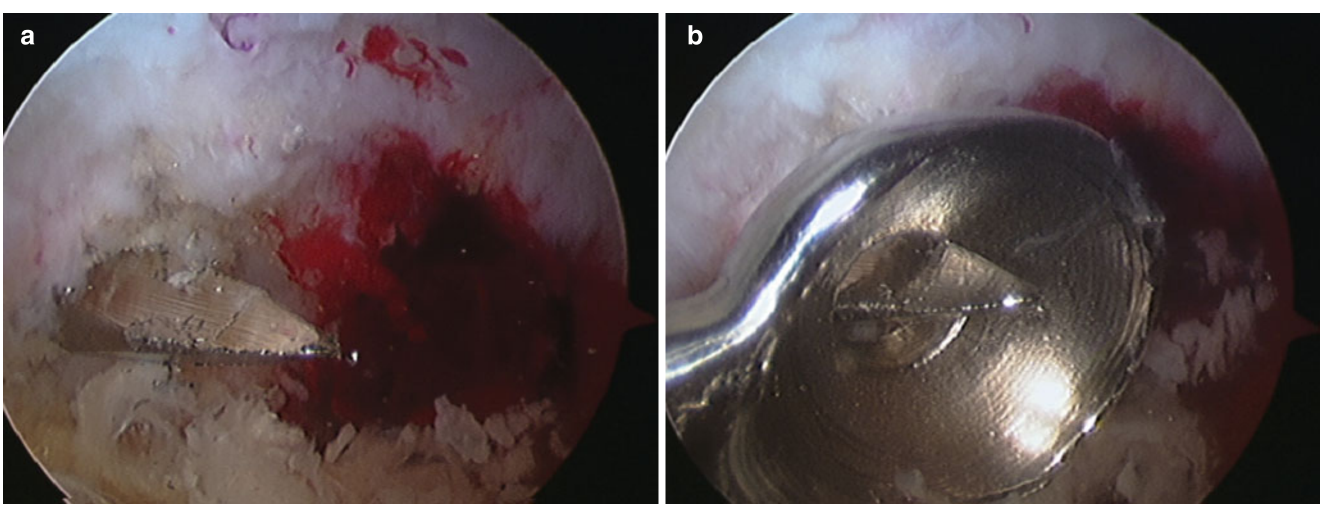


Fig. 7.15 (**a**, **b**) Insertion of the guide pin. Drilling the femoral tunnel after placement of a curette to maintain the guide pin in good position

Graft Passage

A 0.5 mm metal wire is bent at its end to form a loop (Fig. 7.16). It is then passed up through the tibial tunnel inside a 6 mm cannulated reamer. Under fluoroscopy the tip of the metal wire is then passed through a slot at the end of the tibial guide. The wire locks into the slot due to the loop at its end (Fig. 7.17). The tibial guide and the wire are then removed through the anteromedial portal. The wire should be secured at both ends with a Kocher. The graft is now passed through the tibial tunnel using the wire. It is inserted so that the bone remains in the tibial tunnel. The progression of the graft through the tibial tunnel is monitored using the image intensifier. It is considered sufficiently advanced when the end of the bone block is flush with the intra-articular end of the tibial tunnel (Fig. 7.18). The other end of the graft is now delivered into the notch, and the passing sutures (FiberWire) are easily retrieved using a Kelly clamp through the femoral tunnel (Fig. 7.19).

Next, the bone block of the graft is fixed in the tibia. A guide wire is inserted into the tibial tunnel and positioned in front of the bone block. A 9×25 mm absorbable interference screw is inserted over the guide wire and screwed into position. When the screw is flush with the joint line, the tightening is stopped. The advancement is easily assessable under the control of the image intensifier by knowing that the screwhead protrudes 5 mm beyond the tip of the screwdriver (Fig. 7.20a, b).

The tibial fixation is supplemented with a 4.5 mm cortical screw on the anterior cortex of the tibia. The two strands of wire are wound around the screw and the screw is tightened (Fig. 7.21). The graft is then tensioned, after the tibia is correctly reduced in 90° of flexion (Fig. 7.22). The femoral attachment is secured by a 9×25 mm absorbable interference screw through the femoral tunnel in an outside-in manner. The tension of the graft and the absence of residual posterior tibial translation is evaluated clinically and arthroscopically (Fig. 7.23).

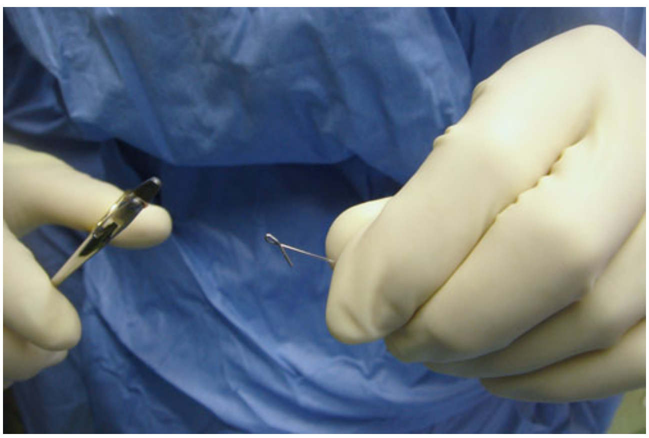


Fig. 7.16 Preparation of metal traction wirer

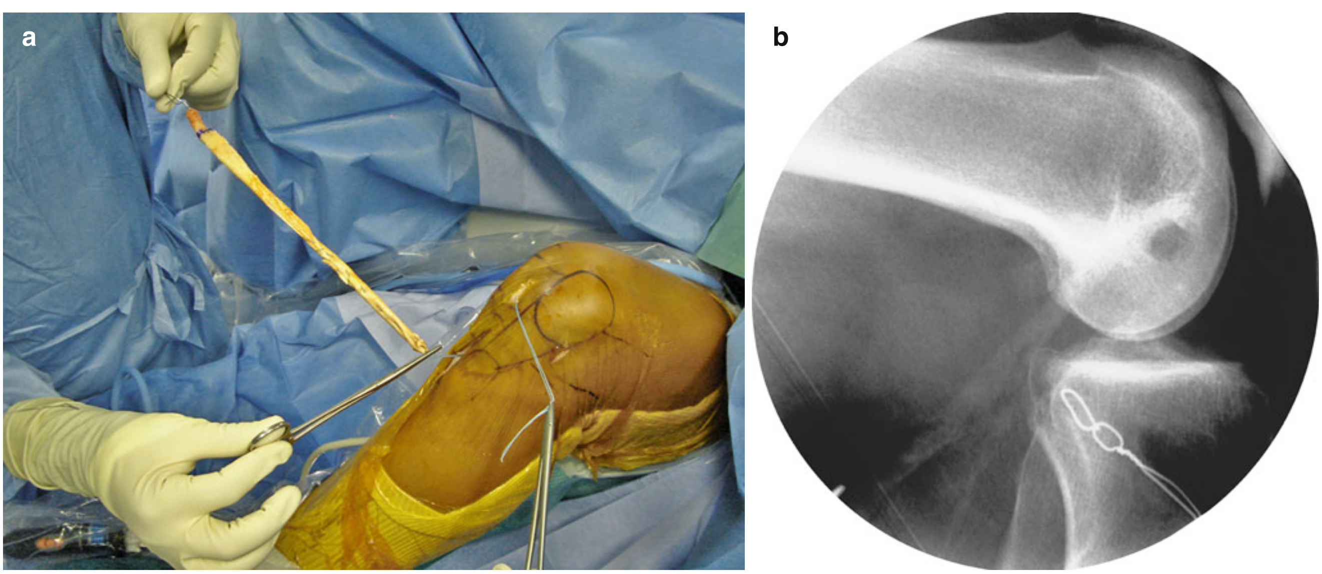


Fig. 7.17 Passage of the wire through the tip of the tibial guide. The guide is then removed through the medial portal to pull the traction wire out the medial portal

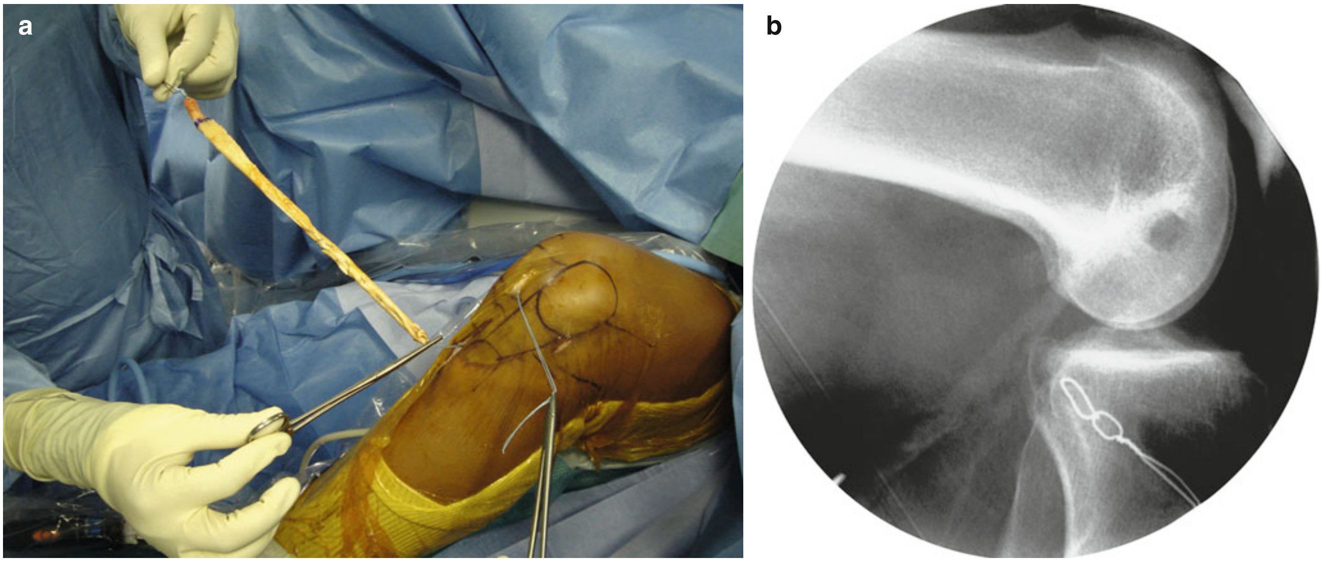


Fig. 7.18 (**a**) Passage of the graft from distal to proximal. (**b**) Positioning the tibial screw near the orifice of the tunnel

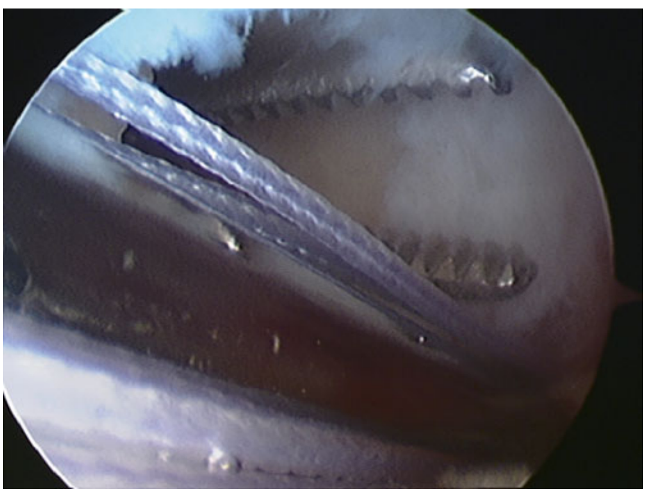


Fig. 7.19 FiberWire is retrieved through the femoral tunnel

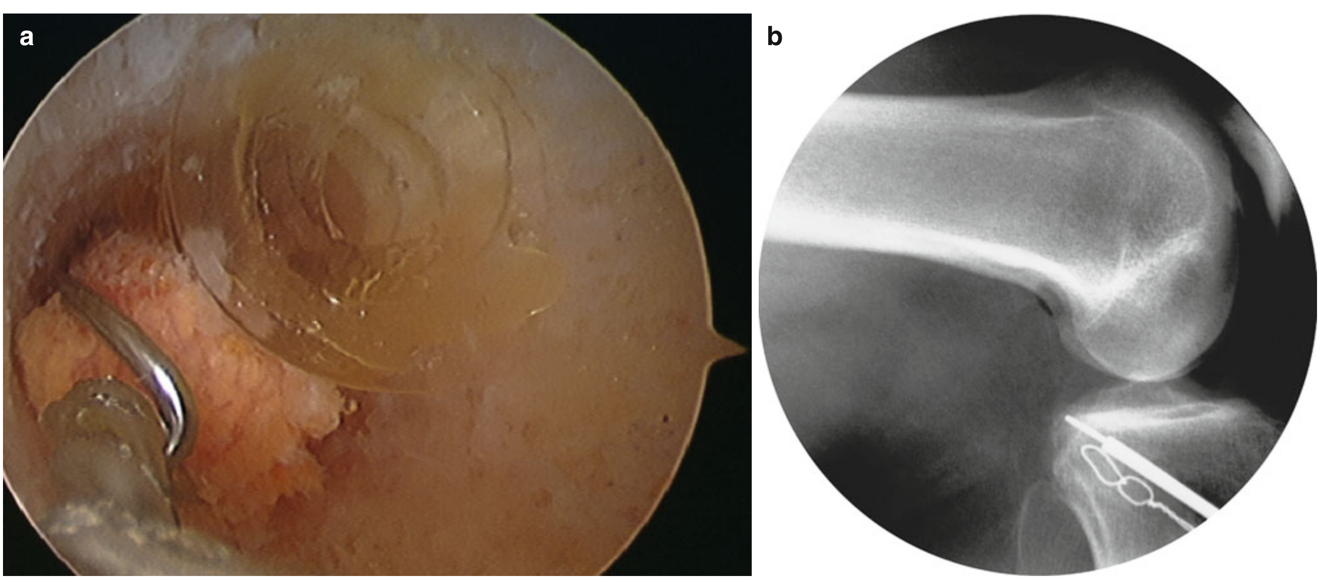


Fig. 7.20 (**a**) Attaching the wand by a tibial interference screw. (**b**) Control arthroscopic proper positioning of the interference screw

Fig. 7.21 Double fixation with wire tied around the metal tibial screw

Fig. 7.22 Manual reduction of posterior drawer and placement of the femoral interference screw

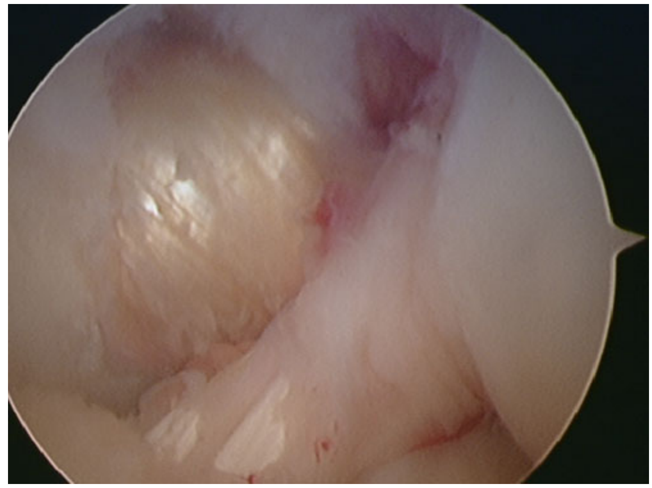


Fig. 7.23 Arthroscopic control

Postoperative Care

Following deflation of the tourniquet, hemostasis is achieved. A suction drain is placed intra-articularly and the wounds are closed. The knee is locked in extension using an extension splint. This should include a wedge or a pillow under the calf to prevent posterior tibial translation due to gravity. The surgeon verifies the presence of distal pulses and normal capillary refill of the limb prior to awakening the patient. An AP and true lateral radiograph of the knee is taken. DVT thomboprophylaxis is continued for a period of 15 days and antibiotics are given for 24 h. Staples are removed from the wounds on the 15th postoperative day. Postoperative follow-up is scheduled 45, 90, and 180 days and one year postoperatively. Rehabilitation is designed to prevent posterior tibial translation and can be done in the prone position.

8 Posterolateral Corner and Lateral Collateral Ligament Reconstruction

E. Servien and Robert A. Magnussen

Introduction

This chapter describes our technique for the reconstruction of the posterolateral corner and the lateral collateral ligament of the knee. Posterolateral corner injuries are complex injuries that remain underdiagnosed. The resultant laxity from this injury can be classified as:

- Horizontal plane laxity (posterolateral corner, PLC)
- Frontal plane laxity (lateral collateral ligament, LCL)
- Or combined in both planes (PLC and LCL)

Careful clinical examination allows the surgeon to define the extent of the laxity and make the correct diagnosis (Table 8.1).

Table 8.1 Clinical findings

	Varus laxity	Lateral hypermobility test	Posterior drawer in external rotation	Recurvatum test (Hughston)
Posterolateral corner (horizontal plane)	0	+	+	+
Lateral collateral ligament (frontal plane)	+	0	0	0
Combined	+	+	+	+

AP and lateral radiographs of the knee both supine and standing should be performed as well as full length films to assess lower extremity alignment. Stress radiographs to assess varus/valgus laxity and anterior and posterior tibial translation should also be considered (Fig. 8.1). MRI is routinely ordered to assess the cruciate ligaments, menisci, and articular cartilage as well as the LCL and PLC.

Fig. 8.1 Varus stress X-rays (Telos® stress device)

E. Servien, MD, PhD (✉)
Department of Orthopaedic surgery, Albert Trillat Center, Croix Rousse Hospital, 69004 Lyon, France
e-mail: elvire.servien@chu-lyon.fr

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University, Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_8, © Springer-Verlag London 2014

Patient Positioning and Initial Setup

The patient is positioned on the operating table in the supine position. A horizontal post is positioned distally on the table to hold the knee in a 90° flexed position. A lateral support holds the knee in this position, the thigh resting on the support with slight external rotation of the hip. A thorough examination is carried out under anesthesia in order to confirm the injury and also to allow a comparative examination at the end of the intervention.

Technique

A 6–8 in. curvilinear incision is made along the lateral aspect of the thigh starting from the posterior aspect of the lateral femoral condyle extending midway between Gerdy's tubercle and the fibular head to1cm below the level of the fibular neck. The fascia lata is incised in the middle in line with its fibers to its insertion on Gerdy's tubercle. Dependant on the level of injury, the incision along the fascia lata may be placed more anteriorly or posteriorly. The first step in the procedure is to identify the various anatomical elements of the posterolateral corner of the knee (popliteal tendon, LCL, lateral epicondyle, fibular head) (Fig. 8.2). If the popliteal tendon and/or lateral collateral ligament are still present, they should be clearly identified using a loop (Figs. 8.3 and 8.4). The choice of graft can either be autograft or an allograft. The harvest and preparation of these will not be described in this chapter. The principal of the reconstruction remains the same irrespective of the graft choice.

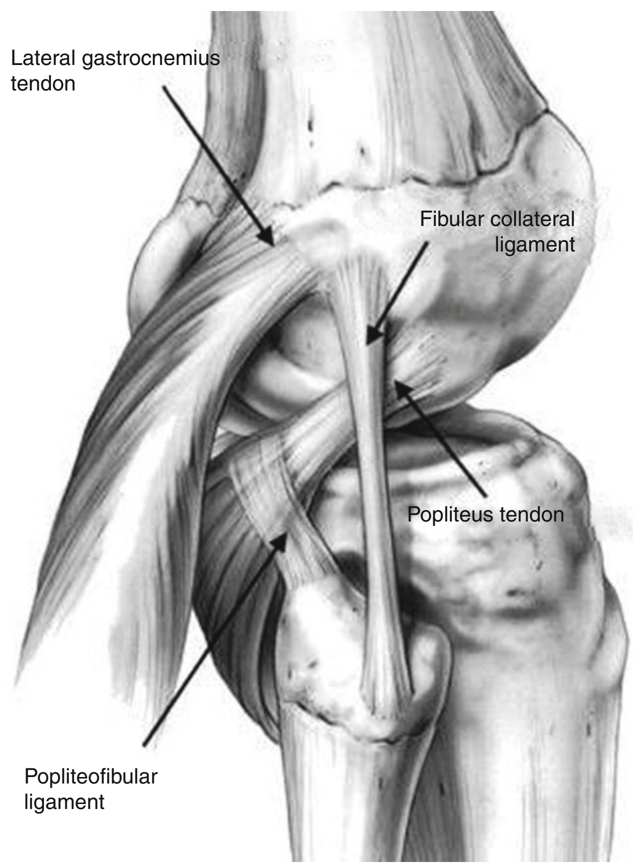
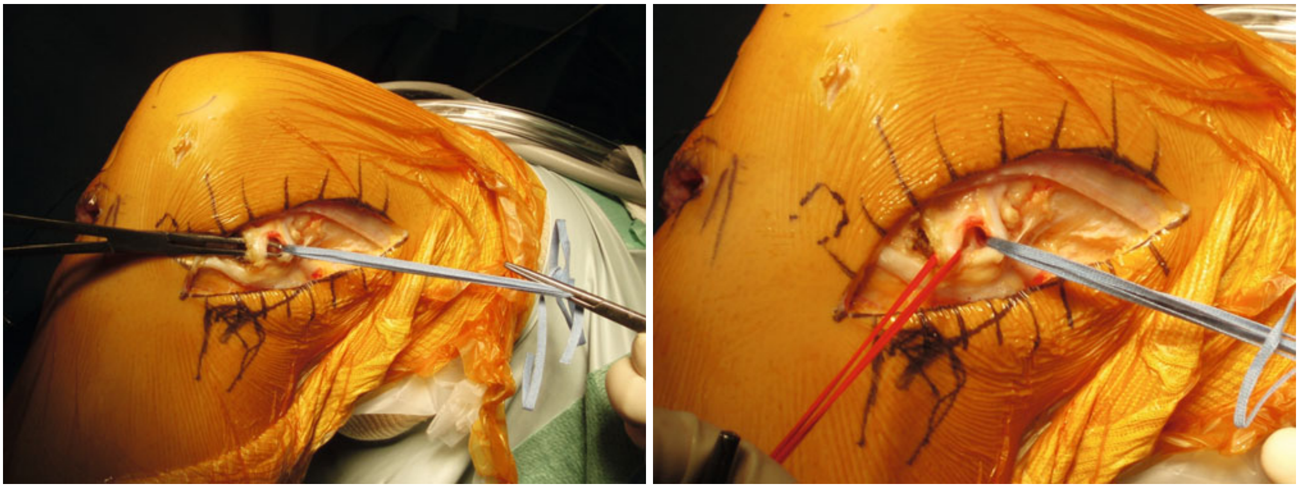


Fig. 8.2 Posterolateral corner anatomy (Reprinted with permission from LaPrade RF, Ly TV, Wentorf FA, Engebresten L. The posterolateral attachments of the knee. Am J of Sports Med. 2003;31:854–60)

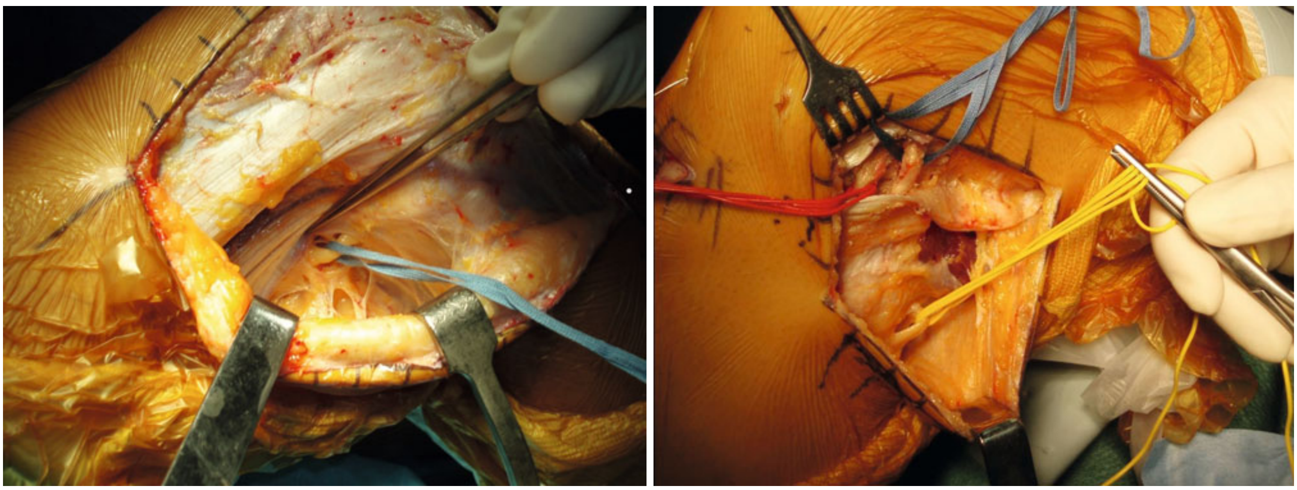


Figs. 8.3 and 8.4 Identification of the LCL and popliteal tendon

Lateral Collateral Ligament

Fibular Tunnel

It is essential that the common peroneal nerve is identified prior to making a tunnel in the fibular head. It is identified proximally just posterior and inferior to the biceps femoris. Once identified, the surgeon must be aware of its position at all times so it is tagged with a vessel loop (Figs. 8.5 and 8.6). The peroneal nerve is explored and freed distally. A tunnel in the fibular head is made using 3.2 mm drill bit and it is then enlarged to 4.5 mm. The tunnel is angled to proceed from lateral to medial as it is drilled from the front of the fibular head toward the back (Fig. 8.7). A drill guide is used throughout to help protect the nerve and provide support the fibular head while drilling.



Figs. 8.5 and 8.6 Identification of the common peroneal nerve

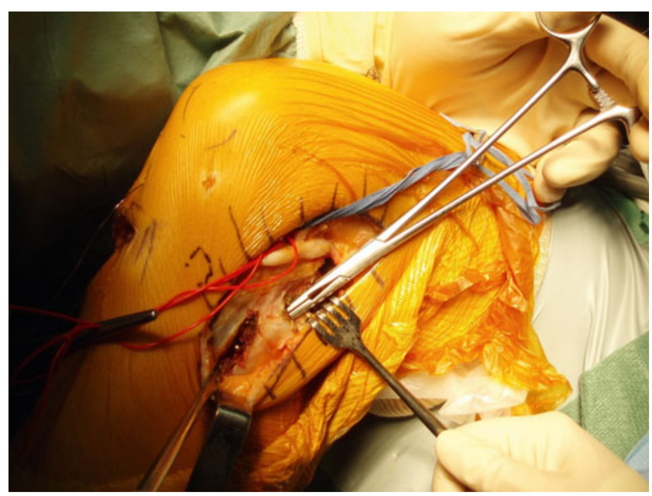


Fig. 8.7 Fibular tunnel

Femoral Tunnel

To reconstruct the LCL, a femoral tunnel is made in the center of the lateral epicondylar eminence. A guide wire with an eye is placed directly perpendicular to the lateral epicondyle (Fig. 8.8). A 7 mm cannulated drill is then used to create a tunnel 25 mm in depth. If reconstruction of both the LCL and the popliteal tendon is required, then a second 7 mm femoral tunnel will be required. In the case of isolated LCL reconstruction, a larger femoral tunnel of 8–9 mm can be made (Fig. 8.9). The graft is fixed in the femur with an absorbable interference screw of the same diameter as the tunnel.

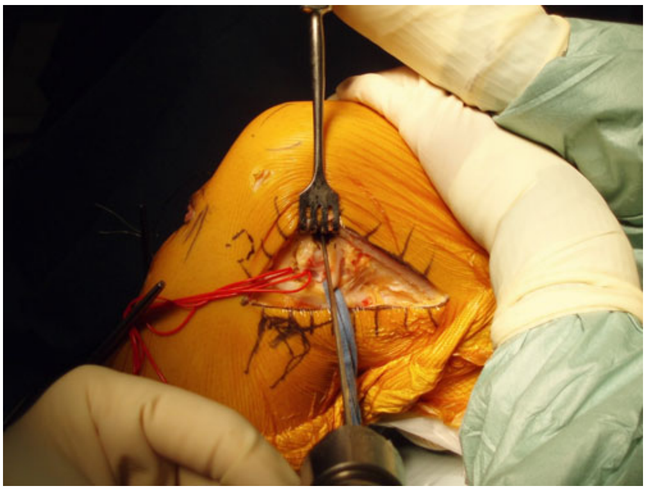


Fig. 8.8 Placement of the guide pin in the lateral epicondyle

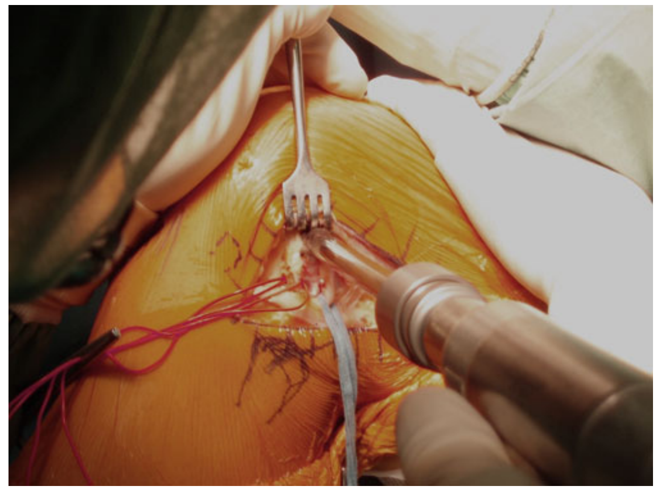


Fig. 8.9 Preparation of the tunnel with a cannulated 9 mm drill bit

The Popliteus Tendon

Graft

If an isolated popliteus tendon reconstruction is required, a single-strand graft with a bone block is used for femoral fixation. To achieve sufficient length (10 cm), an autograft (Achilles tendon) or allograft (quadriceps tendon) is preferred. If reconstruction of the PLC requires reconstruction of the popliteal fibular ligament (PFL), a bifurcated graft is used (Fig. 8.10) and one strand is designed to reconstruct the popliteal tendon and the other the PFL. The role of the PFL defined by Gilles Bousquet is to act as a pulley changing the orientation and the tension of the popliteus tendon. In these cases the reconstruction is almost always combined with an ACL and/or PCL reconstruction.

Fig. 8.10 Y-graft

Femoral Tunnel

The 7 mm femoral tunnel for the popliteus tendon reconstruction is located approximately 11 mm anterior and distal to the femoral tunnel for the LCL at the anatomic insertion site of the popliteus tendon (Fig. 8.11). The preparation of the tunnel is identical to that of the femoral tunnel for the LCL. The graft is fixed with an absorbable interference screw of 7 mm. In case of a multi-ligament reconstruction (LCL, popliteal and cruciate ligaments), it is sometimes necessary to perform a lateral reconstruction with a single tunnel for both the LCL and the popliteus tendon.

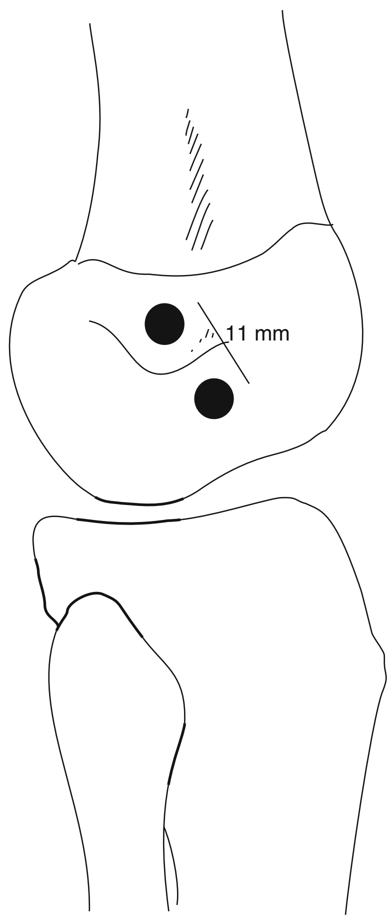


Fig. 8.11 Position of the femoral tunnel for the LCL and popliteal tendon

Distal Tunnel

PFL (Fibular Tunnel)

The short arm of the bifurcated graft is used to reconstruct the PFL. It is passed with the other strand under the fascia lata and then through the tunnel in the head of the fibula from posterior to anterior. It is fixed with the LCL with an interference screw.

Popliteus Tendon (Tibial Tunnel)

Blunt dissection is used to expose the popliteus muscle belly and posterolateral joint capsule on the posterior aspect of the tibial plateau (Fig. 8.12). The tibial tunnel is made using the tibial guide for the ACL. The tunnel is horizontal. The guide wire is passed from just below Gerdy's tubercle to the posterior tibia approximately 1 cm below the joint line. It is prudent to protect the soft tissues at back of the tibial plateau when passing the guide wire. A 6 mm tunnel is drilled over the wire.

The long strand of the graft is passed from back to front and is secured with absorbable interference screw placed from anterior. The grafts are fixed at 30° flexion for the LCL and 90° for the popliteus tendon, with the foot in neutral rotation (Figs. 8.13, 8.14 and 8.15).

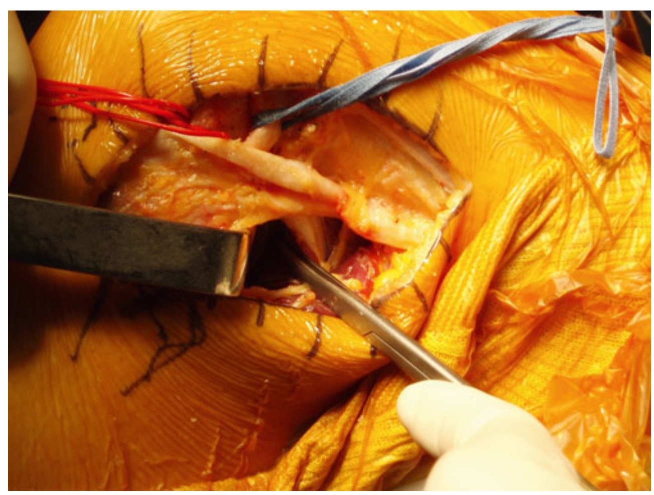


Fig. 8.12 Exposure of the posterior aspect of the tibial plateau

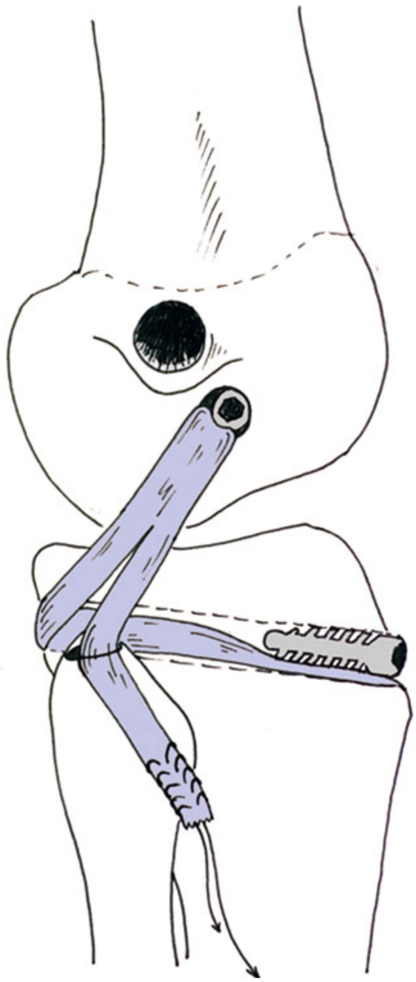


Fig. 8.13 Diagram of the graft LCL, popliteal tendon, and PFL (side view)

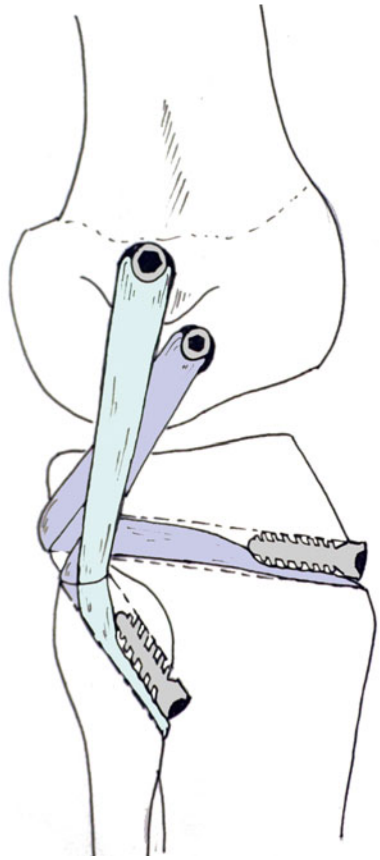


Fig. 8.14 Diagram of the graft LCL, popliteal tendon, and PFL (posterior view)

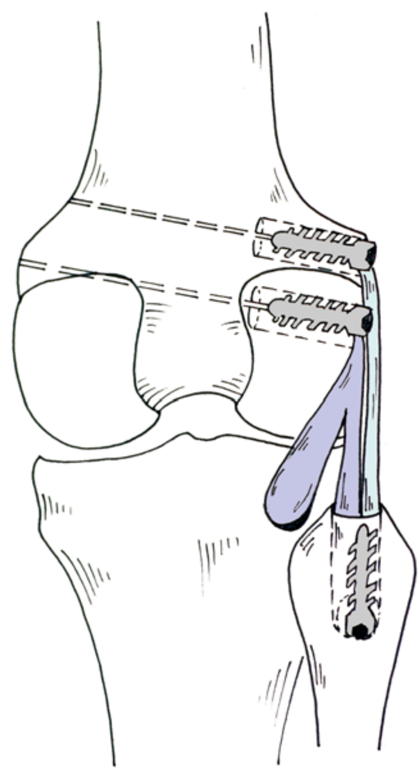


Fig. 8.15 Diagram of the popliteal tendon graft and PFL with second tunnel for the LCL (lateral view)

9 Dislocations and Bicruciate Lesions

S. Lustig and Robert A. Magnussen

Introduction

Knee dislocations usually involve anterior and posterior cruciate ligament injury (except in some rare anterior or posterior dislocations) and injury of the lateral and/or medial knee structures. Dislocations imply a high risk of neurovascular lesions and an angiogram is often indicated. This chapter does not deal with knee dislocations where one of the two cruciate ligaments is not torn.

Diagnosis

In case of knee dislocation, reduction under general anesthesia with fluoroscopic control is an emergency. Radiographs are repeated after immobilization of the lower limb in a posterior knee-ankle splint. AP and lateral radiographs are useful before surgery to evaluate frontal and sagittal laxity. Stress radiographs allow evaluation of:

- Valgus and varus laxity
- Anterior and posterior translation
- Medial and lateral translation

MRI is useful to identify and localize ligamentous, meniscal, and cartilaginous injuries.

S. Lustig, MD, PhD (✉)
Albert Trillat Center, Croix Rousse Hospital,
103 grande rue de la Croix Rousse, 69004 Lyon, France
e-mail: sebastien.lustig@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

Operative Timing

Surgery is done 5–15 days after the initial trauma when the soft tissues are less swollen. The PCL and collateral ligaments are reconstructed in the first operative procedure. The ACL is reconstructed in a delayed manner in order to prevent stiffness and to decrease operative time as multi-ligament surgeries are long and complex.

However, simultaneous ACL and PCL reconstruction is sometimes indicated, particularly when a lateral laxity is associated.

Setup

Patient positioning is the same as is utilized for isolated PCL reconstruction as is described in detail in prior chapters. Fluoroscopy is utilized for the PCL.

Cruciate Ligaments Reconstruction

The first step is PCL reconstruction, by arthrotomy or arthroscopy. We prefer arthroscopic reconstruction.

PCL reconstruction in multi-ligament injuries is the same as in cases of isolated PCL injury. One must be vigilant for the risk of extra-articular fluid leakage because of associated capsular injury. Careful control of the pump pressure is critical.

Joint irrigation is the first step of the procedure to clean out the hemarthrosis. Intercondylar notch cleaning is minimal to preserve residual PCL fibers that could heal in the presence of the PCL graft. PCL graft fixation must be done with careful attention to the position of the tibia

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_9, © Springer-Verlag London 2014

relative to the femur in the sagittal plane. The tibia should be positioned in its reduced position (approximately 1 cm anterior to the femur) or even with a slight anterior tibial translation of 1–2 mm.

Reconstruction Sequence

In case of multi-ligament injury, we recommend first fixing the PCL graft, then the posterolateral corner and finally the posteromedial corner. The ACL may be reconstructed in a second operation, after recovery from the first surgery. However, when both the PCL and ACL are reconstructed in the same surgery, the fixation sequence is PCL graft first, then ACL graft, and finally lateral knee structures.

Lateral Knee Structures Reconstruction

Lateral collateral ligament (LCL) injuries are rarely isolated. Acute repair or reconstruction of LCL is often done in association with PCL and/or ACL reconstruction.

Clinical examination is very important for the diagnosis. The LCL is palpated when the patient is positioned in the "figure of four" position and comparison with the non-injured knee is important. The presence of an LCL tear is confirmed by the presence of lateral opening with varus stress testing.

The exact location of LCL tear is sometimes difficult to localize. Standard radiographs, CT, and especially MRI can help distinguish between a mid-substance tear and a ligamentous avulsion injury with or without bony avulsion from the femur or fibular head.

- *Surgical exposure*
  A lateral incision 6–8 cm in length extends from the posterior part of the lateral femoral condyle to the fibular neck. It is similar to the exposure used to do an extra-articular tenodesis as described by Lemaire.

  The iliotibial band is divided parallel to its fibers, until its insertion on Gerdy's tubercle. The next step is to localize anatomical structures including the popliteus tendon, the LCL, and the biceps femoris tendon. The common peroneal nerve is dissected from proximal to distal and protected.

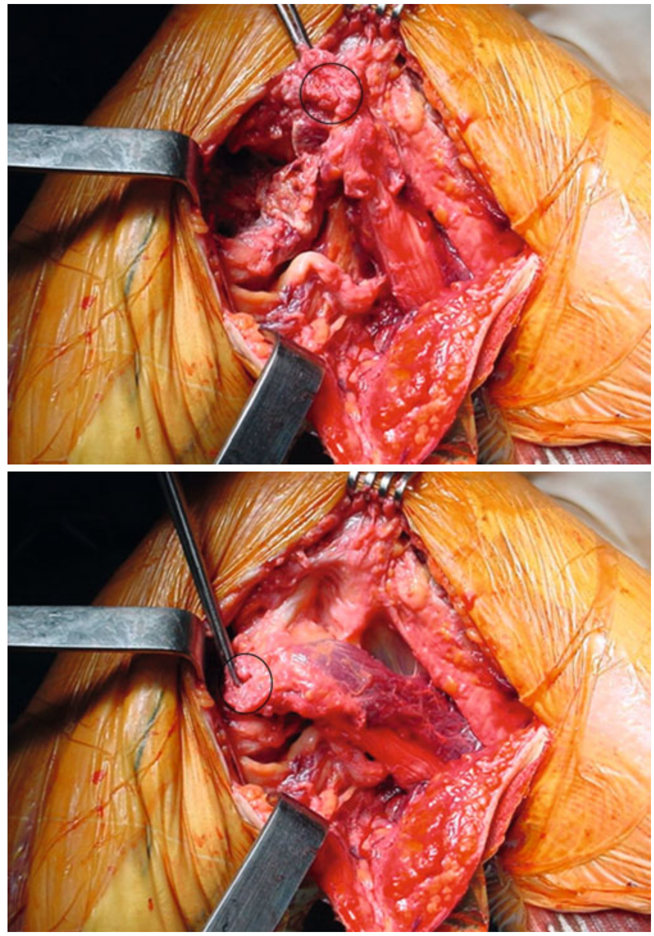
  According to the location of the LCL tear, iliotibial band incision can be moved more or less posterior: more posterior in case of LCL avulsion from the fibular head and more anterior in case of femoral avulsion.
- *Femoral avulsion*
  In case of LCL and popliteus avulsion of the femur, osseous fixation is needed. Many techniques are possible including screws, anchors, and wires. If a bony fragment has been avulsed, it can be fixed with a 3.5 mm screw and washer.

  In case of LCL avulsion without bony fragment, transfemoral fixation with a femoral socket can be done or the LCL can be reattached to the femoral epicondyle with anchors or with transfemoral sutures. To do so, the femoral footprint is roughened up to create a trough for healing, the proximal part of the ligament is sutured with FiberWire® n°2, and two parallel transosseous tunnels directed toward the medial femoral condyle are created. The two ends of the suture previously placed on the LCL are passed through the femur and tied on the medial femoral cortex.
- Fibular head avulsion
  Fibular head avulsion corresponds to avulsion of the LCL alone or with fabello-fibular ligament, fabello-popliteus ligament, and arcuate-popliteus ligament (Fig. 9.1). If the bony fragment is large, the biceps tendon may also be avulsed (Figs. 9.2 and 9.3).

  Depending on the bone fragment size and shape, it can be fixed back to the fibular head with a single screw, a wire, or both.
  - Fixation with a 3.5 mm screw is easier but sometimes not enough if the biceps tendon is inserted on the bone fragment, as it will apply high traction forces on this fragment.
  - A transosseous wire can be used as a suture or a cerclage and is more effective to resist traction forces. A 0.8–1 mm diameter wire is used. It is passed through the bone fragment in a U shape. A tunnel is drilled in the fibular head after protecting the common peroneal nerve. The wire is crossed in an 8-shape and passed through the fibular head. At 20–30° of knee flexion, the wire is tightened until the fragment is reduced and the LCL is re-tensioned. The wire is then cut and the free ends are bent. Cancellous autograft harvested from Gerdy's tubercle can be used to enhance consolidation.
- Mid-substance ligament rupture
  Different suture techniques are possible (U stitch, frame stitch). However, transverse rupture is rare. Usually, ruptures are Z-shaped. The distal half of the ligament looks like a round cord surrounded by a sheath, as compared to the proximal part which is in the capsular tissue. It is thus difficult to identify the proximal tissue and perform an end-to-end suture of the torn ligament. We prefer non-resorbable, braided suture (Ethibond®, Mersuture®, TiCron®, etc.) or a non-resorbable monofilament (FiberWire®) for such repairs.

  More often in such cases, we prefer reconstruction of the lateral structures because repaired tissue is often insufficient. A 6 × 1 cm band of biceps tendon can be harvested and fixed to the lateral femoral epicondyle in a bone socket or with an anchor. Another option is to use an ipsilateral or contralateral gracilis tendon autograft.

Fig. 9.1 Fibular head fracture (X-ray)



Figs. 9.2 and 9.3 Reduction of a fibular head fracture with biceps tendon and lateral collateral ligament avulsions (operative views)

- Posterolateral reconstructions
  This procedure includes reconstruction of the different anatomic structures of the posterolateral corner: the popliteus tendon and popliteo-fibular ligament. In case of bony avulsion, with or without a bone fragment, they should be fixed acutely, as for LCL injuries. In case of mid-substance ligament tears, the remnants of torn ligaments can be sutured, but as with LCL injuries, augmentation with a graft is mandatory.

  G. Bousquet described a reconstruction of the PLC called the "petit poplité," which prevents tibial external rotation and posterior subluxation of the lateral tibial plateau.

  The first step is reconstruction of the popliteo-fibular ligament which is done with a 0.5 × 7 cm band of the biceps femoris tendon left attached on the fibular head. This band is passed under the iliotibial band, around the popliteus tendon, from anterior to posterior and from medial to lateral (in order to pull the popliteus tendon laterally and distally), and is then fixed to the lateral capsule and to the fibular head with the foot in neutral rotation.

  The second step is to tighten the recurrent popliteus tendon with two or three resorbable sutures, which tightens the posterior condylar recess to the anterior border of the lateral retroligamentar arthrotomy (and eventually to the LCL).

  The third and last step is to tighten the fabello-popliteus ligament with a bundle of iliotibial band measuring 1 × 5 cm left attached on its two extremities. This band is fixed to the fabella or to its fibrous nucleus with single stitches of resorbable sutures.

  Reconstruction with iliotibial band have also been described. Jaeger reported a reconstruction with an iliotibial band graft measuring 15–20 cm long, harvested from Gerdy's tubercle. Two tunnels are drilled: a transtibial anteroposterior tunnel of 6 mm diameter from Gerdy's tubercle and a transcondylar anteroposterior tunnel below the femoral lateral epicondyle. The graft is passed in the transtibial tunnel, then through the lateral gastrocnemius, and then in the femoral tunnel. W. Müller has described a reconstruction with a graft of iliotibial band measuring 10–15 cm detached from Gerdy's tubercle, passed in a transtibial tunnel from anterior to posterior, and fixed on the popliteus tendon femoral insertion.

Medial Knee Structures Reconstruction

- *Type of injury*
  Medial knee structure injuries may be a mid-substance ligament tear or a bony avulsion of the ligament insertion.
  Mid-substance tears are usually classified in three grades. The surgeon plans his surgery according to the medial knee laxity found during clinical examination and measured on stress radiographs and according to associated cruciate ligament injuries. When medial knee laxity is present in full extension, other ligamentous injuries may be associated:
  – Posteromedial corner injury (posterior-oblique ligament (POL) as described by Hughston)
  – PCL injury, which may be difficult to diagnose clinically
  – Deep MCL avulsion on the femoral side, which may not heal and can lead to chronic laxity if not diagnosed.
  As described by W. Muller, deep MCL tears are often not at the same level as superficial MCL tears. MCL lesions are often considered to be a minor injury by the surgeon, but not by the patient who is quite restricted in his physical activities.
- *Arthroscopy*
  Arthroscopy may be useful to confirm the diagnosis. It helps the surgeon to determine if the MCL tear is above or below the meniscus. In case of increased space above the meniscus, the MCL is torn on the femoral side, and in case of increased space below the meniscus, the MCL is torn on the tibial side.
- *Mid-substance rupture*
  The MCL can heal with a knee brace allowing flexion and extension but restricting valgus loading of the knee. Surgical reconstruction is rarely needed except in occasional cases of complete rupture. If needed, an end-to-end MCL repair is done. When associated with an ACL reconstruction, an anteromedial surgical approach is used. The skin incision is longitudinal, 2–3 cm medial to the anterior tibial tubercle (ATT). MCL end-to-end sutures favor healing. For superficial MCL tears, we prefer to whip-stitch the entire ligament to tighten it before suturing and fixing it. Anchors can also be used. An augmentation with the gracilis tendon as described by Helfet can also be done.
- *Repair of bony avulsions*
  In case of femoral avulsion, an oblique skin incision over the medial epicondyle allows good visualization of the lesion.
  In case of a large bony avulsion (such as the whole medial epicondyle for example), fixation can be achieved with a 3.5 mm screw and washer, transcondylar FiberWire sutures, or with a staple.
  In case of tibial avulsion, the skin incision is vertical and medial. The sartorius is incised in a reverse L shape and the hamstring tendons are elevated to expose the avulsed superficial MCL. Anchors can be used to reinsert it on the tibia.
- *MCL reconstruction*
  If a direct suture is not sufficient or not possible, a reconstruction can be done. The patient is supine with a mid-thigh tourniquet in 90° of knee flexion. A medial incision extends from the level of the patella to 3 cm below the ATT. Dissection is done to expose the medial epicondyle.
  – *Reconstruction with hamstring tendons*. The sartorius fascia is retracted and the gracilis tendon is exposed, dissected but left attached to the tibia. An open stripper is used to detach it proximally. A vertical tunnel is created underneath the femoral medial epicondyle by drilling two 4.5 mm holes, 10–15 mm apart. O'Shaw claws of increasing diameter are used to join these two holes and create the tunnel. The gracilis tendon previously prepared and whip-stitched with a resorbable suture is passed through the femoral tunnel and sutured back on its tibial insertion with non-resorbable suture.
  – In case of chronic laxity, it is difficult to determine clinically if medial laxity is due to an isolated MCL tear, isolated injury to the posteromedial corner, or both. MRI can help localize the tear, but can be inconclusive in such chronic cases. Usually it is advisable to repair both. The superficial MCL can be whip-stitched over its entire length and sutured in a tightened position. For the posteromedial corner, one or two anchors are inserted on the posterior side of the medial epicondyle via a medial retroligamentar arthrotomy. The surgeon looks for the "lunule sign" described by H. Dejour above the meniscus. It corresponds to an avulsion of the posteromedial capsular recess. It is then anchored on the posterior and proximal side of the condyle, taking care not to overtighten it, which could restrict extension. The POL itself is stitched and anchored back on the posterior side of the medial epicondyle.

Finally, in case of major and chronic laxity, an MCL and POL reconstruction with quadriceps tendon autograft as described by Engebretsen can be done.

- *Postoperative care*
  During the first 45 postoperative days, the patient wears a posterior knee splint in extension and remains non-weight bearing. Knee mobilization in flexion-extension is begun at day 1, limited to 60° until day 21 and then to 95° until day 45. Any valgus/varus stress is avoided for 45 days. Weight bearing is then progressive and flexion is no longer restricted. Sports are forbidden for 4 months. Until 8 months postop, ligaments may be thick and sometimes painful.

ACL Reconstruction

ACL reconstruction technique is the same as the one used for isolated ACL reconstruction. If slight posterior laxity persists after PCL reconstruction, care must be taken not to induce a posterior tibial translation during ACL graft tensioning and fixation.

Synovectomies of the Knee

10

P. Archbold and A. Pinaroli

Indications

In this chapter, the technical principles and in particular the surgical approaches required to perform a synovectomy will be discussed (septic arthritis and tumor pathology and synovectomy after TKA are excluded). A synovectomy may be indicated in:

- Pigmented villonodular synovitis
- Inflammatory diseases
- Rare pathologies: chondromatosis, osteochondromatosis, hemangiosclerosis, desmoid tumors
- More specific synovitis

It must be stressed that a synovectomy is particularly indicated in the young patient with no cartilage loss. For this reason, it is rare for a patient with advanced arthritis secondary to an inflammatory arthropathy to require a synovectomy. A "total" synovectomy in the strictest sense is an overstatement since the configuration of the knee joint is very complex and renders a "total" synovectomy virtually impossible. It would be more appropriate to speak in terms of a "reduction" synovectomy.

The lesions that have not been eradicated during the total synovectomy are better treated with adjuvant chemotherapy or radioactive isotopes. The surgeon must therefore balance the advantages of a total synovectomy with respect to the surgical "goal." In order to make decisions, some objective parameters have to be taken into account. To do so, the surgeon has to know each of the different surgical approaches to the knee. He can then select one or more approaches dependant on the particular situation. This heterogeneity of treatment options makes analysis of the results even more difficult; however, they also make this type of surgery more interesting.

Preoperative Planning

A diagnostic MRI (with gadolinium injection) is useful in locating the lesions. These images help the surgeon's decision-making process in planning how to address each of the individual lesions. Perhaps most importantly, they help evaluate whether there is extra-articular extension of the disease in the soft tissues posteriorly. The size and the location of the lesions will define the surgical technique chosen (arthroscopy or open surgery) and the surgical approaches needed.

Plain radiographies of the knee (anteroposterior (AP) view, single-leg weight-bearing view (AP and lateral), schuss (flexed PA) view, and a skyline view of the patella at 45° of flexion) are mandatory. They help to assess any joint space narrowing and identify any bone lesions.

Others imaging techniques have little importance in the detection of lesions except for maybe the arthroCT, which has the advantage of showing the articular cartilage in great detail. If extension in the proximity of vascular structures is suspected, a MRI angiogram can be of great help. In those specific situations, the availability of a vascular surgeon at the time of the intervention is required.

P. Archbold, MD (✉)
The Ulster Independent Clinic, 245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

A. Pinaroli, MD
Clinique Médipole de Savoie, Avenue Massettes, 73190 Challes-les-Eaux, France
e-mail: a.pinaroli.j.henner@wanadoo.fr

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_10, © Springer-Verlag London 2014

Surgical Techniques

Arthroscopic Synovectomy

Limited Synovectomy

This intervention is indicated in focal PVNS. For the arthroscopy, the patient is placed supine with a vertical lateral post at the level of the proximal femur (to resist the knee during valgus strain) and a horizontal distal post (to hold the knee in the 90° flexed position).

A tourniquet is positioned high on the thigh and inflated to 300 Hg. Its use is helpful for visualization during the arthroscopy since resection of synovitis is typically associated with significant intra-articular bleeding.

The arthroscopic portals are chosen depending on the location of the lesions. The frequently used portals are described in detail in the chapters on arthroscopy and meniscectomy.

For lesions in the suprapatellar pouch or in the notch, the anterolateral and anteromedial portals are frequently sufficient. In order access lesions situated in the femoral gutters, a superolateral or superomedial portal is necessary. For lesions situated more posteriorly in the knee, i.e., behind the PCL or behind the femoral condyles, a posterolateral or posteromedial portals can be necessary as described by Philippe Beaufils.

A posteromedial portal is made with a knee in 90° of flexion. The entry point of this portal is made at the edge of the posteromedial border of the condyle, 1 cm above the joint line. This portal allows visualization of the posterior aspect of the medial condyle and the medial portion of the distal PCL. The round-tipped obturator is then reintroduced into the sleeve, gently perforating the synovial tent covering the PCL while staying in contact with the posterior condyles. The arthroscope is reintroduced into the sleeve and the posterior part of the lateral condyle can be visualized. Transillumination of the posterolateral region is of major importance: the portal has to be ventral to the biceps tendon to eliminate the risk for nerve damage. The posterolateral entry portal can be made with an 11 blade in 90° of flexion following spinal needle localization (Fig. 10.1). The posterolateral portal allows the use of a shaver (Fig. 10.2). Shaving of the lesions in this region can thus be done under arthroscopic control (Fig. 10.3).

The instruments used in this technique include a 30° arthroscope, a biopsy grasper and a 5.5 shaver blade. A 70° arthroscope can be of help in the case of a posterior synovectomy. The use of an arthroscopic pump (pressure set at 40 mmHg) helps in visualization due to the possibility of excessive intra-articular bleeding.

When localized PVNS is suspected, we recommend performance of several synovial biopsies in order to confirm that the PVNS is not diffuse.

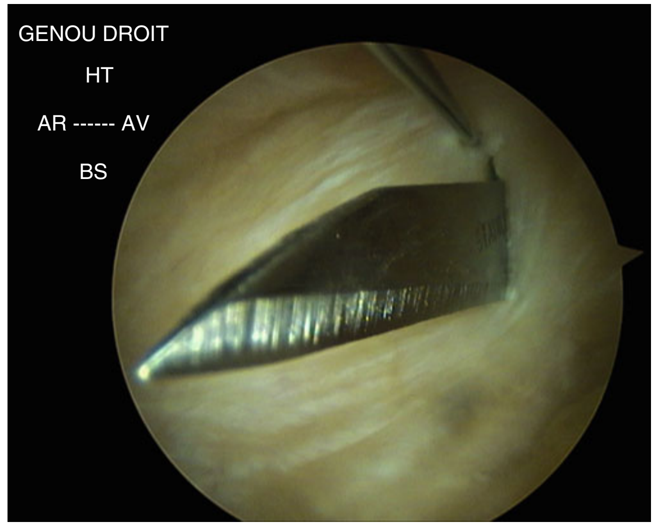


Fig. 10.1 Posterolateral entry portal with an 11 blade

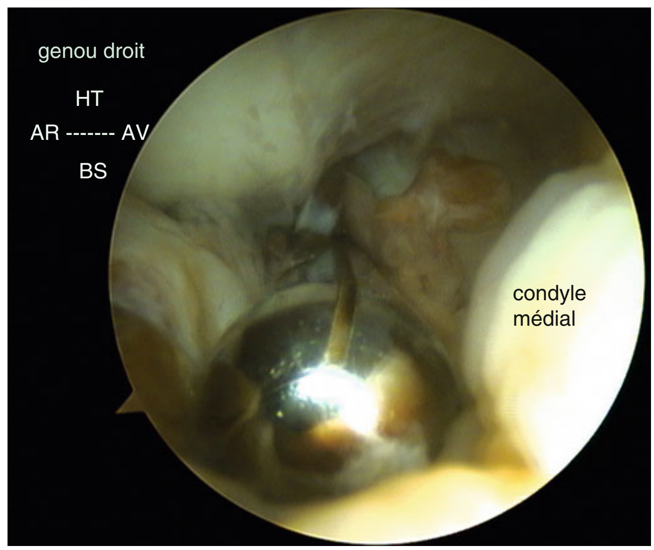


Fig. 10.2 Shaver used through the posteromedial portal (posterolateral portal view)

Total Synovectomy

This surgical approach can be used for diffuse forms of PVNS and for nonspecific synovitis without extra-articular involvement. The volume of the lesions must be fairly limited.

The setup and instrumentation are identical to that required for a "limited" synovectomy. Four portals are used, anterolateral, anteromedial, superolateral, and superomedial, which allow for a total synovectomy in the anterior compartment of the knee using a shaver (Fig. 10.4).

In PVNS, the technique introduced by P. Beaufils is of particular interest when the lesions are situated just posteriorly to the PCL without extra-articular involvement into the popliteal fossa (Fig. 10.5).

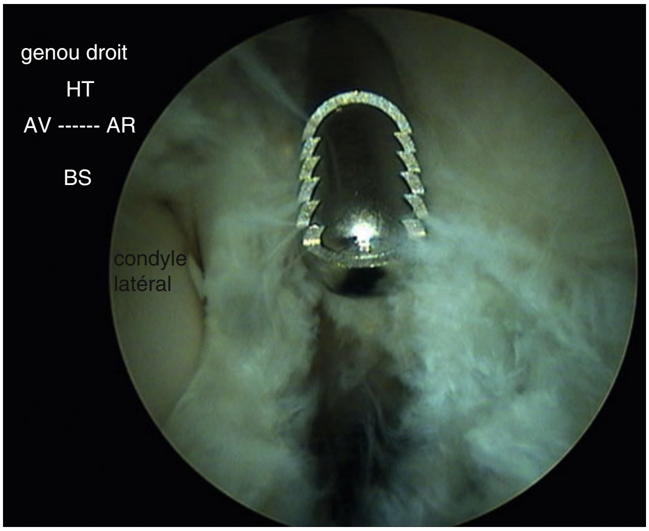


Fig. 10.3 Shaving of the posterior compartment synovial

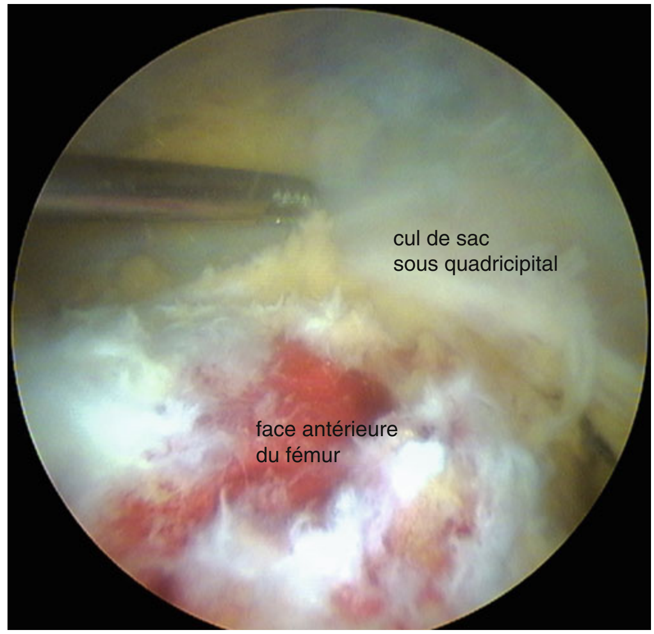


Fig. 10.4 Synovectomy of the anterior compartment

Fig. 10.5 Synovectomy of the posterior compartment using P. Beaufils technique

Open Synovectomy (with Arthrotomy)

Limited Synovectomy

This technique can be used for focal PVNS. The arthrotomy allows for a complete "en bloc" resection of the lesions. Many of these lesions could also be addressed arthroscopically. Nevertheless, some areas in the knee are more difficult to access arthroscopically, and in some cases the surgeon could be uncertain about the completeness of the excision (because of the limited accessibility by instruments but also because of the difficulty in interpreting the arthroscopic images). Furthermore, the arthroscopy does not allow an "en bloc" resection of the lesions. Yet, an arthroscopic approach has the advantage to allow a complete exploration of the joint cavity and to perform multiple biopsies. These considerations frequently justify a combination of both techniques. The surgical approach largely depends on the location of the lesion(s) (Figs. 10.6 and 10.7). Each common approach to the knee can thus be used, always taking into account the existence of previous skin incisions.

Fig. 10.6 Cutaneous incision after open limited synovectomy

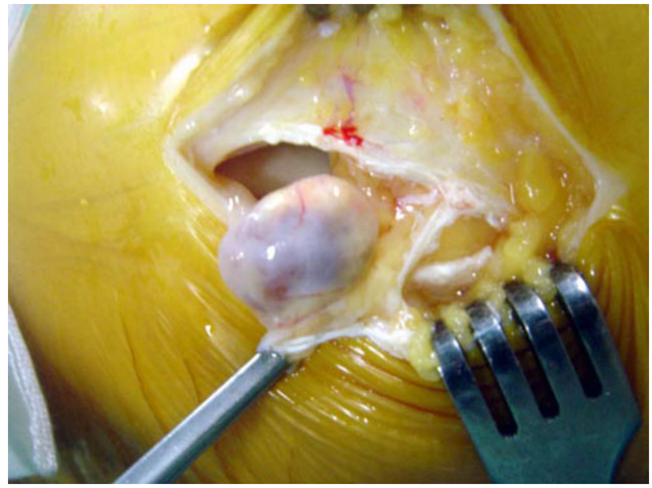


Fig. 10.7 Resection of localized pigmented villonodular synovitis

Total Synovectomy

The patient is placed in a supine position with a vertical lateral and a horizontal distal post. A tourniquet is inflated high on the thigh. This technique is used for diffuse PVNS and nonspecific synovitis without involvement of the popliteal fossa. We typically use an anteromedial and an anterolateral skin incision (Fig. 10.8). This method avoids one single large midline incision that would require significant subcutaneous dissection resulting in an increased risk for skin necrosis. Arthrotomies posterior to the medial and lateral collateral ligaments allow for intra-articular access posterior to the PCL. Posteromedial lesions situated between the medial head of the gastrocnemius muscle (MGM) and the semimembranosus are accessible by the medial approach. The posteromedial and posterolateral approaches not only give intra-articular access but also allow extra-articular lesions to be addressed.

(a) The anteromedial approach

An anteromedial vertical skin incision is made with a knee in 90° of flexion starting 1 cm proximal to the patella and extending distally to a point just medial to the tibial tuberosity.

The length of incision is about 8–10 cm. An extended resection of the supra patellar pouch can thus be done using a scalpel with the knee in extension and the extensor apparatus retracted with a Farabeuf retractor. (For a complete resection of this area, it is advised to combine this approach with an anterolateral approach.) A Volkman retractor is used to retract the anteromedial capsule. A synovectomy of the medial gutter can also be performed with the help of a large grasper (Fig. 10.9). At first sight, this technique could seem rather imprecise and less elegant, but in our hands it is considered very efficient and reproducible. Synovial tissue is easily caught without any resistance between the teeth of the instruments, while ligamentous and capsular tissues are much tougher. The scalpel has to be carefully manipulated in the presence of the cruciate ligaments and collateral ligaments but allows easy identification of the different planes of dissection and allows one to quickly proceed with a "en bloc" resection. The synovectomy underneath and above the meniscus can be performed using the same approach and the same instruments but care has to be taken not to damage the cartilage. The intercondylar notch is easily accessible using this approach. A specific patellar retractor can reflect the patellar tendon and the extensor mechanism laterally (Fig. 10.10). The same instruments can be used to perform a synovectomy of the Hoffa fat pad and the cruciate region (arthroscopic grasper).

(b) The posteromedial approach

– Direct

The skin incision is vertical with the knee in 90° of flexion and centered on the posterior border of the medial condyle (Fig. 10.11). The anteromedial arthrotomy can be used to palpate the posterior border of the medial collateral ligament and thus the exact location of the posteromedial skin incision can be determined. The skin incision extends from the superior and posterior borders of the medial condyle to the tibial insertion of the semimembranosus approximately 8–10 mm distally to the joint line. The anatomic advantages of this skin incision are disput-

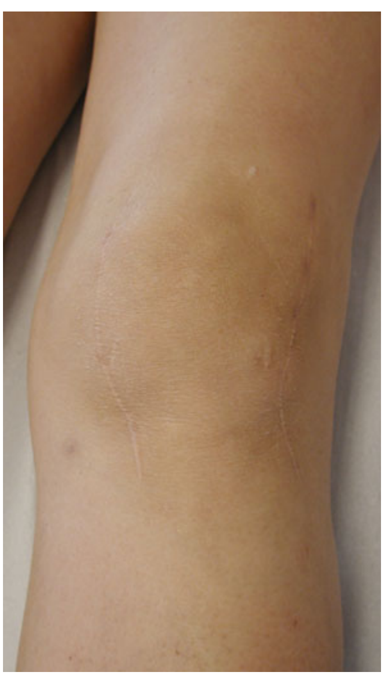


Fig. 10.8 Cutaneous incision after open total synovectomy

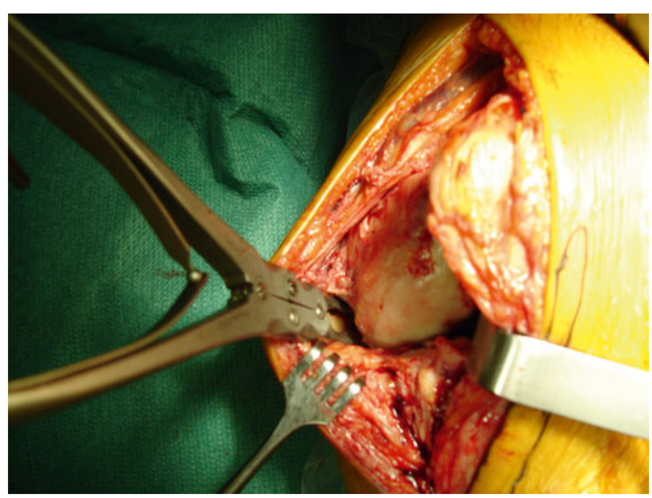


Fig. 10.9 Synovectomy of the medial gutter performed with a large grasper

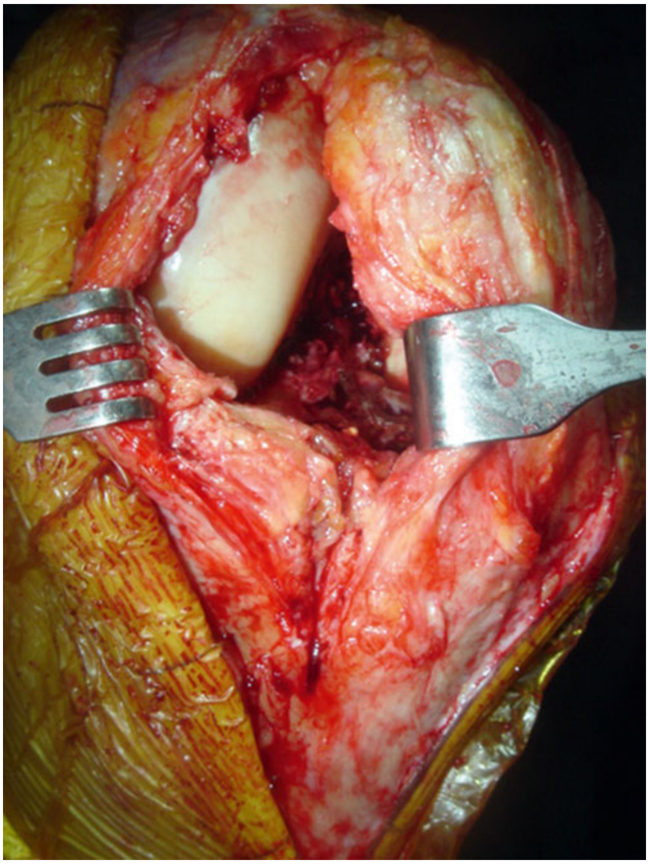


Fig. 10.10 Medial parapatellar arthrotomy and intercondylar notch view

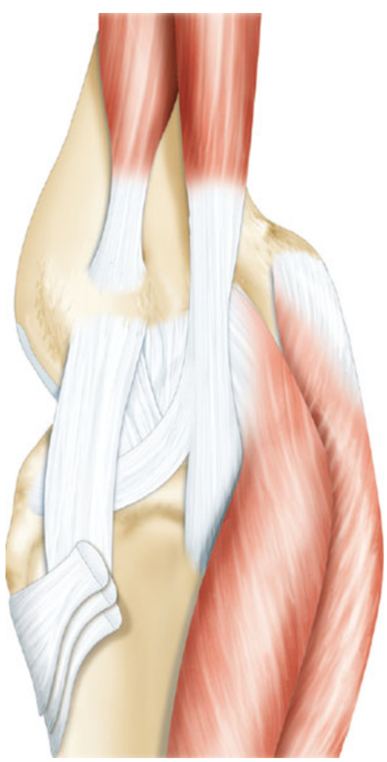


Fig. 10.11 Posteromedial approach and anatomy

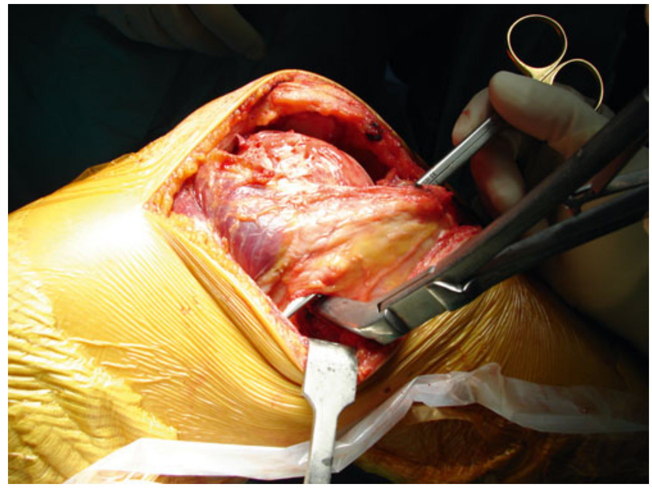


Fig. 10.12 The synovectomy in the posteromedial compartment and posterior to the posterior cruciate ligament is performed with the use of a large grasper

able. Moreover, lesions of the saphenous nerve and its branches are frequently noted.

– Approach with subcutaneous undermining (preferred technique)

This approach requires an extended skin incision 3 cm proximal to the superior edge of the patella to 2 cm distal to the regular medial approach. This skin and the subcutaneous fat are elevated using a Farabeuf retractor. The knee is now placed in a 90° flexed position in the figure-of-four position. The posterior border of the medial collateral ligament serves as a landmark as does the posterior edge of the tibial plateau and the medial femoral condyle. The vertical arthrotomy is performed just posteriorly to the medial collateral ligament and stops just superior to the medial meniscus. One has to take care not to cut the posterior corner of the medial meniscus. For an extended exposure, it is sometimes necessary to release the posterior capsule for a couple of millimeters from the femoral condyle. By doing this, it is possible to obtain a good view in the posteromedial compartment. At the end of the procedure, the released capsule can be reattached using an anchor or suture. The synovectomy in the posteromedial compartment and posterior to the posterior cruciate ligament is performed with the use of a large grasper. The knee is always kept in a flexed position and in varus in order to maximally relax the posterior capsule (Fig. 10.12).

(c) Anterolateral approach

With the knee in a 90° flexed position, a second anterolateral skin incision is performed starting from the mid part of the patella and extending 10 cm proximally in the direction of the upper border of the iliotibial band (ITB)

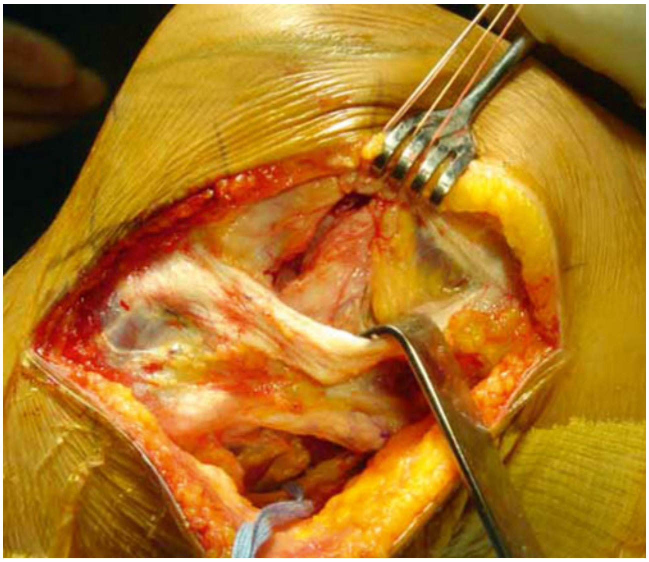


Fig. 10.13 Anterolateral approach and ITB exposure

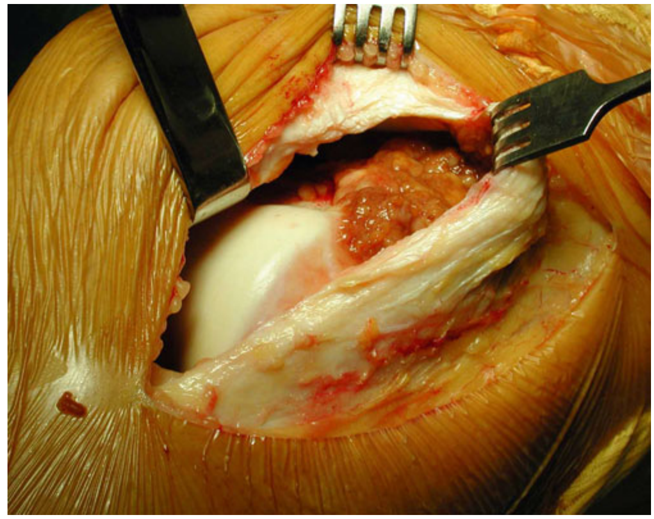


Fig. 10.14 Suprapatellar pouch exposure through a lateral parapatellar approach

(Fig. 10.13). In order to avoid skin necrosis, the anterolateral and anteromedial skin incision should be at least 4 finger widths apart. It is also advisable to place the anterolateral (superolateral) skin incision proximally and the anteromedial (inferomedial) skin incision more distally to avoid skin necrosis. If a posterolateral arthrotomy is planned and the skin is to be undermined, the anterolateral skin incision should be made somewhat more laterally, i.e., on the middle part of the ITB. An extended lateral approach necessitates longer skin incisions notably at the height of Gerdy's tubercle distally that could compromise the cutaneous vascularization in the prepatellar and infrapatellar region. The lateral parapatellar arthrotomy starts distally at the inferior pole of the patella and goes up 3 cm in a vertical direction always staying lateral to the midline. The lateral condyle, the superior border of the lateral meniscus, and the lateral portion of the infrapatellar fat pad can thus be visualized.

With the knee in full extension, an incision in the quadriceps tendon allows for visualization of the suprapatellar pouch. The complete extensor mechanism can now be lifted with a "Farabeuf" retractor (Fig. 10.14) or a specific patellar retractor. A synovectomy can now be performed in the same way as with a medial parapatellar arthrotomy. In order to have access below the meniscus, the skin incision has to be extended distally (always keeping attention to the minimum required distance between both skin incisions) and then a small horizontal arthrotomy is performed underneath the meniscus. This synovectomy on the undersurface of the meniscal body and on its posterior part is more difficult with this open approach than with an arthroscopy.

(d) Posterolateral approach

– Direct

  In combination with an anterolateral approach, a direct vertical arthrotomy just posterior to the lateral collateral ligament and superior to the lateral meniscus can be performed. The exact location of the lateral collateral ligament can be found with the knee in the "figure-of-four" position. The skin incision is now performed with the knee in 90° of flexion and neutral rotation. Additional transillumination with the arthroscope can provide some additional help. A skin incision is made from the posterosuperior border of the lateral condyle vertically down to tibial plateau always staying just posterior to the lateral collateral ligament (Figs. 10.15).

– Approach with subcutaneous undermining (preferred technique)

  With the ITB as landmark, the posterolateral compartment can be accessed above, through, or under the ITB.

  Access to the posterolateral capsule

  The posterolateral knee capsule can be accessed through the ITB (incising it in the direction of the fibers) or just anterior to it. The lateral collateral ligament and the anterior border of the lateral head of the gastrocnemius muscle can be palpated with the Metzenbaum scissors (Fig. 10.16). The knee should always be flexed. Thus, a vertical arthrotomy can be performed just posterior to the lateral collateral ligament (Fig. 10.17). A small artery is frequently present and care should be taken to achieve hemostasis. Attention should be paid not to cut the posterior corner of the lateral meniscus or the popliteus tendon. The latter blocks access to the tibial plateau, especially

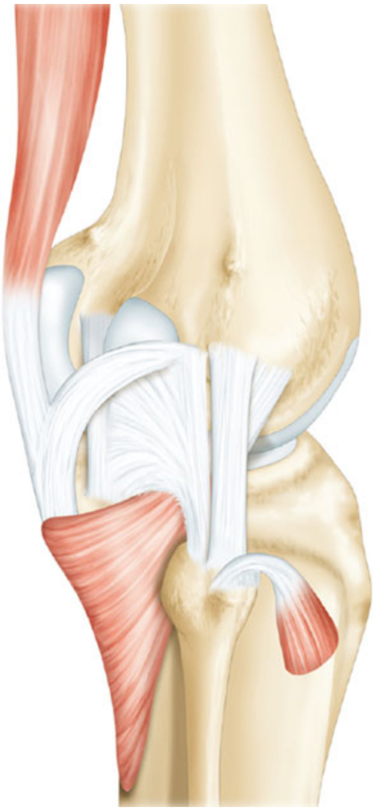


Fig. 10.15 Posterolateral approach and anatomy

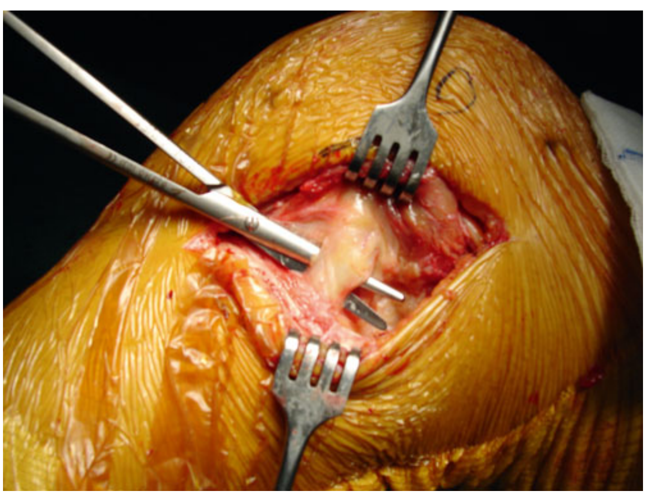


Fig. 10.16 Dissection of the lateral collateral ligament

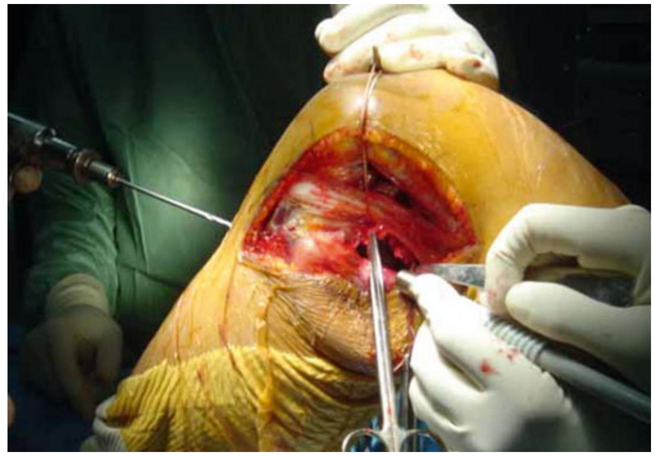


Fig. 10.17 Vertical arthrotomy posteriorly to the lateral collateral ligament

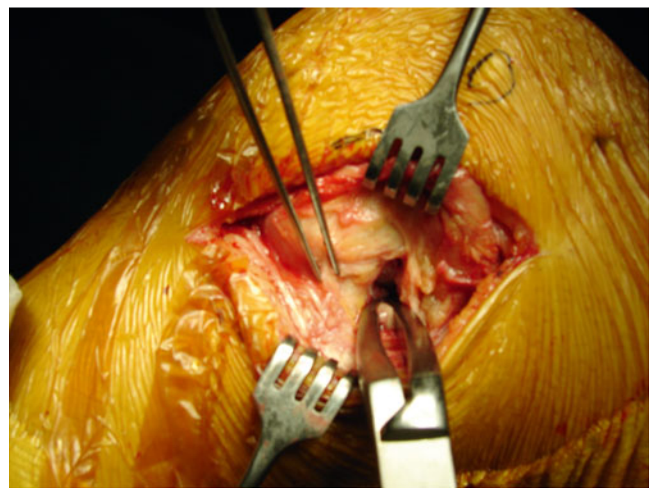


Fig. 10.18 Posterolateral synovectomy using a large grasper

to its posterior part and to the posterior recess. The posterior border of the lateral tibial plateau and femoral condyle can now be palpated. The synovectomy of the posterolateral supra-meniscal recess and the posterior cruciate ligament can be performed using a large grasper (Fig. 10.18). As for the medial side, the approach can be extended by dissecting the posterior capsule from the femoral condyle; this provides access to the posterior part of the lateral tibial plateau. The exposure of this zone is very difficult through the previously described approach. It can be necessary to go posterior to the distal ITB. This allows visualization of the popliteal hiatus and the posterior border of the lateral tibial plateau. If increased exposure is required, incision of the lateral meniscus in the red-red zone is necessary.

(e) Posterior approach
This approach is needed in diffuse PVNS with lesions posterior to the PCL or extra-articular lesions in the popliteal fossa. In some rare cases, one can encounter localized PVNS or a benign tumor located posterior to the PCL that must also be addressed via this approach. The first surgical step is always the anterior synovectomy, either arthroscopically or using arthrotomies.

Fig. 10.19 Posterior midline skin incision (prone position)

After skin closure, the patient is placed in the prone position. The surgical field is left in place. The surgical team turns the lower limbs of the patient, while the anesthesia team turns the thorax and head of the patient. Rotation of the patient is performed clockwise for a right knee and counterclockwise for a left knee when viewed from the patient's feet.

A new stocking and extremity sheet are applied, and the flexion crease of the knee is marked by placing a skin marker in the flexion crease and flexing the knee. The marker is then slowly retracted while exactly marking the flexion crease. A sterile opsite is then applied.

The posterior approach is performed according to Trickey. A lateral vertical skin incision of approximately 5 cm is performed just medially to the biceps tendon. It is continued horizontally in the flexion crease from lateral to medial to the insertion of the medial gastrocnemius muscle. The incision is then extended distally in a vertical direction, for about 7 cm. An angled skin incision is to be avoided. The skin incision is performed with a knee in extension (Fig. 10.19). With the support under the foot and the knee in slight flexion, the subsequent surgical steps are performed. First, one identifies the small saphenous vein, which is never easy. The head of the medial gastrocnemius muscle is retracted medially and its fascia is incised vertically. This exposes the hamstring tendons superficially and the deeper semimembranosus tendon. These tendons guide the surgeon to the posterior area of the tibia and thus to the "safe zone" avoiding potential damage to the neurovascular structures in cases where the posterior border of the posterior cruciate ligament needs to be exposed. The posterior tibia is covered with the popliteus muscle. The neurovascular elements can be retracted carefully by placing a Homan retractor in contact with the tibia. Finally a capsulotomy is performed. The arthrotomy is vertical and extending towards the posteromedial border of the lateral condyle. In specific cases, it can be necessary to perform a partial section of the head of the medial gastrocnemius muscle in its tendinous part for approximately 15 mm. This allows an improved view of the posterior capsule. The posterior synovectomy in the zone behind the posterior cruciate ligament can now be performed using the large grasper.

Some extensive lesions in the popliteal fossa are situated more superficially. The popliteal neurovascular structures should be identified and carefully retracted using a Farabeuf retractor (Fig. 10.20). The posterior extra-articular lesions are carefully dissected (Fig. 10.21). When in close contact with the vascular structures, the assistance of a vascular surgeon is sometimes advisable, especially in revision operations with adhesions that require exploration both medial and lateral to the neurovascular structures.

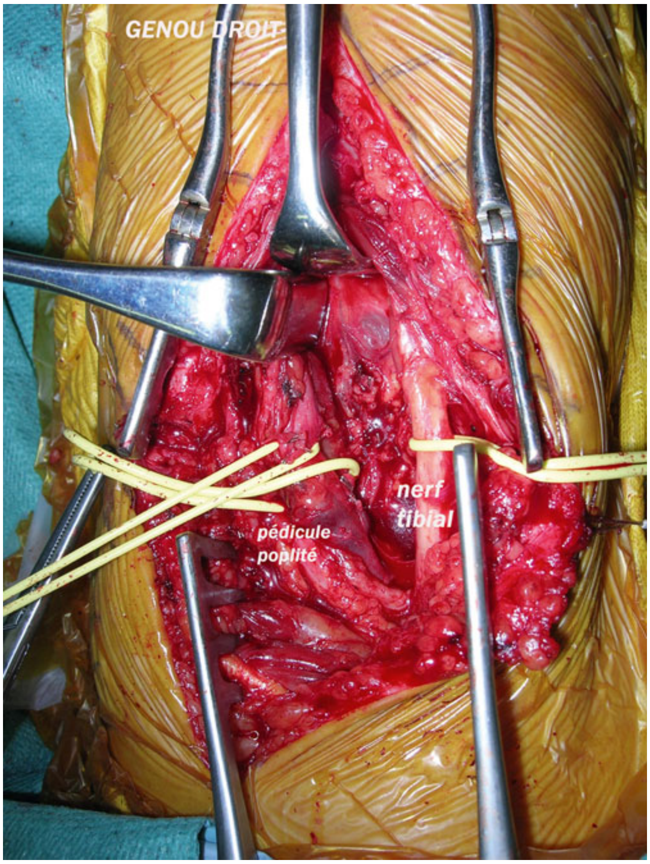


Fig. 10.20 Dissection of tibial nerve and popliteal blood vessels

Fig. 10.21 Resection of a large posterior lesion (posterior approach, prone position)

Combined Synovectomies

The indication for this surgery is typically a revision operation for diffuse PVNS with limited lesions in the anterior compartment but extensive posterior lesions or lesions not accessible by arthroscopy. The first surgical step is an arthroscopy of the anterior compartment as described previously. It allows for arthroscopic evaluation and multiple biopsies. After closure of the arthroscopic skin portals, the patient is turned in a prone position as described previously and a Trickey approach to the posterior compartment is performed.

Total Knee Arthroplasty

Placement of a total knee arthroplasty offers the opportunity to perform an extensive synovectomy.

This surgical intervention is performed using a single classic approach to the knee. The bony cuts allow a more extended exposure to the different compartments. Only in cases of extensive extra-articular lesions, an additional approach may be necessary. A primary total knee arthroplasty can be justified in the elderly with articular destruction but is less frequently performed in PVNS of the knee compared to that of the hip. Nevertheless, the exposure during the TKA does not allow removal of extra-articular pathology.

Postoperative Care

Because of the risk of extensive intra-articular bleeding after a synovectomy and hence increased risk of skin necrosis, anticoagulants are avoided in our department. To prevent DVT, weight bearing, mobilization of the ankle and foot, and early ROM exercises are encouraged. Postoperative stiffness is a well-known complication in this type of surgery. In order to limit the risk after a total synovectomy, the position of the knee is frequently changed from extension to flexion using a specifically designed flexion brace. The knee is held in this flexed position during 1 or 2 h every 6 h.

Continuous passive motion is allowed from the first postoperative day on. Time should always be taken to look for any signs of skin problems.

Specific Cases

Pigmented Villonodular Synovitis

The aim in the treatment of this type of pathology should be a single procedure involving a total synovectomy with multiple biopsies (Fig. 10.22). Limited PVNS does not need specific postoperative surveillance. In diffuse PVNS, we prefer a total synovectomy with an arthrotomy. In case of surgical failure, a chemical synovectomy can be performed 4–6 weeks after the surgical intervention. Recurrence should be looked for during follow-up (clinical examination and MR imaging every year during the first 3 years following surgery and following this if there is any clinical suspicion of recurrence). One must remember that findings at pathology (clean margins) do not predict recurrence. Recurrence rates decreased with the passage of time, but the surgeon must carefully follow these patients for many years.

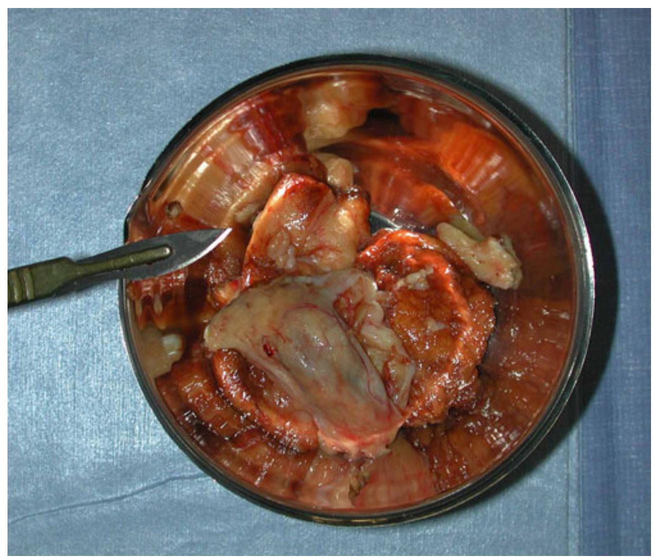


Fig. 10.22 Pigmented villonodular synovitis (resected lesions)

Primary (Osteo) Chondromatosis

Arthroscopic treatment of this pathology is in most cases effective. In contrast with our aggressive treatment for PVNS, we believe that the symptomatic, limited treatment of primary osteochondromatosis is appropriate. Of course, one should take into account the extent of the pathology in every patient. The typical grains of rice can be attached to the synovial tissue (early stage of primary osteochondromatosis) necessitating a debridement of the synovial tissue using the shaver. In a later stage, joint lavage and a limited synovectomy in those regions of synovial hypertrophy can suffice. This type of surgery can be repeated if needed, and in many cases the extent of the patient's symptoms diminishes over time. Malignant transformation is rarely described in the literature. It is very important to identify and debride the regions underneath the lateral and medial meniscus. In order to remove the grains of rice that are located in the popliteal hiatus, manual pressure in the posterolateral region of the knee and the popliteal fossa is applied while repeatedly flexing and extending the knee. This forces the grains of rice into the knee joint from which they can be removed easily.

11 Surgical Management of Chondral and Osteochondral Lesions

P. Archbold, T. Aït Si Selmi, and C. Bussière

Basic Principles

Different surgical techniques exist for the treatment of chondral and osteochondral lesions. A distinction has to be made between those techniques that debride or microfracture the subchondral bone and those that transplant cartilage. Cartilage transplantation encompasses the transplantation of osteochondral grafts or a chondrocyte cell suspension. Microfracture and abrasion will result in the formation of a fibrocartilaginous repair tissue with biochemical and biomechanical characteristics inferior to those of articular cartilage. This fibrocartilage is characterized by an extracellular matrix which mainly consists of type I collagen rather than type II collagen and an absence of differentiated chondrocytes. The aim of chondrocyte cell transplantation is to reproduce a hyaline-like cartilage with differentiated chondrocytes and an extracellular matrix rich in type II collagen and proteoglycans.

Surgical Techniques

The majority of the techniques described in this chapter are performed on a regular basis in our department. Techniques such as chondrocyte transplantation are only performed in a clinical research setting.

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

T.A. Si Selmi, MD
Centre Orthopédique Santy,
24 avenue Paul Santy, 69008 Lyon, France
e-mail: tarik.aitsiselmi@gmail.com

C. Bussière, MD
Orthopaedic Center, Dracy-Le-Fort,
2 rue du Pressoir, 71640 Dracy-Le-Fort, France
e-mail: cbussiere@aliceadsl.fr

Perforations of the Subchondral Bone

Numerous methods exist to perforate the subchondral bone.

- Pridie drilling: the perforations of the subchondral bone are performed using a drill. After debridement of the lesion, multiple perforations with an interval of 2–3 mm are made using a 2.0 drill. The depth of the perforations is approximately 15 mm. After the surgery the tourniquet is deflated to verify bleeding from the perforations.
- Microfracture according to Steadman: these perforations are performed using a microfracture awl.
- Abrasions: this technique performs an abrasion of the subchondral bone using a high-speed burr.

Osteochondral Grafting and Mosaicplasty

Following the first founding symposium of the International Cartilage Repair Society in Fribourg in 1997, Tarik Aît Si Selmi introduced this technique into our department. The first two procedures were performed in the presence of R. Jakob.

Basic principles

Mosaicplasty encompasses the transplantation of osteochondral plugs for the treatment of chondral and osteochondral lesions. This technique was originally described by Matsusue (1981) and was popularized by L. Hangody during the 1990s. In the English literature, Vladimir Bobic from the UK is one of the leading authors. The osteochondral autografts are harvested from the medial or lateral border of the trochlea or in the intercondylar notch. Small osteochondral grafts are transplanted into the lesions and arranged in a mosaic-like fashion. Although initially described for the treatment of femoral condyle lesions, this technique has been extended to other joints. Donor areas now also include the contralateral knee and the proximal tibiofibular joint. Allograft is an alternative source (department of René Verdonk, Gent, Belgium).

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_11, © Springer-Verlag London 2014

Diagnosis

Imaging is mandatory to visualize the lesion, localize it, measure its depth (grade III or IV lesion according to ICRS specification), differentiate between chondral and osteochondral lesions, and evaluate its size. These variables will define which type of graft as well as the surgical approach is necessary. An arthroCT scan is the imaging modality of choice, but an arthroMRI with an intra-articular injection of gadolinium may also be used. These examinations allow evaluation of the articular lesions, the meniscii, and the ligamentous structures.

Preoperative Planning

Preoperative planning includes a plain radiograph. Additionally, a "Schuss" view allows visualization of possible kissing lesions. A long leg film evaluates the axial alignment and will indicate the necessity for associated osteotomy. For posteriorly located lesions, a lateral radiograph in knee hyperflexion will indicate if the lesion is accessible.

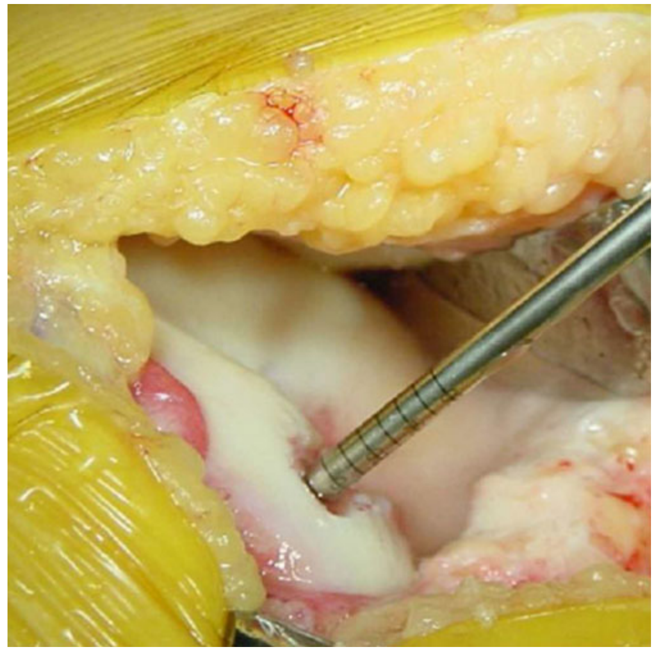


Fig. 11.1 Mosaicplasty: specific calibrated drill. The direction of the drill hole is perpendicular to the articular surface

Surgical Technique

The patient is placed in a supine position. A vertical lateral and a horizontal distal post are positioned and a tourniquet is used. The surgical approach depends on the location of the lesion. Most frequently, an anteromedial parapatellar arthrotomy is used. In the case of a lateral lesion, a lateral parapatellar approach is used. This approach can be associated with an osteotomy of the tibial tubercle to gain access to the posterolateral compartment. The arthrotomy, either medial or lateral, is performed in a subvastus fashion. The knee joint is systematically explored for associated lesions.

As a first step, the bottom and edges of the lesion are debrided. This step allows evaluation of the dimensions and the depth of the lesions. The number of plugs needed and their diameter can then be chosen. The osteochondral grafts should cover at least 70 % of the lesion.

In the second step, the lesion area is prepared using a specific calibrated drill. The direction of the drill hole is perpendicular to the articular surface. The depth of the hole should be 15 mm in case of a chondral lesion and 25 mm with an osteochondral lesion (OCD) (Fig. 11.1).

Using a tubular harvester, the first osteochondral plug is harvested in the donor area. The primary donor area is the medial trochlea followed by the lateral trochlea or the intercondylar notch area. Again the direction of the harvester should be perpendicular to the articular surface. The harvester is calibrated so the depth of the osteochondral plug can be measured (Fig. 11.2).

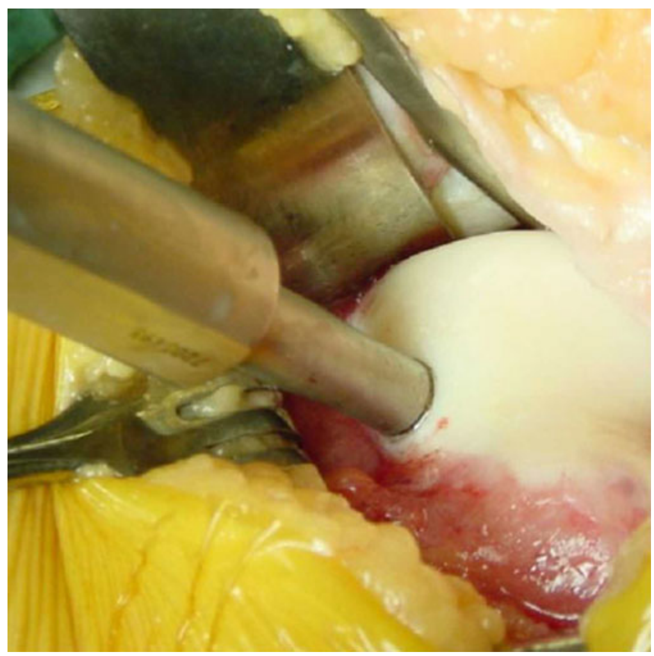


Fig. 11.2 Mosaicplasty: first osteochondral plug harvested using a tubular harvester in the donor area (medial trochlea)

Harvesting the osteochondral plug is done by rocking the harvester or by rotating it. This depends on the type of

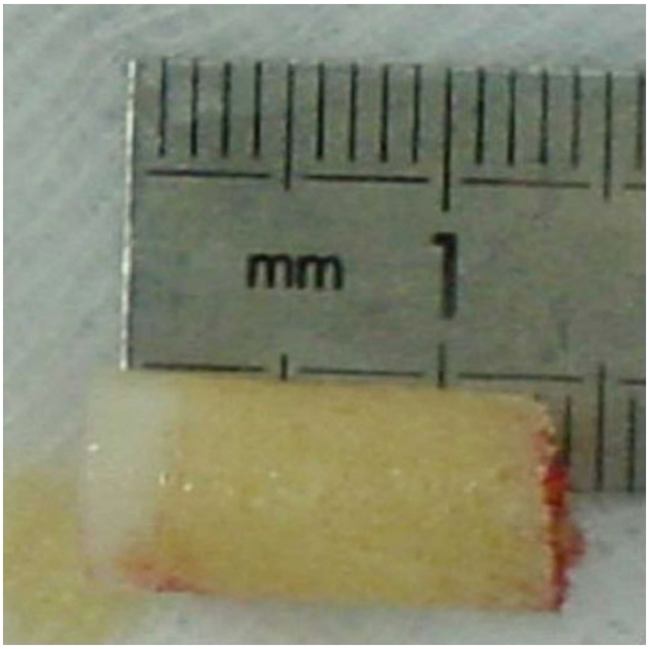


Fig. 11.3 Mosaicplasty: osteochondral plug sizing (length 15 mm, width 4.5 mm)

Fig. 11.4 Mosaicplasty: graded adjustable plunger

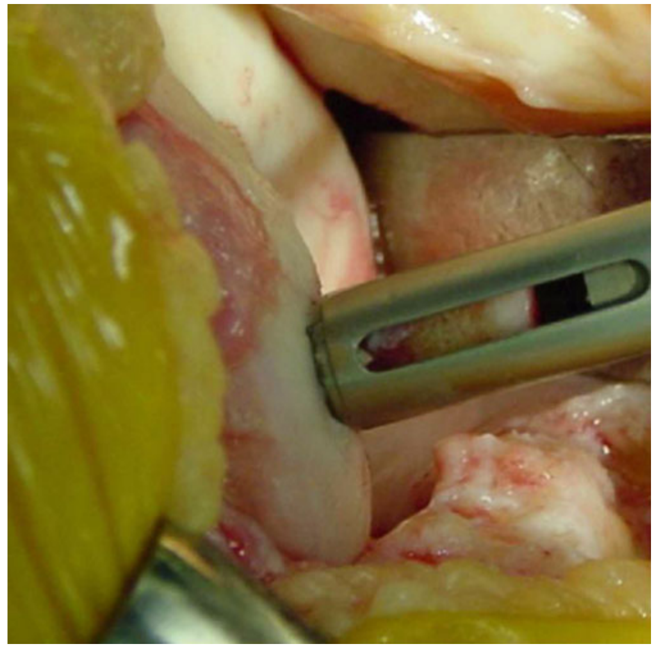


Fig. 11.5 Mosaicplasty: insertion of the osteochondral plug in the acceptor tunnel

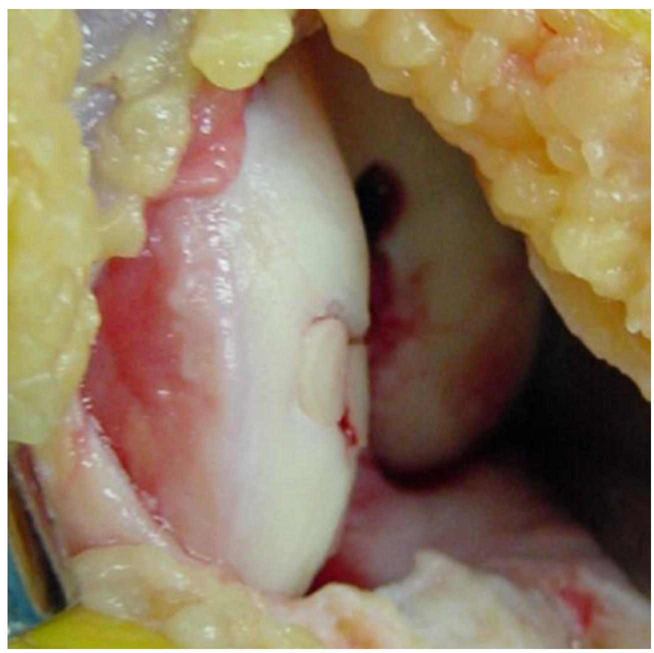


Fig. 11.6 Mosaicplasty: final aspect. The levels of the osteochondral plugs are in line with the adjacent cartilage

instrumentation. The graft is extracted from the harvester by gently tapping on the osseous end of the graft or using an adapted pusher through the harvester (Fig. 11.3).

Dilatation of the acceptor drill hole is done with a calibrated dilator. The insertion of the osteochondral plug in the acceptor tunnel is performed using a graded adjustable plunger (Fig. 11.4). This allows exact control of progression and final depth of the osteochondral plug in the acceptor tunnel without the application of undue force (Fig. 11.5).

The level of the osteochondral plug should be in line with the adjacent cartilage. Too prominent a graft or too deep a graft should be avoided (Fig. 11.6).

Postoperative Guidelines

The patient should wear a brace. Weight bearing is prohibited for 45 days and thromboprophylaxis is administered for this period. Continuous passive motion is allowed on the first postoperative day. The patella should be mobilized. Open and close kinetic chain exercises are prescribed. Return to sports is allowed after 6 months.

Osteochondral Allograft

When addressing very large lesions (over 6 cm^2), harvesting sufficient autologous cartilage for a classic mosaicplasty is impossible. Specific large diameters instruments are available in order to use the same technique with allograft material. For very large lesions, a monoblock allograft with custom dimensions can be obtained. In these cases the donor condyle should be of the same size and curvature as the native condyle to obtain a perfect match (Fig. 11.7).

Fig. 11.7 Osteochondral allograft. Note the perfect match (appropriate size and curvature)

Autologous Chondrocytes Transplantation

The evaluation and preparation of lesions and the surgical approach have been described previously. Autologous chondrocytes transplantation can address lesions up to 5 mm in thickness.

Chondrocytes Cultures

Autologous chondrocytes are proliferated in vitro. First, a cartilage biopsy of approximately 200 mg is harvested arthroscopically from the medial trochlea or the intercondylar notch. The cells are isolated by enzymatic digestion of the matrix and are subsequently cultured as a monolayer in order to obtain the desired cell quantity (approximately ten millions cells).

Implantation

Technique According to Brittberg and Peterson (ACI: Autologous Chondrocyte Implantation)

The cells are transplanted as a cell suspension. To contain the cells within the defect, a periosteal or collagen membrane is needed to cover the defect. This membrane is sutured to the defect edges as has been described by Brittberg (Fig. 11.8).

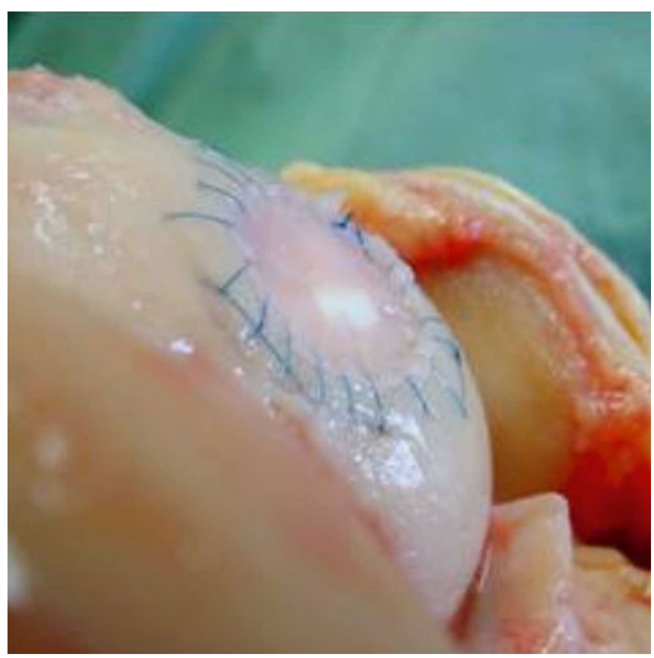


Fig. 11.8 Autologous chondrocyte implantation (ACI, Brittberg and Peterson)

Cell transplantation with the use of a three-dimensional matrix improves chondrocyte redifferentiation and thus ensures the correct production of different extracellular matrix proteins. Different types of matrices are available on the market: such as sponge-type matrices (Fig. 11.9) or gels (alginate and agarose gel such as Cartipatch) (Fig. 11.10).

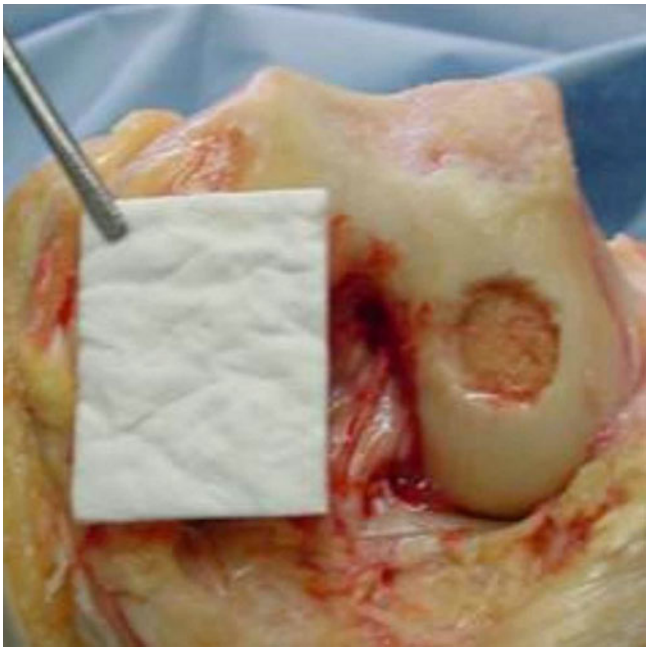


Fig. 11.9 Three-dimensional collagen matrix (Geistlich)

Cartipatch Technique

The Cartipatch technique is very similar to the mosaicplasty. Pre operative planning and preparation however is mandatory. A biopsy harvest arthroscopy should be performed as well as preoperative imaging to evaluate the lesion. According to the size of the lesions a number of Cartipatch grafts can be prepared. The Cartipatch graft is available in three different diameters: 10, 14 and 18 mm. For lesions close to the intercondylar notch, primary stability of the Cartipatch graft is obtained as long as the graft is contained along at least two thirds of it circumference. Specific instrumentations including calibrated drill bits are available to prepare the recipient area (Fig. 11.11). Trial components allow evaluation of the position and the height of the defect with respect to the normal cartilage (Fig. 11.12). The graft is subsequently introduced into the prepared defect using a needle (Fig. 11.13). The needle will guide the positioning, evacuate the air, and temporarily fix the graft in the defect in case of multiple grafts (Fig. 11.14). At the end of the intervention, the tourniquet is deflated to observe possible expulsion of the graft. The knee is then cycled to test primary stability of the grafts within the defect. The knee is immobilized for 48 h, thromboprophylaxis is prescribed, and weight bearing is not allowed for 45 days. Continuous passive motion of the knee between 0 and 90° is prescribed for 1 month. Sports are allowed after 1 year.

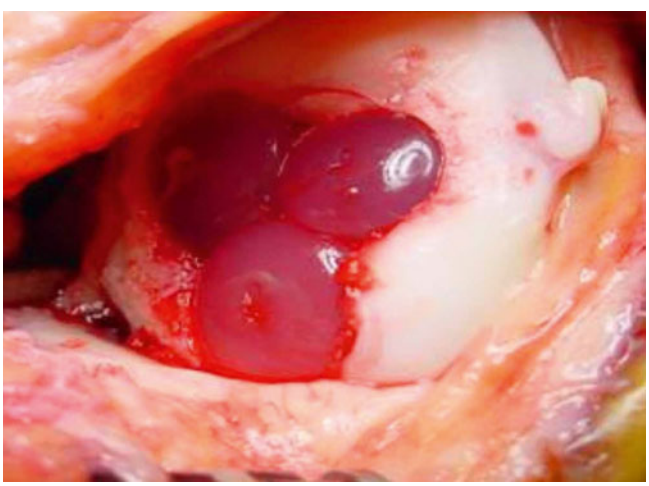


Fig. 11.10 Cartipatch®: 14 mm diameter grafts

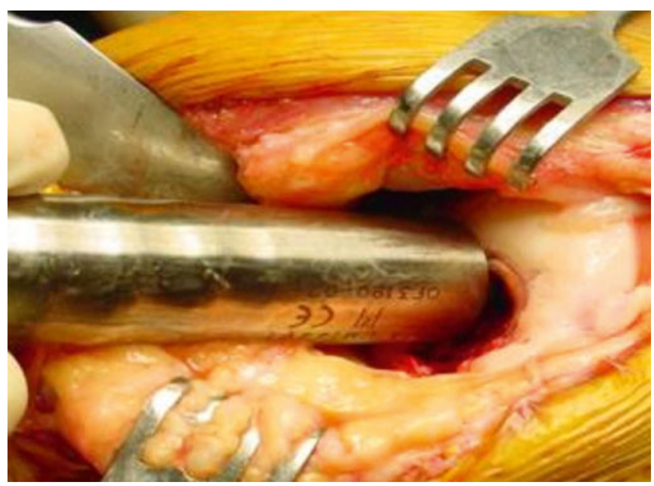


Fig. 11.11 Cartipatch®: calibrated drill bit

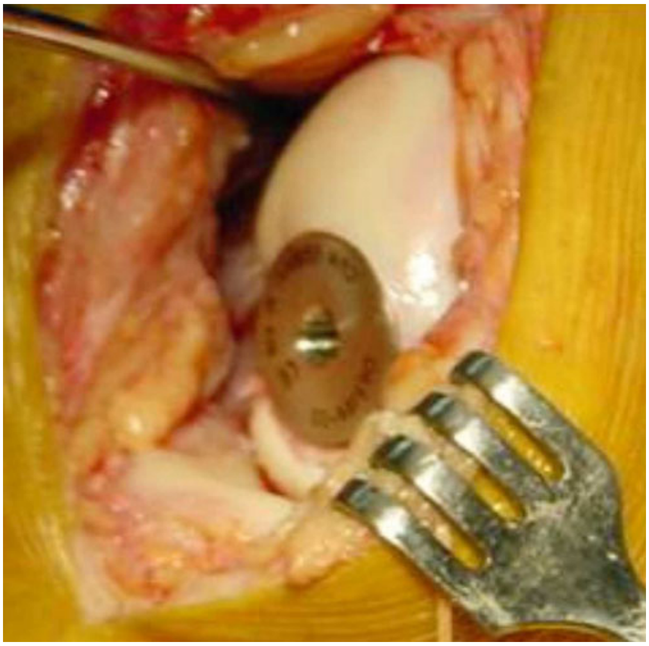


Fig. 11.12 Cartipatch®: trial component

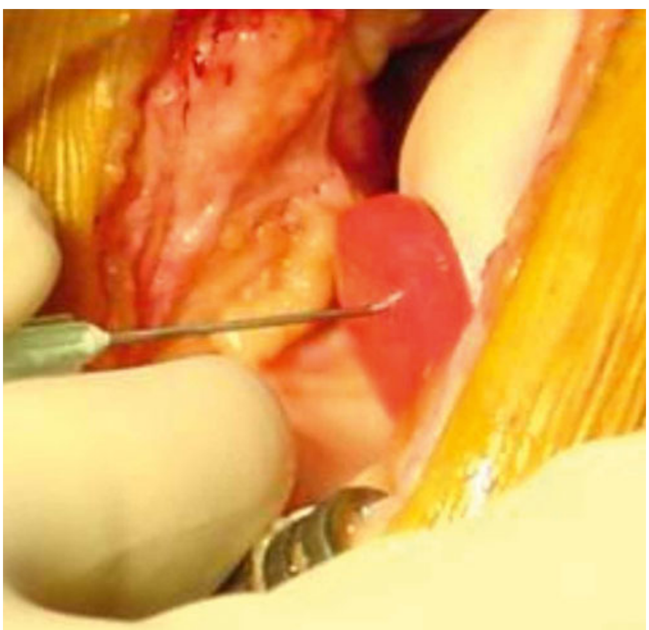


Fig. 11.13 Cartipatch®: insertion of the graft using an IM needle

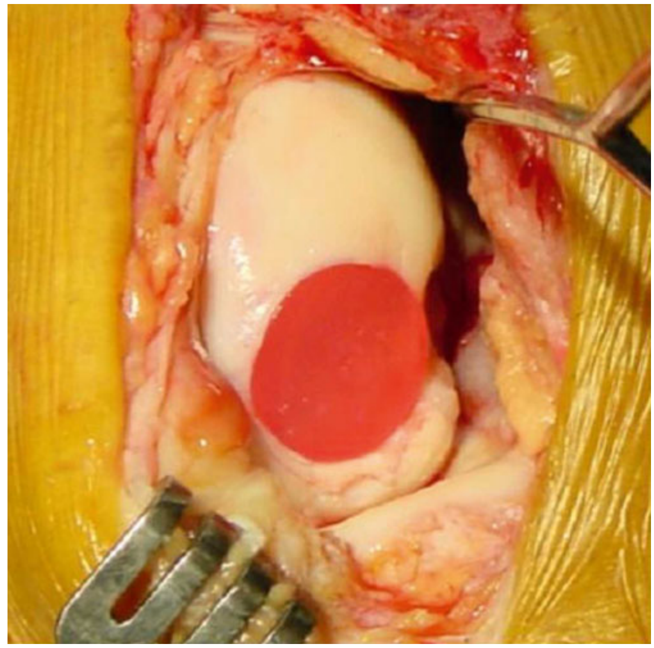


Fig. 11.14 Cartipatch®: single 18 mm diameter graft

Associated Procedures

Specific associated conditions can negatively affect the outcome of a cartilage lesion. Therefore these conditions have to be corrected previously or concomitantly. These associated lesions include ligamentous laxity (anterior cruciate ligament rupture) and meniscus lesions. Malalignment of the lower limb exceeding 5° can be addressed by an osteotomy and should be discussed within the context of the chondral lesions or others associated lesions.

Conservative Surgical Techniques

Fixation

A traumatic osteochondral lesion or osteochondritis dissecans (OCD) lesion can be treated with fixation. Several fixation devices are available including sutures, pins, and screws (resorbable or not). The common characteristic is that these devices can be inserted completely and that they do not harm the opposing cartilage. Herbert screws are very useful for this. This technique can be performed as open surgery or under arthroscopic control. During the arthroscopy, an intramuscular needle inserted perpendicular to the defect surface will illustrate the trajectory and will indicate the correct position of the portal. Very frequently a trans-tendinous portal (according to Gillquist) (Fig. 11.15) is used. Image intensified control can help to obtain the perfect direction and placement of the screw (Fig. 11.16).

OCD lesions in a child have a good chance of healing spontaneously as long as the cartilage is intact. If the articular cartilage is breached or the fragment has become unstable, the bony lesions have to be debrided in order to stimulate bony healing. Sometimes it will be necessary to use autologous bone graft to fill the underlying bony defect. Since the bony lesion is frequently smaller than the cartilage lesion, fixation of the lesion can result in articular incongruity (Fig. 11.17).

Fig. 11.15 Fixation: trans-tendinous portal according to Gillquist

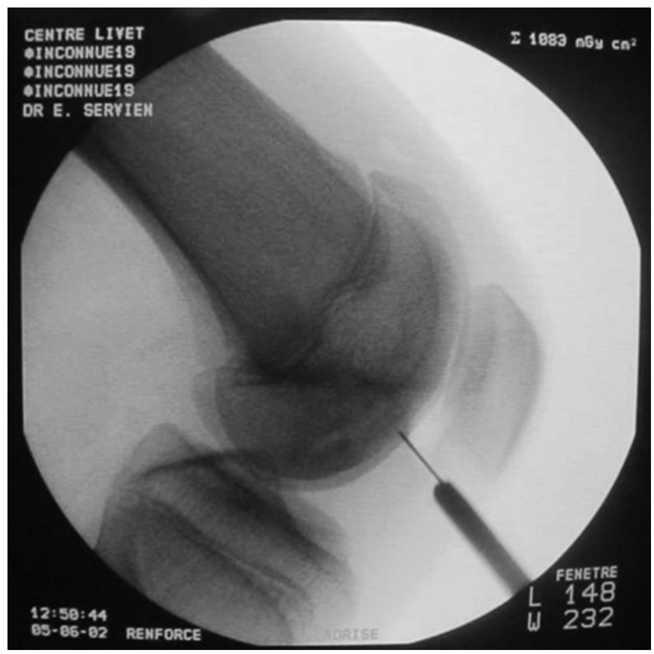


Fig. 11.16 Fixation: fluoroscopic control of the direction and placement of the screw

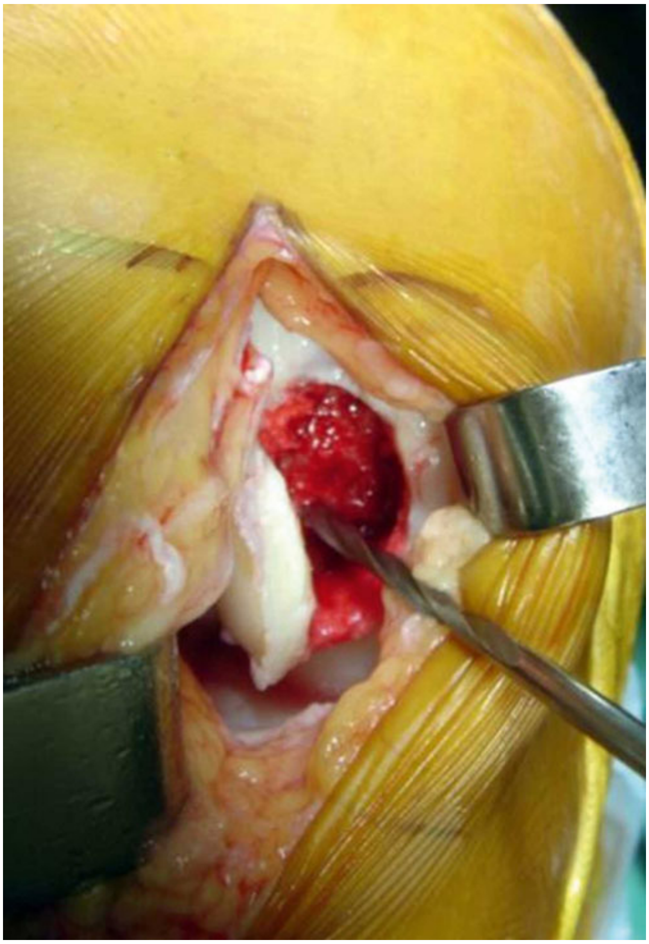


Fig. 11.17 Fixation: debridement and autologous bone graft are sometimes necessary to the fill the underlying bony defect

Debridement

In a number of conditions, more specifically in the osteochondritis dissecans in the child with no breach of the articular cartilage, the bony lesions can be perforated arthroscopically from within the knee joint with a 2.0 mm drill in a retrograde fashion.

In case of an unstable lesion, additional fixation can be provided by a mosaic plug or screws.

Postoperative Guidelines

Weight bearing is not allowed for 45 days. Rehabilitation starts on day 1.

Pearls

Kissing lesions are a contraindication for cartilage transplantation (best identified on the Schuss view).

Conservative treatment is the treatment of choice for OCD lesions in the child.

If an osteotomy is considered, the therapeutic value of cartilage surgery should be questioned.

12 Iliotibial Band Syndrome

P. Archbold and G. Mezzadri

Iliotibial band syndrome (ITBS), also known as iliotibial band friction syndrome (ITBFS) or runner's knee, is a common condition among athletes. It is the leading cause of lateral knee pain in long-distance runners. We have frequently observed this pathology among cyclists as well.

The pain is due to friction between the iliotibial band (ITB) and the lateral epicondyle, enhanced by tensioning of the ITB in single-leg stance. The origin of this syndrome is multifactorial, and aggravating factors are consistently found: sports overuse, poor equipment (shoes and soil), and training errors such as lack of stretching before exercise.

Conservative treatment is usually effective and includes analgesic and anti-inflammatory drugs associated with rest and a change of activity as well as physical therapy (ITB stretching and deep tissue massage). Injections are sometimes used for more refractory cases.

However, a minority of patients remain resistant to these treatments, and surgical treatment can be discussed in these highly motivated athletes. The procedure consists of a release of posterior fibers of the iliotibial tract facing the lateral epicondyle. Surgical treatment is offered after 6 months of conservative treatment has been well conducted. The results are generally good and the morbidity is low, with a fast return to sport frequently observed.

Surgical Indication

The main reason for surgical treatment is tendinitis of the iliotibial band that is manifested by lateral knee pain and preventing the practice of sport.

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

G. Mezzadri, MD
Avenue John Fitzgerald Kennedy, 26200 Montelimar, France
e-mail: guillaume.mezzadri@free.fr

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_12, © Springer-Verlag London 2014

Preoperative Clinical Evaluation

History and physical examination should be systematic and detailed.

In the history, patients report lateral knee pain that occurs under physical exercise (running) that usually forces the patient to stop. There are not episodes of locking, instability, or effusion.

On examination, pain is reproduced with the Noble test. The patient is placed in the supine position with the knee flexed at 90°. Pressure is applied to the lateral condyle 2–3 cm above the lateral tibiofemoral joint line as the knee is progressively extended. The pain occurs at 30° of flexion (Fig. 12.1). Sometimes palpable crepitus is also present.

Knee range of motion is normal without joint effusion or ligamentous laxity. The diagnosis is mainly clinical and requires elimination of all other potential causes of pain in the lateral compartment of the knee.

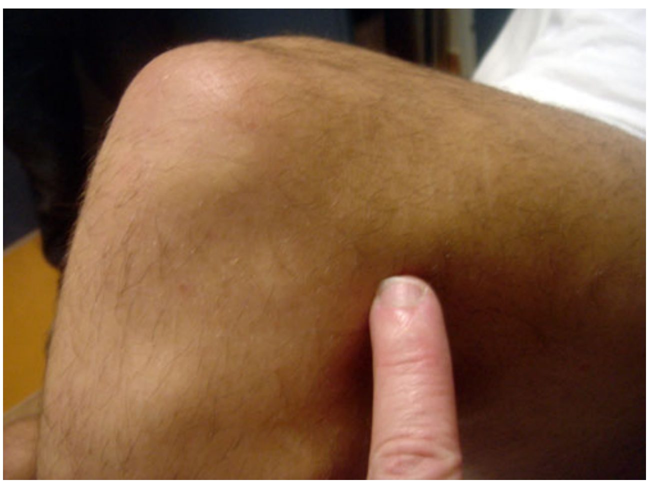


Fig. 12.1 Left knee pain reported by the patient next to the lateral epicondyle, over the joint line

Imaging Before Surgery

All patients should have plain radiographs of both knees and MRI of the painful knee.

The radiographic assessment includes the anterior view, lateral view, schuss view, and axial view of the patella at 30° flexion. All images are generally normal.

The clinical diagnosis of ITBS is confirmed by MRI. An area of hyperintense signal between the ITB and the lateral condyle reflects an inflammatory thickening in this area (Fig. 12.2). One can also find moderate oedema of the lateral condyle. MRI can also rule out associated lesions, particularly involving the lateral meniscus.

Fig. 12.2 MRI, axial section left knee. The *arrow* shows the high signal interposed between the iliotibial band and the lateral femoral condyle

Treatment Strategy

Conservative treatment is offered in all cases including sports rest, NSAIDs, icing, and physical therapy (including deep transverse massage by the physiotherapist). Treatment continues with stretching to the tensor fascia lata and strengthening of the gluteal muscles. Formal therapy should be complimented by self-rehabilitation (learning self-stretching).

Surgical treatment is indicated after failure of a well-conducted conservative treatment protocol lasting at least 6 months.

Surgical Technique

The procedure is performed under either general or epidural anesthesia. The patient is placed in supine position with a vertical post just lateral to the proximal thigh. The knee is maintained at 90° of flexion with horizontal post. A tourniquet is routinely applied.

The procedure is performed in two stages.

The first stage consists of knee arthroscopy with use of the anteromedial portal (for the arthroscope) and the anterolateral portal (for instruments), allowing full knee joint exploration. All associated lesions are treated. The knee arthroscopy is performed to eliminate any potential intra-articular pain sources. The lateral compartment is usually normal on arthroscopic evaluation.

The second stage consists of an open approach with the knee held in flexion. A short skin incision 15–20 mm in length is created parallel to the ITB at its posterior margin at the level of the lateral epicondyle. The incision is carried down through the skin and subcutaneous tissue until the posterior border of the ITB is visualized (Figs. 12.3 and 12.4). A transverse incision 10 mm in length is made in the posterior fibers of the ITB and is performed with an 11 blade. The anterior fibers of the iliotibial band are left intact. The incision of the posterior fibers leads to the formation of a "V" opening posteriorly and facing the lateral epicondyle. The synovium is not opened and synovectomy is not performed.

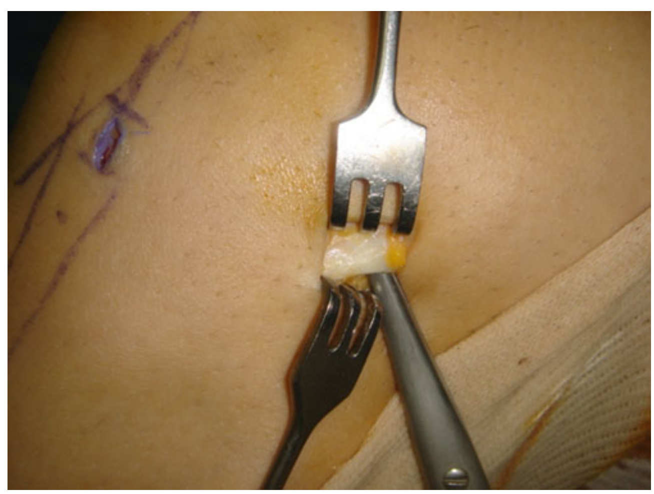


Fig. 12.3 Dissection of the iliotibial band

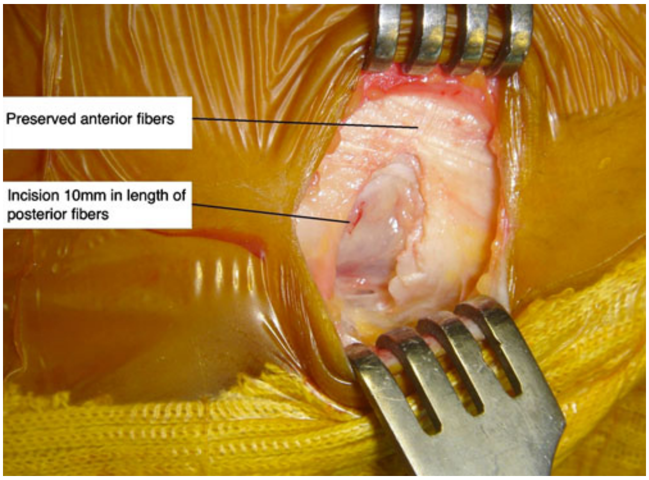


Fig. 12.4 Posterior fibers of the iliotibial band are sectioned transversely for 10 mm. The anterior fibers are left intact

Postoperative Care

This operation is performed as an outpatient surgery. Full weight bearing is allowed immediately postoperatively without immobilization. The skin sutures or staples are removed between day 12 and day 15. The patient should initiate physical therapy during the recovery period. Anticoagulation is generally not indicated. Patients are generally out of work for 10 days. The resumption of sports activity takes place during the second month postoperatively.

13 Surgical Indications in the Treatment of Osteoarthritis

P. Archbold and J.L. Paillot

Introduction

When conservative management of knee arthritis fails, one of the following surgical procedures may be indicated: osteotomy, unicompartmental arthroplasty (UKA), or total knee arthroplasty (TKA). Arthroscopy and lavage as well as arthrodesis will not be described here. The procedure indicated is dependent on the clinical history from the patient, as well as his or her functional complaints, motivations, clinical examination, and radiological findings.

An overview of the anatomic and clinical parameters is given.

Anatomic findings	Clinical findings
Stage of osteoarthritis	Weight
Analysis of the deformity and its reducibility	Age, level of activity, function Medical conditions (diabetes, rheumatoid arthritis, use of anticoagulants)
Ligamentous status (frontal and sagittal laxity)	Surgical history
Range of motion	

The procedure chosen by the surgeon is also influenced by geographical factors (an osteotomy is more frequently performed in continental Europe than in the UK or USA), cultural factors (osteotomy more frequently in Asian and Muslim countries, arthroplasty more frequently in English-speaking countries), and economical factors (UKA is not recognized and taught as a treatment option in certain countries).

Patient Expectations and Information

A patient's satisfaction following surgery is the result of the difference between his expectations (functional expected result) and the obtained functional result (Figs. 13.1 and 13.2).

This equation is therefore dependent on informing the patient in detail of the risks, benefits, and expected outcome of the surgical procedure that is to be performed. Importantly, this information must be adapted to the patient's level of understanding. Unrealistic patient expectations can be a common reason for dissatisfaction following surgery.

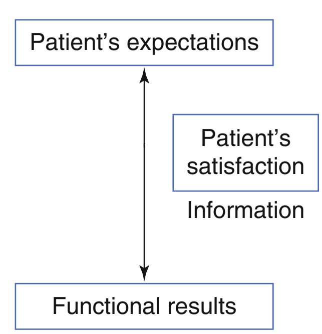


Fig. 13.1 A patient's satisfaction following surgery is the result of the difference between his expectations (functional expected result) and the obtained functional result

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

J.L. Paillot, MD
Clinique Herbert, Aix-Les-Bains, France
e-mail: paillot.jl@free.fr

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_13, © Springer-Verlag London 2014

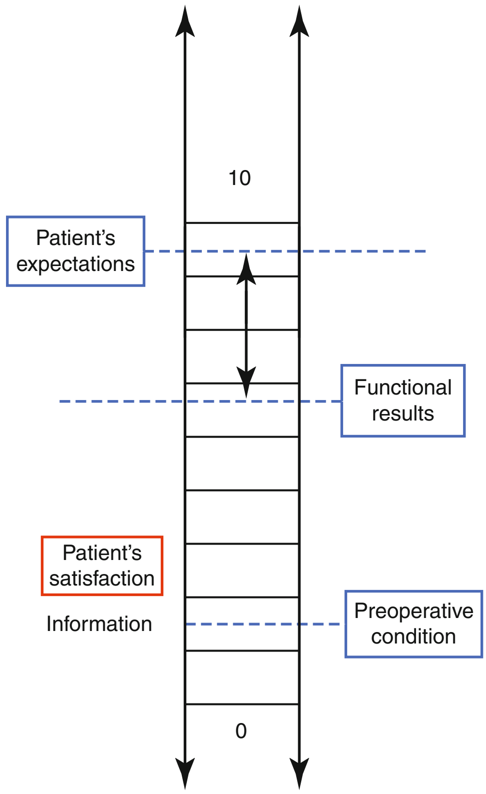


Fig. 13.2 A patient's satisfaction following surgery is the result of the difference between his expectations (functional expected result) and the obtained functional result

The Concept of the Functional Envelope Described by Scott Dye Applied to Osteoarthritis (Fig. 13.3)

The X-axis represents the frequency of the applied forces/load, while the Y-axis represents the intensity of the applied forces/load. The surface under the curve defines the functional envelope of the knee. The upper limit thus defines the threshold above which a clinical reaction may be observed (discomfort, pain, swelling, stress fracture). The definition of the functional envelope remains a theoretical concept with a large variation between individuals and over time. It remains difficult to determine the individual upper and lower threshold.

Nevertheless, the profile of the functional envelope can be modified by medication, surgery, and rehabilitation. Each type of intervention will modify the functional envelope in a specific way. Total knee arthroplasty will change the shape of the curve differently than an osteotomy.

It has to be remembered that:

1. The patient has the possibility to modify his activity (or his body weight) to reenter the functional envelope.
2. The aim of surgery is to enlarge this envelope. If the area of the envelope is reduced, it has to be clearly explained to the patient. If the patient applies excessive forces, above the threshold, the risk for failure is increased.

Expected functional outcome after a total knee arthroplasty of which the patient should be informed:

1. Pain: pain-free (95 %), forgotten knee (40 %).
2. Stability (98 %).
3. Walking distance of at least 5 km.
4. Normal stair climbing.
5. No limping or use of crutches.
6. Swelling of the knee is possible.
7. Hunting, golf, doubles tennis, and gardening are expected.
8. Full extension, flexion up to 120°.
9. Slow postoperative recovery for the patient: immediate weight bearing, 5–7 days' hospitalization, rehabilitation center (3–4 weeks), activities of daily life, and driving of the car possible 30–45 days postoperatively.
10. Necessity for long-term follow-up, revision TKA possible.

Survival curve: *90 % at 15 years*

Infection rate: *1.5 % in the 10-year-period postoperative*

Functional result after unicompartmental knee arthroplasty:

1. Pain: pain-free (95 %), forgotten knee (70 %).
2. Stability (98 %).
3. Walking distance of at least 10 km.
4. Normal stair climbing and descending.
5. No limp or use of crutches.
6. No swelling.
7. Walking on uneven terrain, hiking, skiing, and tennis are possible.
8. Full extension, flexion of up to 145°.
9. Demanding intervention for the surgeon: immediate weight bearing, 5 days hospitalization, return to home or rehab center 2 weeks, functional autonomy and driving of a car possible 30 days postoperatively.
10. Strict surveillance during follow-up, revision to TKA possible.

Survival curve: *90 % at 10 years*

Infection rate: *0.5 % on the 10-year postoperative period*

Functional result of an osteotomy:

1. Pain: pain-free (95 %), forgotten knee (80 %).
2. Stability (90 %).
3. Unlimited walking distance.
4. Normal stair climbing and descent.
5. No limp, no use of crutches, no swelling.
6. All sports (impact and contact) are possible but are not recommended.
7. Full extension, flexion to 145°.
8. Slow recovery: weight bearing is not allowed until 2 months postsurgery, 5 days' hospitalization, return to home, functional autonomy, and driving (75 days); it takes 4–6 months to adapt to the modified biomechanics and degree of valgus.
9. Revision total knee arthroplasty is easy (see chapter of revision of an osteotomy).

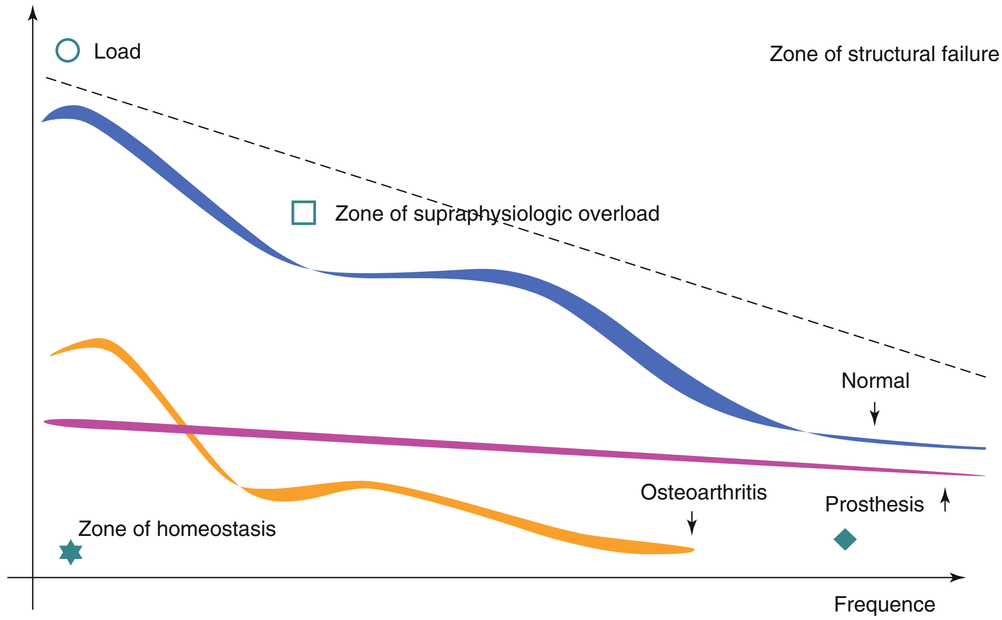


Fig. 13.3 Concept of the functional envelope (described by Scott Dye) applied to osteoarthritis. Situations: *circle*, jump from 3-m height; *square*, patient playing basketball; *star*, sitting in chair; *diamond*, walking 10 km

Survival rate: *70 % to 10 years*
Infection rate: *less than 0.5 %*

Indications

The indication is often a compromise, and it should be a choice made by both the patient and the surgeon. For teaching purposes, we would like to remind you that it is not always possible to have ideal indications. Sometimes one or more criteria will make the indications limited or disputable.

Osteotomy:

- Ideal indication
  - Clinical exam:
    - Pain localized on the tibiofemoral joint line
    - Normal range of motion
    - Normal ligamentous status
    - Nonreducible deformity (Fig. 13.4a, b)
    - No inflammatory arthritis
    - Less than 70 years old
    - No obesity
  - Radiological findings (Fig. 13.5a–c):
    - Partial or complete joint space narrowing in one compartment
    - No contralateral tibiofemoral joint space narrowing or patellofemoral joint space narrowing
    - Extra-articular deformity more than 5°
- Disputable indications:
  - Patellofemoral arthritis
  - Flexion <100° or fixed flexion deformity
  - Intra-articular deformity
  - Age >70 years
  - Obese women

Unicompartmental prosthesis:

- Ideal indication
  - Clinical examination (Fig. 13.6a–c):
    - Pain at the tibiofemoral joint line
    - Normal range of motion
    - Normal ligament status
    - Reducible deformity
    - Above 60 years old
    - Weight limited to 80 kg
    - No inflammatory arthritis
  - Radiological findings (Fig. 13.7a–c):
    - Unicompartmental partial or complete joint space narrowing
    - No contralateral tibiofemoral or patellofemoral joint space narrowing
    - No ligamentous laxity
    - Reducible deformity without hypercorrection
    - No frontal laxity
    - Extra-articular deformity <5°
- Disputable indications:
  - Asymptomatic patellofemoral arthritis
  - Flexion <100°
  - Extra-articular bony deformity between 5 and 8°
  - Surgical history including malunion, HTO, UKA
  - Age <60 years old
- Contraindications:
  - Inflammatorys arthritis
  - Chronic anterior laxity

Fig. 13.4 (**a**, **b**) Nonreducible deformity

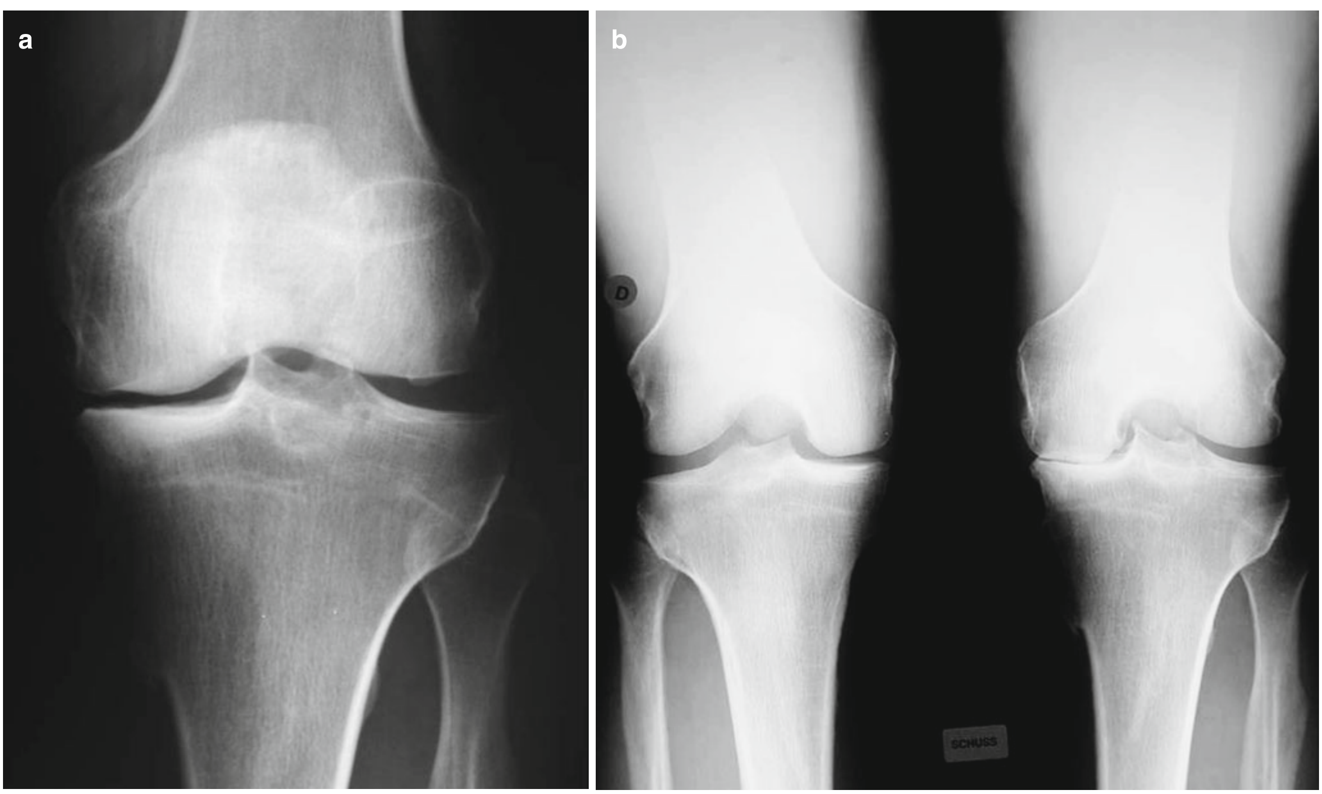


Fig. 13.5 Full weight-bearing X-rays. (**a**) AP view. (**b**) Schuss view at 45° of flexion. (**c**) Lateral view (30° of flexion)

Fig. 13.5 (continued)

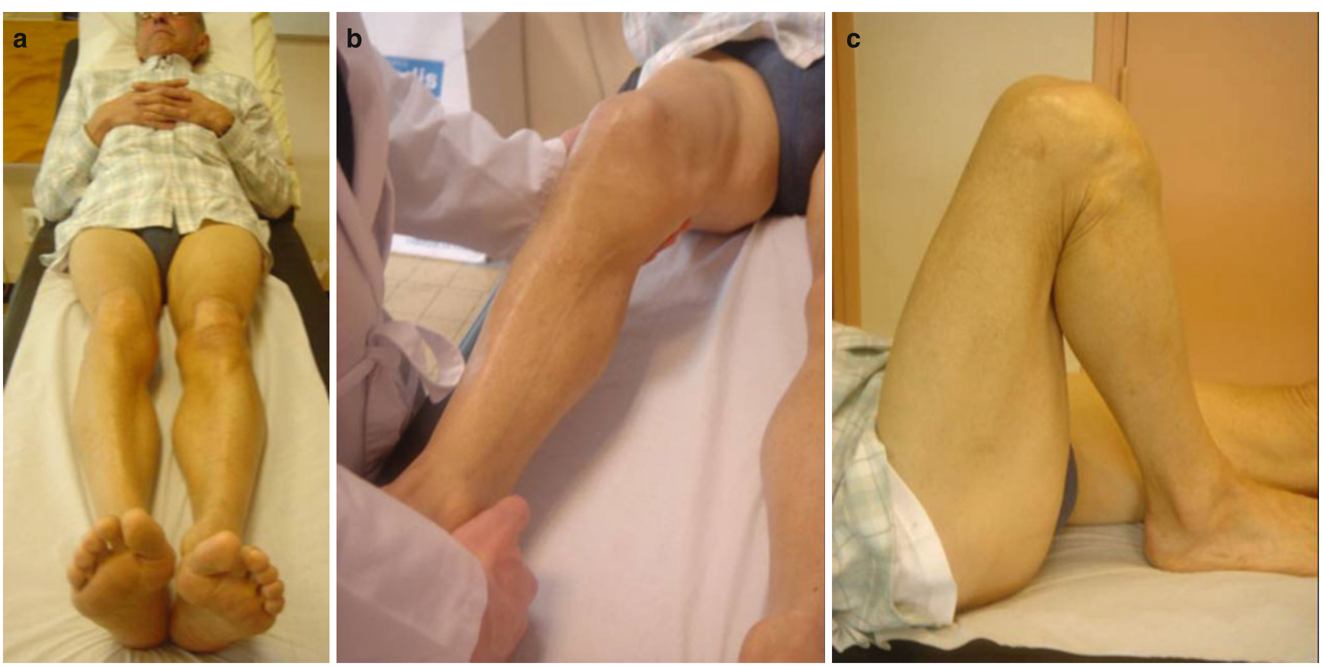


Fig. 13.6 Clinical examination. (**a**) Mild deformity. (**b**) Reducible deformity. (**c**) No flexion stiffness

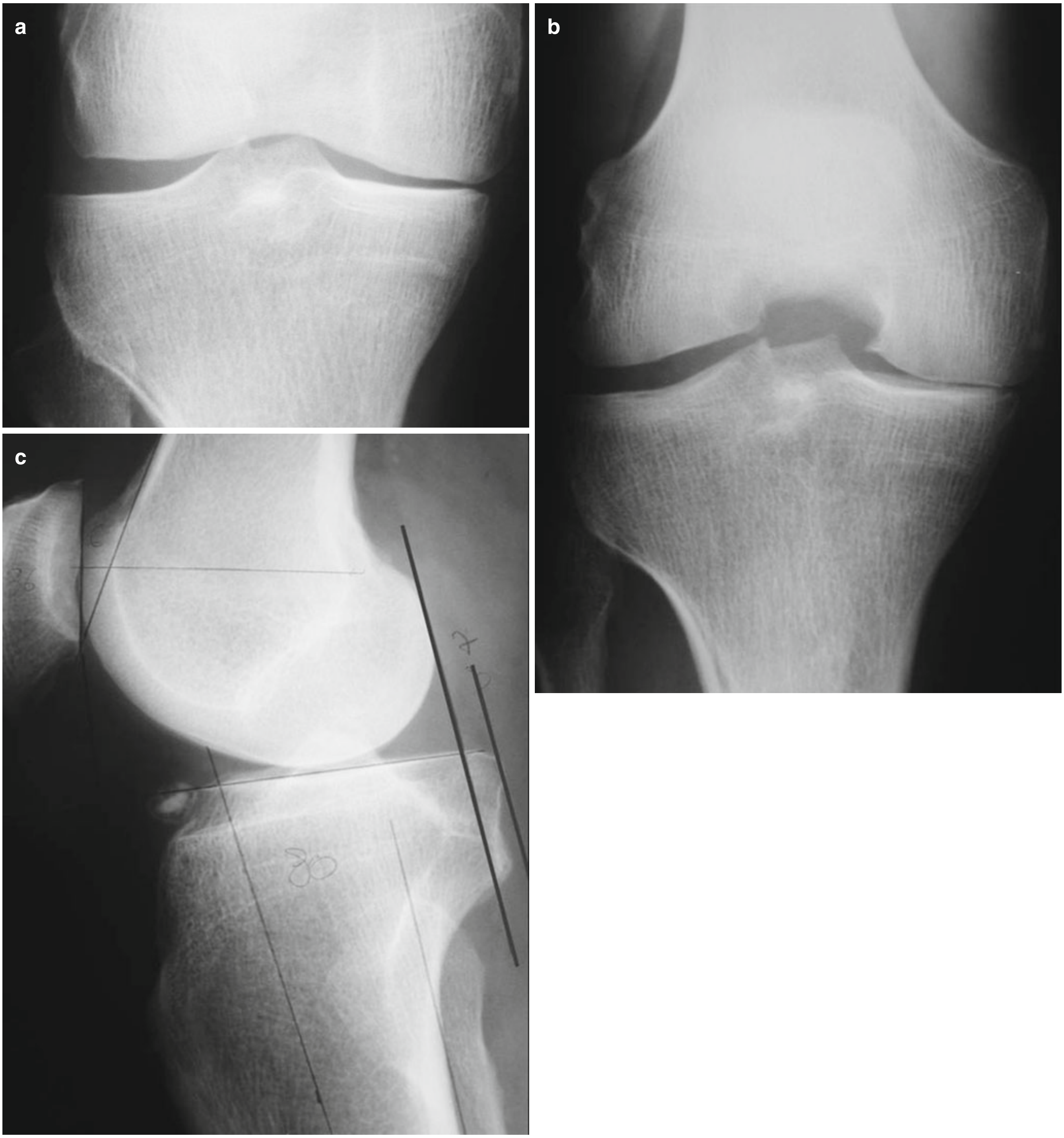


Fig. 13.7 X-ray findings. (**a**) AP view. (**b**) Schuss view. (**c**) Lateral view

Total Knee Arthroplasty: All Other Indications

The decision to proceed to a TKA is the most commonly selected surgical option. A "monoculture" surgeon is tempted to propose a TKA for the majority of his/her patients. Others will only proceed to a TKA in the presence of contraindications for a unicompartmental arthroplasty or an osteotomy.

Clinical examination:

- Reduced quality of life
- Weight is not a contraindication, no influence on wear (Fig. 13.8).

Fig. 13.8 Obesity is not a contraindication to TKA

Radiological Evaluation

The radiological evaluation is the same for all three types of intervention (osteotomies, unicompartmental knee, and total knee replacement). It includes:

At the Time of the Consultation (Minimum Work-Up)

- Single leg AP view: type of arthritis, location, presence of osteophytes, cysts, foreign bodies, obliquity of the joint line.
- Single leg lateral view at 30° of flexion: presence of a capsule, patella height, tibial slope, anterior tibial translation, malunion with flexion deformity. This view is the most important view for anti-recurvatum osteotomies.
- Skyline view of the patella in 30° of flexion: to examine the patellofemoral joint.
- Bilateral leg stance at 45° of flexion view (schuss view). This view is excellent to evaluate tibiofemoral joint space narrowing that is frequently underestimated on the AP view.

Prior to the intervention:

Preoperative planning is essential. It includes:

Bilateral full leg view: allows measuring of the different angles and axes.

- The mechanical femoral axis is represented by a line connecting the center of the femoral head and the middle of the tibial spine.
- The mechanical tibial axis connects the middle of the tibial spine and the middle of the ankle joint.
- The mechanical lower limb axis represents the overall deformity of the lower limb.

This view is of interest:

- *For osteotomies*: it will define the origin of the deformity (at the level of the femur or tibia) and will thus indicate the level to perform the osteotomy, the importance of the overall deformity, and the amount of correction that will have to be performed.
- *In unicompartmental knee prosthesis*: it will define the deformity and will illustrate reducibility (full leg stress X-rays).
- *In total knee arthroplasty*: it will determine the overall deformity and possible bony defect and will allow planning of the femoral and tibial cuts.

Stress radiographs in varus and valgus will illustrate intra-articular laxity and reducibility of the deformity.

Of interest is the measurement of the constitutional varus:

- Epiphyseal axis defined by Levigne: line connecting the middle of the tibial joint line and the middle of the line connecting the tibial epiphysis. This axis forms a constant angle of 90° ± 2° to the lateral tibial plateau (Fig. 13.9).

The constitutional deformity of the tibia is defined as the angle between the epiphyseal axis and the tibial mechanical axis (Fig. 13.10).

- Sometimes it is difficult to determine the middle of the tibial joint line and to perform the measurement. Therefore, we prefer to determine the level of the original tibial plateau by the line tangent to the normal contralateral tibial plateau. Subsequently, the mechanical tibial axis is drawn. The angle between both axes is the angle alpha. The constitutional varus is defined by the complementary angle 90-alpha (Fig. 13.11).

  Additional radiological investigations:

For anti-recurvatum osteotomies: two long profile hyperextension views of the lower limb (the femoral recurvatum is the angle defined by the line tangent to the anterior cortex and the line tangent to the Blumensaat line; the tibial recurvatum is defined by the tibial slope).

CT imaging will determine the presence of rotational problems. Certain patients with a frontal valgus or varus deformity develop a unilateral arthritis at the side of the convexity of the malunion. This lateralization of the degenerative process can be explained by the rotational problem. An internal medial rotation will cause lateral tibiofemoral arthritis, while an external femoral rotation will cause medial tibiofemoral arthritis.

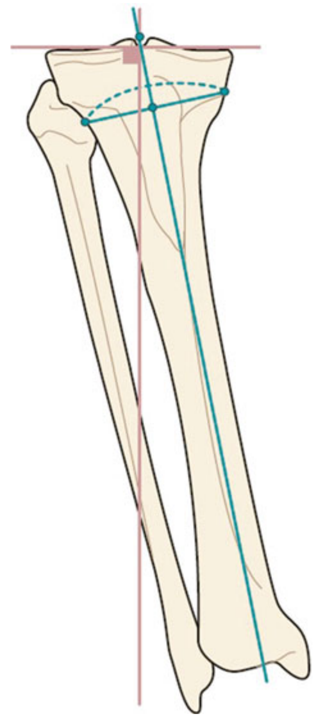


Fig. 13.10 The constitutional deformity of the tibia is defined as the angle between the epiphyseal axis and the tibial mechanical axis

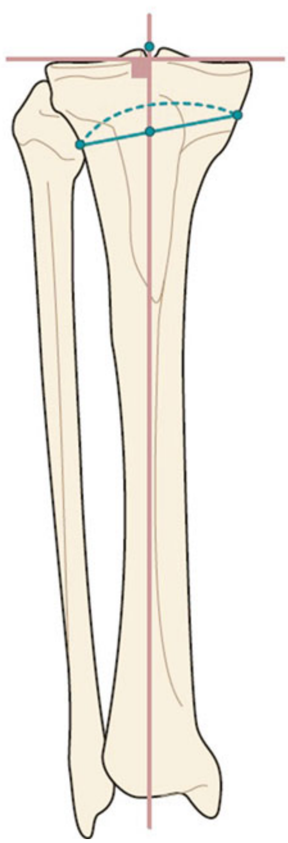


Fig. 13.9 Epiphyseal axis defined by Levigne

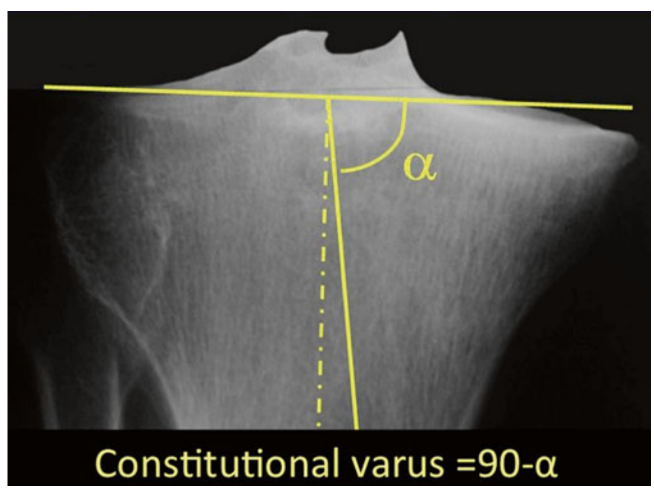


Fig. 13.11 The constitutional varus is defined by the complementary angle 90-alpha

14 Osteotomy: General Concepts and Indications

P. Archbold and J.L. Paillot

Introduction

Before the introduction of the total knee arthroplasty into clinical practice, an osteotomy was the treatment of choice for osteoarthritis. Today, an osteotomy is considered technically difficult for the surgeon and demanding for the patient. Nevertheless, in our daily practice, osteotomies are an important treatment option for arthritis of the knee because they allow a return to a high level of activities including sports. An osteotomy delays the need for a total knee prosthesis in young active patients. Obviously, the following variables have to be taken into account: the type of arthritis, clinical and radiological criteria, and patient expectations. In this chapter, we will not discuss the criteria that make us chose an osteotomy over a total knee prosthesis for degenerative knee pathology, but rather which type of osteotomy is indicated in different clinical situations.

Type of Arthritis

Medial Osteoarthritis

Certain factors support the use of a tibial osteotomy:

- The origin of the medial gonarthritis is usually on the tibial side and is usually in the proximal metaphyseal region.
- The clinical outcome of an osteotomy in medial osteoarthritis is reported to be good, reliable, and durable with a survivorship of approximately 70 % at 10 years.
- An osteotomy restores the morphology with a horizontal joint line.

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

J.L. Paillot, MD
Clinique Herbert, Aix-Les-Bains, France
e-mail: paillot.jl@free.fr

- Technically, the objective of this procedure is to obtain an overcorrection between 3 and 6° of valgus, as measured on the mechanical tibiofemoral angle between 183 and 186°.

Opening Wedge of Osteotomy

Advantages:

- Very precise correction
- Fewer problems with the peroneal nerve

Disadvantages:

- Need for bone graft; consolidation is more difficult (8–10 weeks).
- Tensioning of the extensor system and to a less degree the medial collateral ligament and medial tendinous structures.

We prefer an opening wedge high tibial osteotomy in the young patient with preosteoarthritis or limited osteoarthritis.

Closing Wedge Osteotomy

Advantages:

- Easy consolidation (7–8 weeks)
- Natural tendency to decrease posterior tibial slope

Disadvantages:

- Peroneal nerve at risk
- More variability in the obtained correction

We prefer a closing wedge high tibial osteotomy in the somewhat older patient with advanced osteoarthritis. In case of evolving osteoarthritis secondary to chronic anterior laxity, this is the technique of choice.

Lateral Osteoarthritis

- This type of OA is of mixed origin both on the femur (hypoplasia of the lateral femoral condyle) and on the tibia.
- The clinical outcome is less reproducible.
- We aim for a correction between 0 and 2° of varus.

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_14, © Springer-Verlag London 2014

Opening Wedge Distal Femoral Osteotomy

Since the origin of the valgus knee is often situated in the distal femur, an osteotomy of the distal femur seems logical. Nevertheless, we have to understand that a correction by osteotomy is only obtained in the frontal plane, in extension (P. Chambat). The anatomy and alignment is not changed in flexion, and thus a valgus knee will persist in flexion after a distal femoral osteotomy. Therefore, the indication for a distal femoral osteotomy is a valgus knee in extension (Figs. 14.1, 14.2 and 14.3). If the knee is well aligned in extension but a joint space narrowing is observed on the tunnel view, the options for treatment are a medial high tibial closing wedge osteotomy or a unicompartmental prosthesis. For the moment, we believe that the classification of the valgus knee according to the origin of the deformity is not yet well understood and that deformities at the level of the diaphysis are not yet included. A distal femoral osteotomy requires rigid fixation, is associated with more blood loss, and has a high risk for arthrofibrosis.

We generally perform a distal femoral osteotomy in older patients with a valgus of distal femoral origin. The patients should be well motivated.

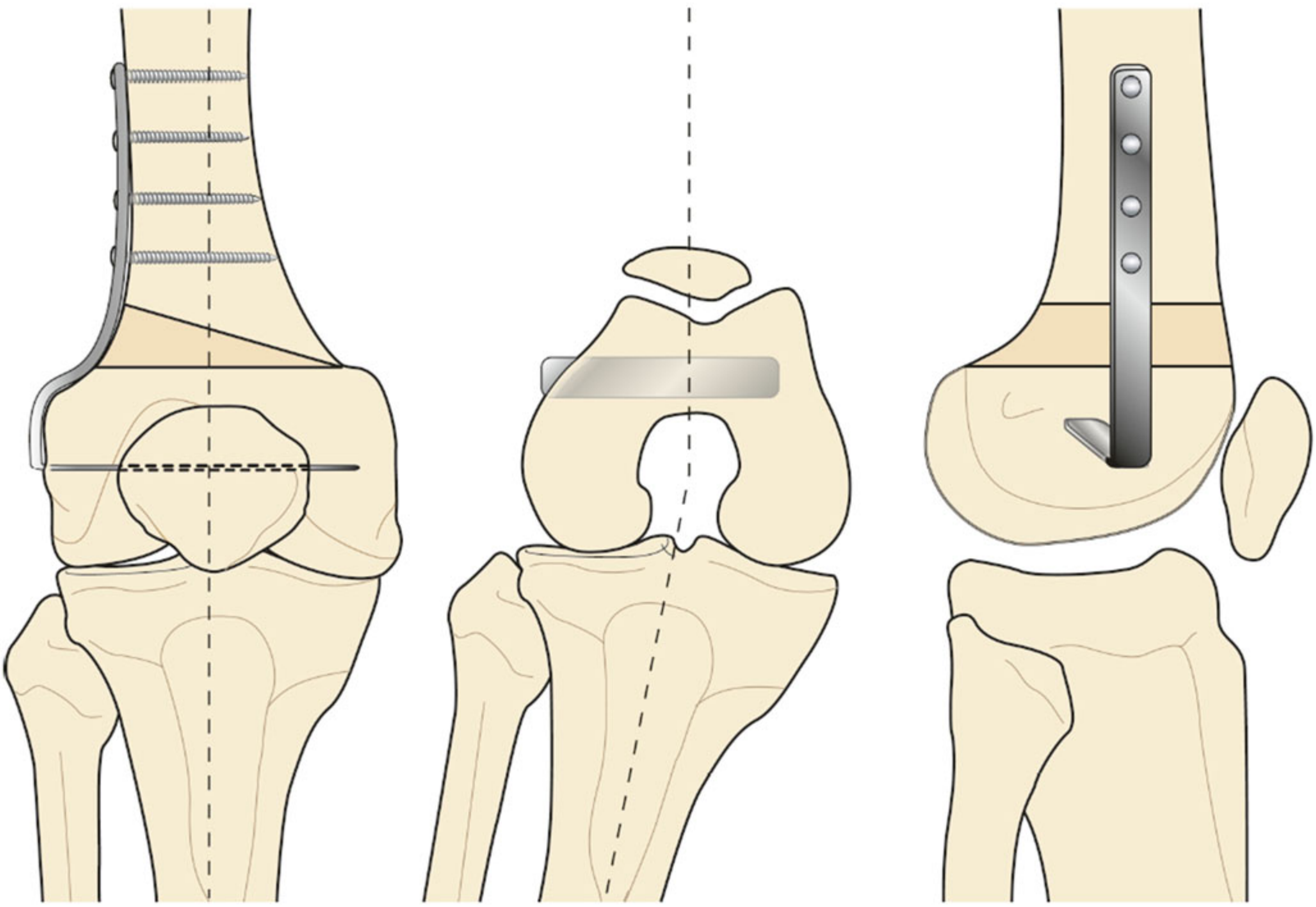


Fig. 14.1 A correction by femoral osteotomy is only obtained in the frontal plane, in extension (P. Chambat)

Figs. 14.2 and 14.3 Patient should be examined in extension and in flexion. In this case, the genu valgum (right knee) is greater in knee flexion than in extension

High Wedge Tibial Osteotomy for Varization (Medial Closing High Tibial Osteotomy)

This type of osteotomy on the contrary will have an effect both in extension and in flexion. It is indicated and justified in those valgus knees of a mixed origin. However, it is accompanied with a risk of significant obliquity in the joint line. This obliquity, if superior to 10°, can generate excessive stress on the patellofemoral joint, especially on the medial side. We propose a medial closing wedge high tibial osteotomy for the patient around 60 with a high level of activities including sport, with a valgus knee of mixed origin or of tibial origin which is less than 8°.

Clinical and Radiological Criteria

Age

In a young patient with limited or early medial gonarthritis, we prefer an opening wedge high tibial osteotomy.

Weight

Morbid obesity has a negative influence because of both loss of correction in the osteotomy and difficulties during the non-weight-bearing period.

Arthritis Secondary to ACL Rupture

Because the wear pattern is located more posteriorly on the tibial plateau (due to the ACL rupture), decreasing the tibial slope will limit the anterior tibial translation. Therefore, a closing wedge high tibial osteotomy is more appropriate.

Origin of the Deformity

- If extra-articular (constitutional or malunion), the osteotomy is considered “corrective” since it will correct the bony deformity.
- If intra-articular (wear), the osteotomy is considered “palliative” because the wear deformation is compensated by creating a bony deformity.

Expectations of the Patient

The preoperative level of activity and the expected postoperative level of activity of the patient will influence the indications for an osteotomy. We are more likely to treat an older patient with a high level of activity, including sports, with an osteotomy.

Advice to Give to the Patients Before Surgery

- Adapt your home (carpets, animals, stairways) to decrease the risk of a fall.
- Physiotherapy should be initiated preoperatively to learn how to walk with crutches.
- Advise weight loss preoperatively (this is possible in the young patient, but it remains difficult in the older patient).
- Advice to quit smoking since this has a negative effect on the achievement of union and on wound healing.

In conclusion, our main indications are as follows:

Medial Osteoarthritis

Opening wedge high tibial osteotomy:

- Young patient.
- Early OA: stages 1 and 2.
- Specific case: combination ACL reconstruction and osteotomy.
- In the exceptional case of a constitutional varus knee without OA (constitutional varus superior to 8°, if bilateral or with more than four fingerwidths of space between the condyles). In these rare cases, the aim is to leave some residual varus (2–3°).

Closing wedge high tibial osteotomy:

- Older patient but active
- Stages 3 and 4
- Patella infera
- Chronic anterior laxity with posterior wear on the tibial plateau

Femoral osteotomy and double osteotomy are exceptional: these techniques are indicated in secondary arthritis due to malunion, vit. D deficiency, etc.

Lateral Arthritis

Tibial osteotomy:

- To correct abnormalities of mixed origin (femoral and tibial) only if the obliquity of the joint line will not be superior to 10° after your osteotomy and in a valgus knee inferior to 8°.
- We prefer a medial closing wedge osteotomy.
- Lateral opening wedge high tibial osteotomy with a revision osteotomy of the fibula is only indicated secondary to an excessive lateral closing wedge high tibial osteotomy with an overcorrection.

Femoral osteotomy:

- Valgus knee of femoral origin.
- Valgus with a fixed flexion deformity or a hyperextension of more than 20°: this pathology can be addressed more appropriately with a femoral osteotomy than with a tibial osteotomy. However, the morbidity of the femoral osteotomy is more significant and has to be integrated into the indication flowchart in order to prevent complications.

In case of a large deformity

Double osteotomy combining a lateral distal femoral opening wedge osteotomy and a medial closing wedge high tibial osteotomy can be considered.

15 Distal Opening Wedge Femoral Osteotomy for the Treatment of a Valgus Deformity

P. Verdonk and Robert A. Magnussen

Introduction

In this chapter, we present the surgical steps to perform an opening lateral wedge distal femoral osteotomy, which is fixed using a 95° angled blade plate. The overall aim of this osteotomy is to correct the mechanical axis of the lower limb to a normal varus (0–3° of varus). In general, it is better to slightly overcorrect than to undercorrect. During preoperative planning one can determine the desired angle of correction and the opening that will be needed to obtain this correction.

P. Verdonk, MD, PhD (✉)
Antwerp Orthopedic Center, Monica Hospitals,
Harmoniestraat 68, 2018 Antwerp, Belgium
e-mail: pverdonk@yahoo.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
2050 Kenny Rd, Suite 3100, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_15, © Springer-Verlag London 2014

Radiological Workup

Cf. chapter on surgical indications for osteoarthritis.

The radiographs serve not only to determine the proper indications but also to measure the correction needed (Figs. 15.1, 15.2, and 15.3).

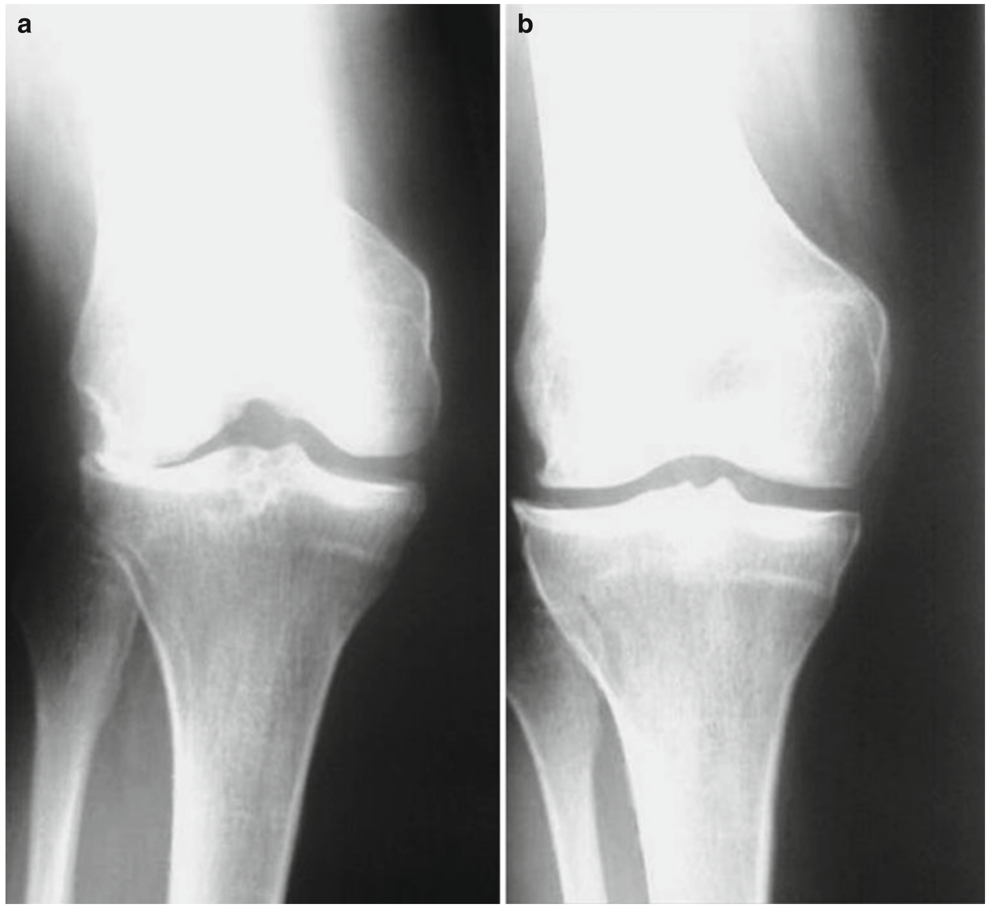


Fig. 15.1 Schuss X-rays PA flexed knee views) (**a**) have better sensitivity for osteoarthritis diagnosis than full extension X-rays (**b**), particularly for lateral femorotibial OA

Fig. 15.2 Long leg films (full weight bearing) are required to measure the femorotibial mechanical axis, the femoral mechanical axis, and the tibial mechanical axis and to diagnose a lower limb length discrepancy

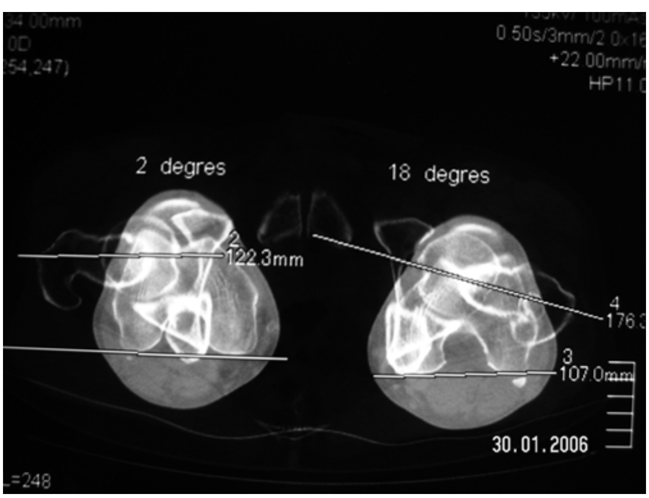


Fig. 15.3 In case of rotational deformity, a CT scan is required to measure the femoral neck anteversion/retroversion according to the posterior condyles line

Surgical Technique

With the knee in 90° of flexion, a lateral skin incision starts 15 cm proximal to the joint line and ends at a level of Gerdy's tubercle (Fig. 15.4). The fascia lata is incised slightly anteriorly in the direction of its fibers, and the lateral vastus muscle is elevated. The perforating arteries of the vastus lateralis are carefully coagulated or ligated. Subsequently, the vastus lateralis is elevated from the lateral border of the femoral diaphysis using a periosteal elevator. The patellar tendon is identified and a limited lateral arthrotomy is performed: this is to visualize the orientation of the trochlea and the condyles. Two guide pins are inserted into the joint: one at the femorotibial joint line and another in the patellofemoral joint (Fig. 15.5). The guide pins act as guide to help orient the surgeon to accurately place the blade plate. This step reduces the radiation due to imaging. Next, the osteotomy site is prepared. The osteotomy is horizontal, just proximal to the lateral part of the trochlea. With the knee in extension, the suprapatellar pouch is elevated, and with the knee at 90° of flexion, soft tissues on the posterior side of the metaphyseal region are elevated. With the oscillating saw, a landmark is made on the lateral side of the femur perpendicular to the horizontal osteotomy. This mark will serve as a guide to determine the rotation following osteotomy (Fig. 15.5).

Fig. 15.4 The skin incision is from 15 cm proximal to the joint line to Gerdy's tubercle

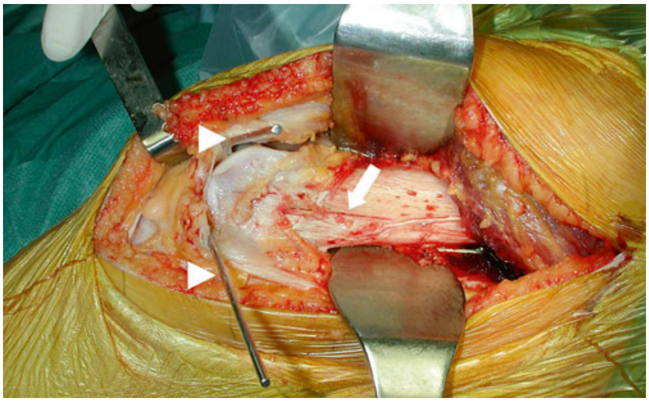


Fig. 15.5 Preoperative view showing the lateral cortex of the femur (*left knee*). A proximal arthrotomy is necessary. Two wires (*left arrows*) are inserted into the femorotibial joint and patellofemoral joint. A rotational landmark is superficially placed on the femoral cortex using the saw (*right arrow*)

Introduction of the Blade

The blade should be introduced into the epiphyseal region, 30 mm proximal to the joint line. The blade plate is 5.6 mm in thickness, 16 mm in width, and the distance between the screw holes is 16 mm. The guide for the blade plate should be introduced anteriorly and proximally to the femoral insertion of the lateral collateral ligament. The angle of insertion depends on the level of the deformity. If the deformity is situated at the diaphyseal level, the blade should be introduced obliquely to the joint line (Fig. 15.6). To obtain a varization of 10°, the angle should be set at 75° (85–10°; complementary angle to the anatomical distal femoral angle (95°) – angle of correction). If the deformity is situated at the metaphyseal level, the blade should be introduced parallel to the joint line (Fig. 15.7). This is the most common situation. When introducing the blade parallel to the joint line, an automatic correction to the normal anatomical femoral valgus of 5° is automatically obtained by introducing a 95° angled blade plate. In others words, if the femur is normal, no correction would be obtained when the blade plate is introduced parallel to the joint line. If we are confronted with a combined deformity or mixed with a metaphyseal component (lateral condyle hypoplasia or diaphyseal malunion), the angle of introduction should be even smaller and the blade plate should be introduced at a smaller angle. This preoperative planning is essential to evaluate the correction needed.

Intraoperative Control

The position of the blade can be checked using the image intensifier. The angle of correction can now be measured on a printout by drawing a line tangent to the medial and lateral condyle and another line tangent to the blade.

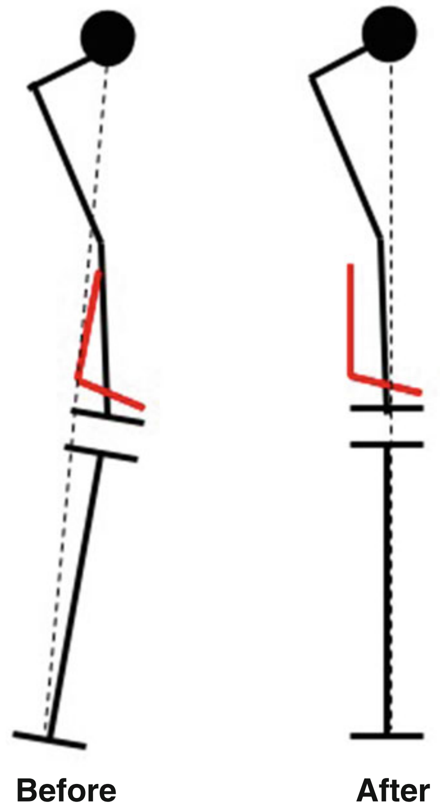


Fig. 15.6 Diaphyseal deformity: the blade should be introduced obliquely to the joint line. The correction angle will be equal to the femoral deformity angle

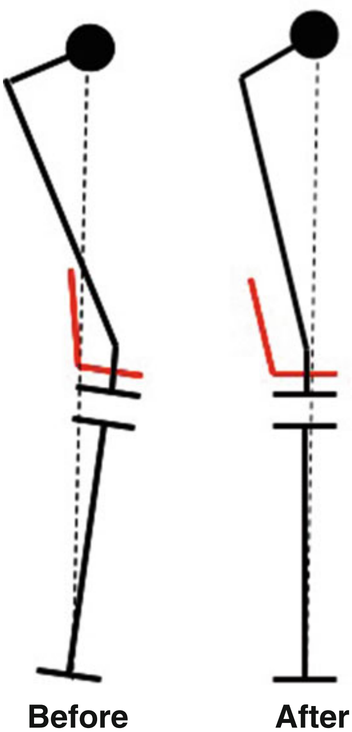


Fig. 15.7 Metaphyseal deformity: the blade should be introduced parallel to the joint line. An correction to the normal anatomically femoral valgus of 5° is automatically obtained

The Osteotomy

The femoral osteotomy is performed with an oscillating saw. The medial cortex should not be cut (the saw should “knock on the door” of the medial cortex as said by Henri Dejour). The blade plate is introduced, and the medial cortex is weakened using a 3.2 mm drill bit. Two or more osteotomes are then introduced into the osteotomy. It is, however, the impaction of the blade plate that will progressively open up the osteotomy once in contact with the diaphysis. Temporarily, a screw is placed in the distal oval screw hole (Fig. 15.8a). The blade plate is now impacted. The screw is in the proximal zone of the hole (Fig. 15.8b). Subsequently, a screw is introduced in another screw hole while the former is taken out (Fig. 15.8c). The impaction of the blade plate is continued and the osteotomy will progressively open up until the blade plate is in full contact with the lateral side of the femoral diaphysis (Fig. 15.9).

Progressive impaction allows opening of the osteotomy. Provisional fixation with one screw helps to control the correction and gives additional stability. By playing with the impaction and the positioning of the screws, one can either augment or decrease the amount of opening. If the blade plate is impacted with the screw left in place, the correction will be halted. To the contrary, if an additional screw is again placed in the distal part of the screw hole and the former screw is taken out, the correction can be augmented (Fig. 15.8c). Final fixation of the blade plate is achieved by four cortical screws of 4.5 mm diameter (Fig. 15.10). Cortical and cancellous iliac crest bone grafts are used to fill the osteotomy site. The soft tissues and skin are closed over a drain, which is introduced underneath the fascia lata.

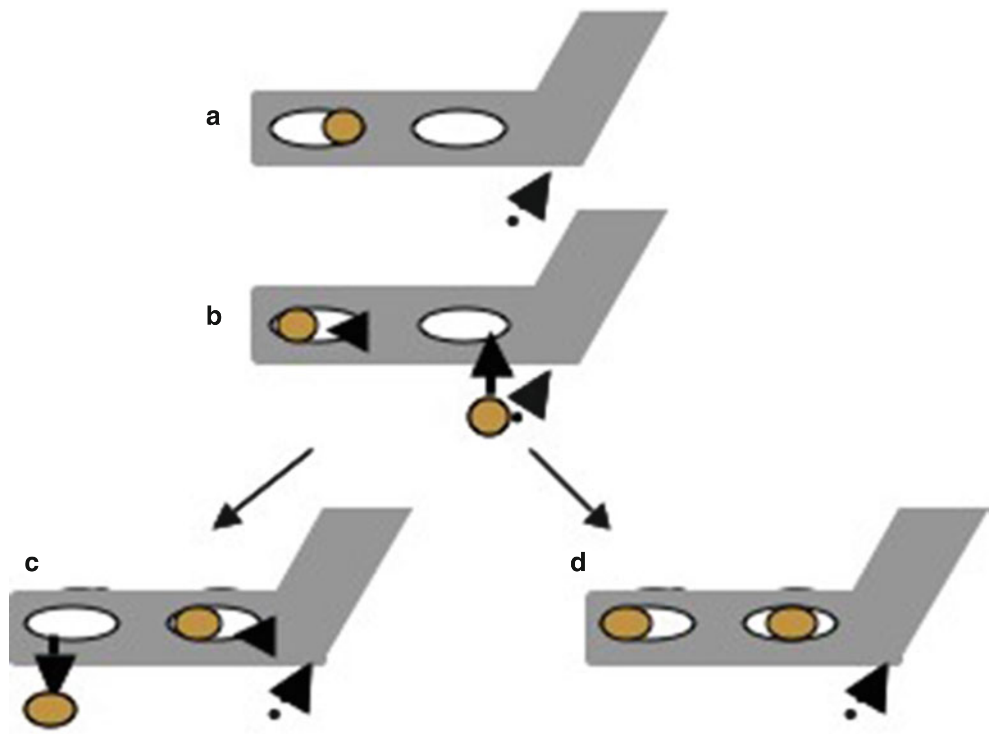


Fig. 15.8 A screw is temporarily placed in the distal oval screw hole (**a**). The blade plate is then impacted. The screw is in the proximal zone of the hole (**b**). Subsequently, a screw is introduced in another screw hole while the former is taken out. First situation: the blade impaction enhances the corrective effect if the first screw is removed (**c**). Second situation: the blade is impacted without removal of the first screw stopping the corrective effect (**d**)

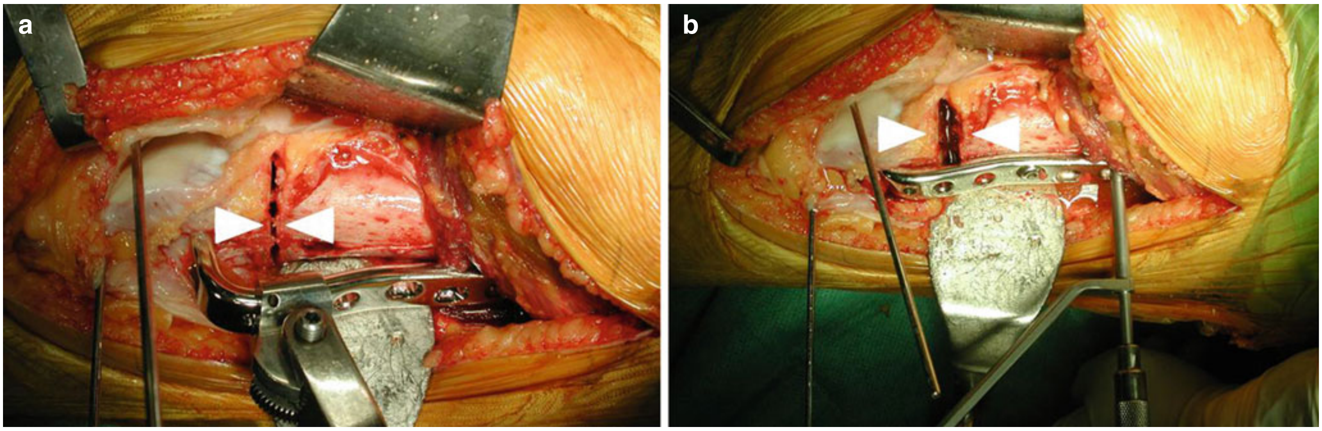


Fig. 15.9 (**a**) During blade impaction, the oseotomy site remains closed prior to contact of the proximal aspect of the plate with the femoral dia[hysis (**b**). The impaction of the blade plate is continued and the osteotomy progressively opens until the blade plate is in full contact with the lateral side of the femoral diaphysis

Fig. 15.10 Postoperative AP (**a**) and Lateral (**b**). X-rays showing a 95° angled blade plate with four proximal cortical screws. The final femorotibial angle is good

Postoperative Guidelines

Continuous passive motion is initiated immediately postoperatively. The flexion should be limited to 120° for the first 15 days postoperatively. Non-weight bearing is continued for 2 months and an extension brace is applied. Complications are observed somewhat more frequently than after a tibial osteotomy. Specifically, blood loss can be significant, and stiffness of the knee and delayed union are more frequent. Complications can be minimized by careful surgical technique and adherence to a specific postoperative rehabilitation protocol.

High Tibial Osteotomy

16

R. Debarge, F. Trouillet, G. Demey,
and Robert A. Magnussen

Introduction

In patients who have osteoarthritis of the medial compartment of the knee in association with genu varum, a high tibial osteotomy 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° of valgus.

The main reasons for failure are:

1. Initial undercorrection with the presence of a residual varus deformity
2. Overcorrection with progressive lateral arthritis
3. Development of patellofemoral arthritis

Two surgical techniques are available:

The medial opening wedge high tibial osteotomy (HTO) requires the use of a tricortical bone graft from the iliac crest for large corrections, and the lateral closing wedge high tibial osteotomy 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. More recently, we have started to use the TomoFix plate in medial opening wedge osteotomies. This technique has the benefit of not requiring a bone graft.

Radiological evaluation: See the chapter on surgical indications and 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. 16.1).

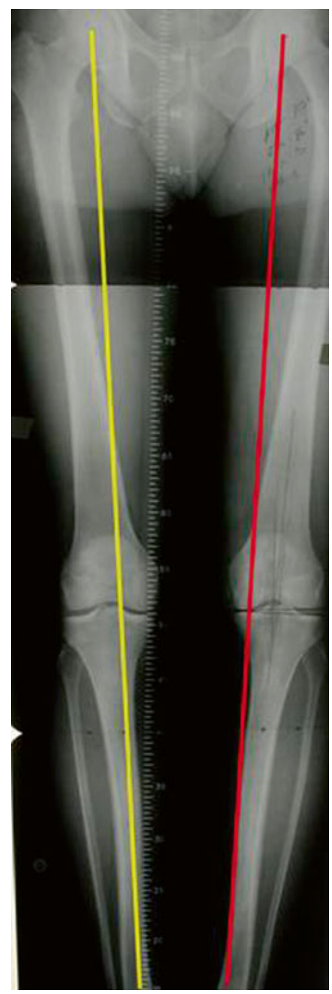


Fig. 16.1 Femorotibial mechanical angle of 174°: a correction of 9° (6+3) is planned for the osteotomy

R. Debarge, MD
Clinique Jean Causse,
Traverse de Béziers, 34440 Colombiers, France
e-mail: r_debarge@hotmail.com

F. Trouillet, MD
Renée Sabran Hospital,
550 Boulevard Edouard Herriot, 83400 Giens, France
e-mail: ftrouillet@hotmail.com

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, 69009 Lyon, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_16, © Springer-Verlag London 2014

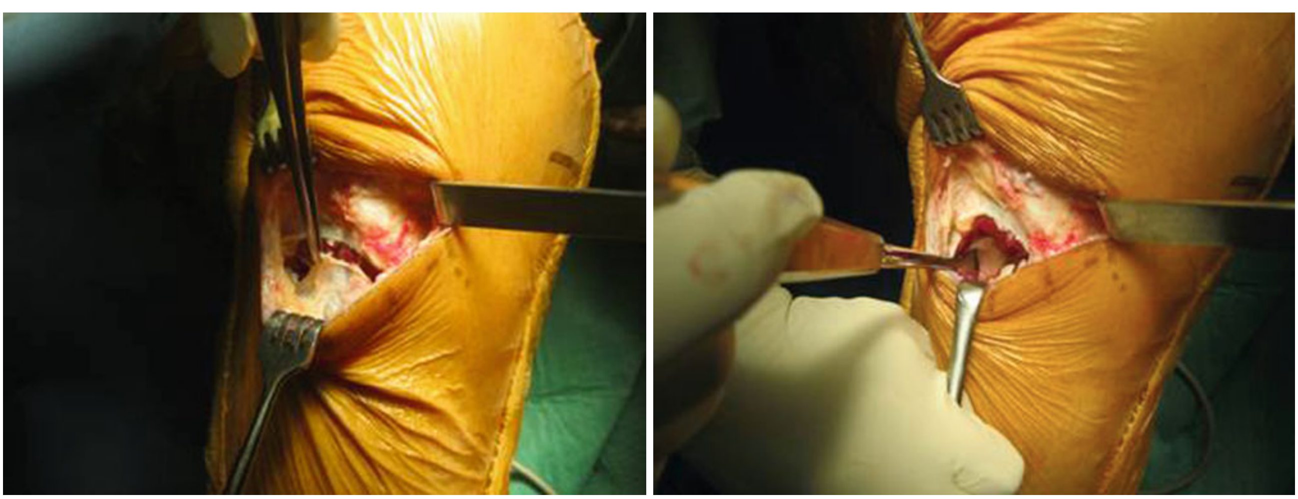
Lateral Closing Wedge HTO

Setup

The patient is placed in the supine position. A tourniquet is generally used. The patient is draped using an extremity sheet (Fig. 16.2) and the image intensifier is positioned. 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. 16.3). 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 (Figs. 16.4 and 16.5).

Fig. 16.2 Patient installation

Fig. 16.3 Skin incision



Figs. 16.4 and 16.5 The tibialis anterior muscle and the long toe extensor muscle are released from the tibial metaphysis

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. 16.6).

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 fibular shaft should be freely mobile. Care is taken that the peroneal nerve is not in contact with the osteotomy site.

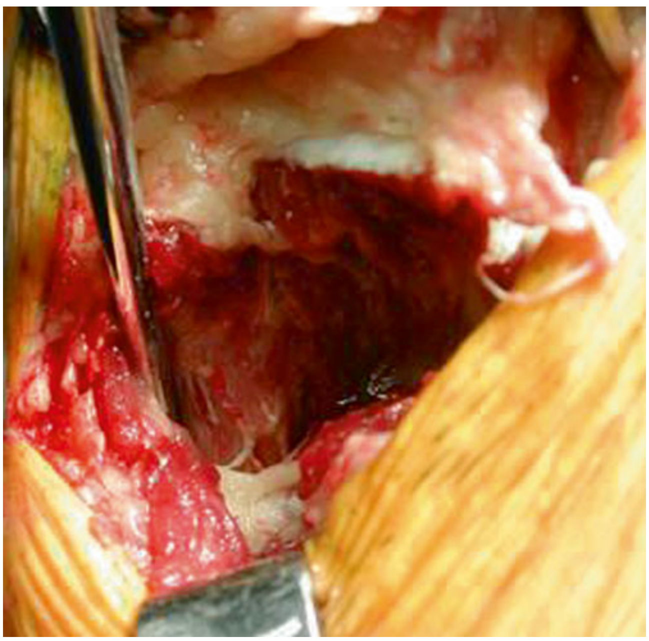


Fig. 16.6 Protection of the peroneal nerve

High Tibial Osteotomy (HTO)

Specific instruments are available to perform – in a reproducible way – the high tibial osteotomy (HTO) and achieve its fixation.

Closing Wedge High Tibial Osteotomy (HTO)

The osteotomy is performed proximal to the tibial tubercle in an oblique direction.

Identification of the osteotomy site with imaging is not necessary if the following rules are respected.

- Laterally, the osteotomy should start distally 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. The correct direction of the osteotomy is shown in Fig. 16.7
- 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.

We currently use the high tibial osteotomy (HTO) Intrasoft instrument for the fixation (Fig. 16.8). This blade plate/screw system has been specifically designed to minimize subcutaneous irritation. Different lengths of the blade and the screws are available to fit different width of the tibia:

(a) *Introduction of the guide pin parallel to the joint line* (Fig. 16.9)
A small guide pin is introduced at the level of the joint line, and an alignment guide is subsequently introduced over this guide pin. This guide will position the second guide pin parallel to the joint line and 1 cm distal to it.

(b) *Blade reamer introduction over the second guide pin* (Figs. 16.10 and 16.11)
Length of the blade should be 1 cm shorter than the total width of the tibia.

(c) *Box preparation for the blade* (Fig. 16.12)
The box preparation guide is introduced over the guide pin and impacted. Four drill holes are made with 6 mm diameter.

(d) *Introduction of the HTO blade* (Figs. 16.13 and 16.14)
The blade is introduced and impacted into the box.

(e) *Distal cut of the closing wedge osteotomy* (Figs. 16.15 and 16.16)
Many surgeons use a guide pin for the distal cut of the osteotomy. We do not feel this is necessary. The posterior surface of the tibia is protected by a large periosteal elevator; anteriorly the patellar tendon is retracted. An oscillating saw is used to perform the distal cut.

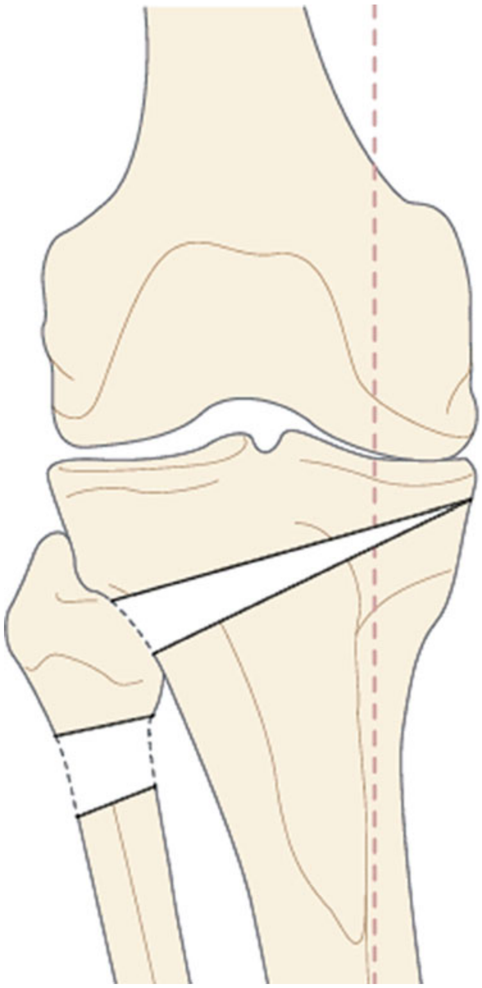


Fig. 16.7 Closing wedge high tibial osteotomy

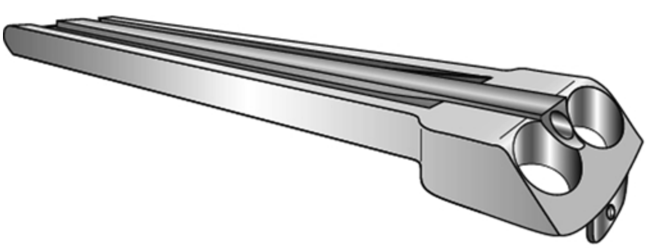


Fig. 16.8 HTO blade (Intrasoft, Tornier®)

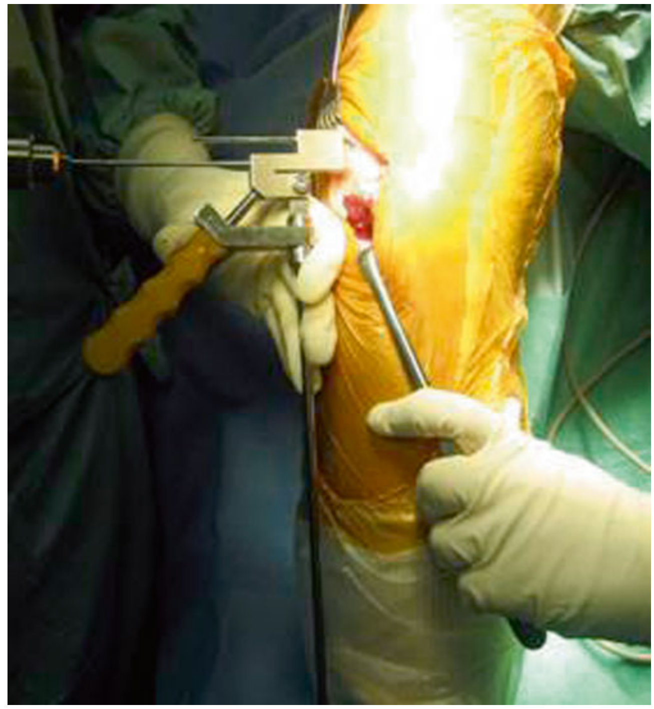
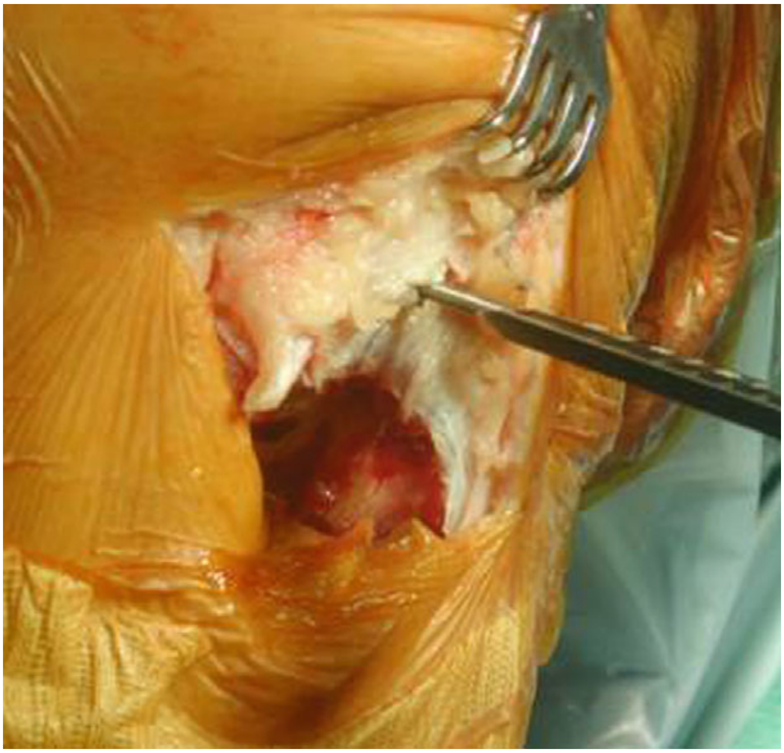
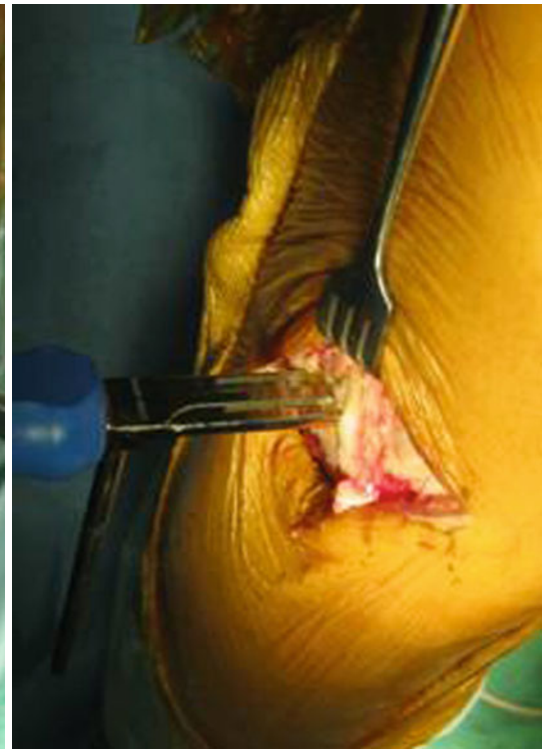


Fig. 16.9 Introduction of the guide pin parallel to the joint line

(f) *Proximal cut*
An angled cutting guide (6-8-10°) is introduced in the distal cut of the osteotomy; the proximal cut is now performed using this angle. The cutting guide should be introduced and impacted on the medial cortex. An oscillating saw is used (Fig. 16.17). The bone wedge is removed (Fig. 16.18).

(g) *Closing the wedge and image intensifier control of the obtained mechanical axis*
The medial cortex is breached with a 3.2 mm drill. Distal from the osteotomy a temporary unicortical screw is positioned. This screw will be used as support for the reduction clamp. The wedge is closed with the reduction clamp (Figs. 16.19 and 16.20). 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. 16.21 and 16.22).

(h) *Fixation of the osteotomy* (Figs. 16.23 and 16.24)
Two bicortical screws are then introduced through the blade into the distal tibia. The muscle insertions are closed over a drain. The skin is closed with interrupted sutures.

Figs. 16.10 and 16.11 Blade reamer introduction

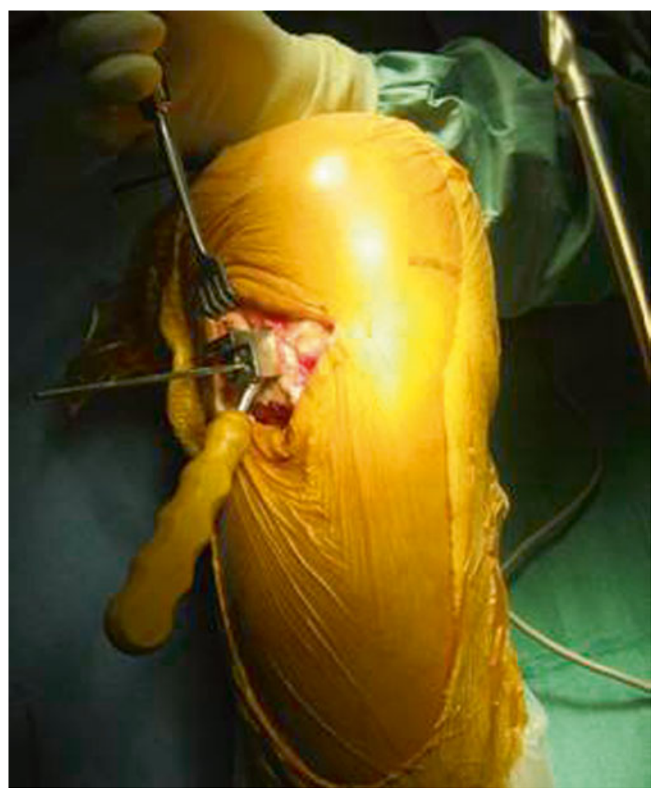
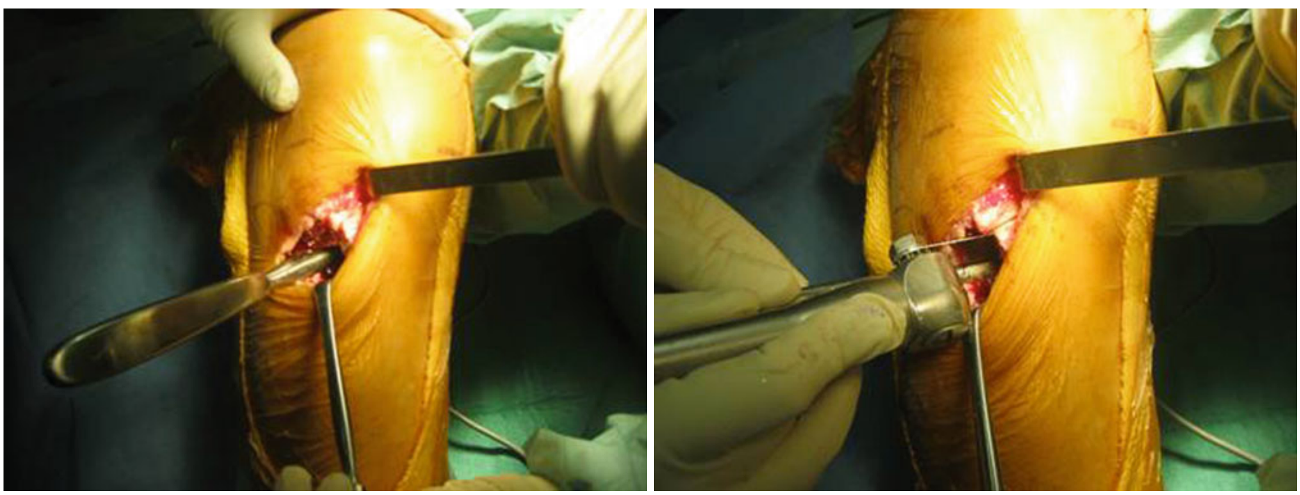


Fig. 16.12 Box preparation for the blade

Figs. 16.13 and 16.14 Introduction of the HTO blade



Figs. 16.15 and 16.16 Distal cut of the closing wedge osteotomy

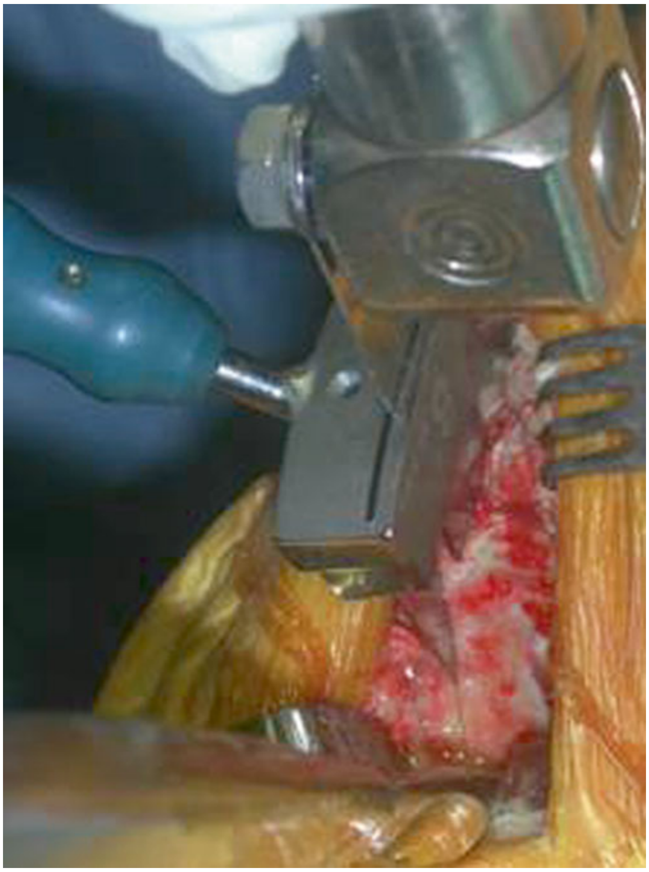
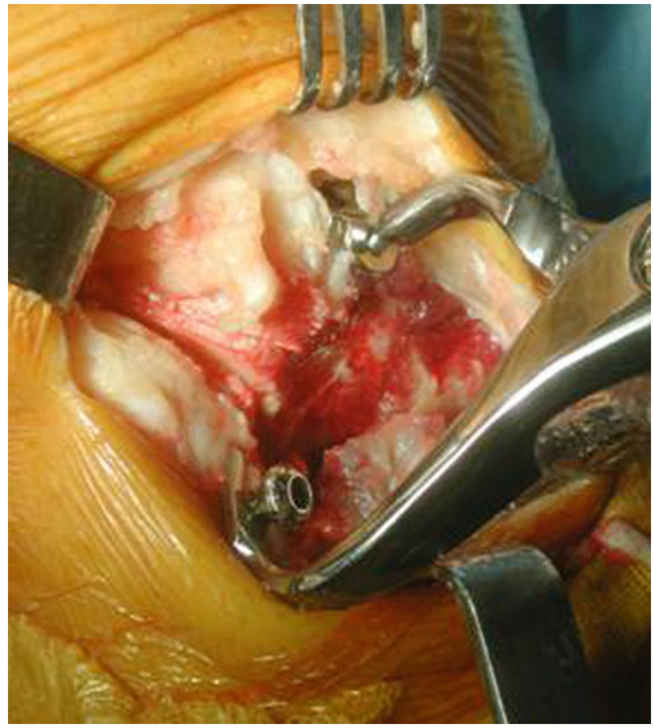
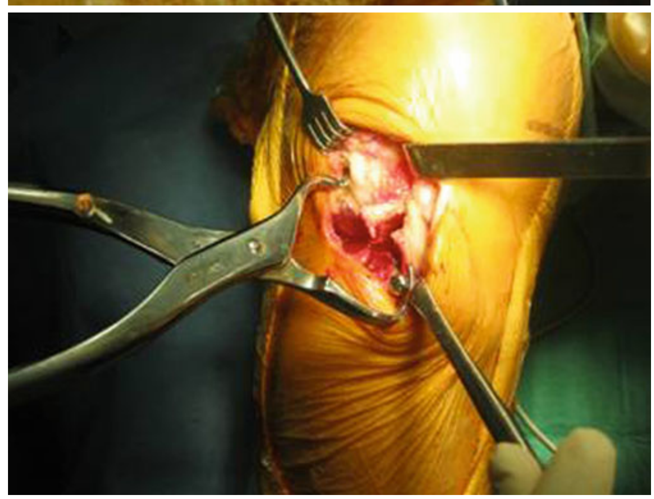


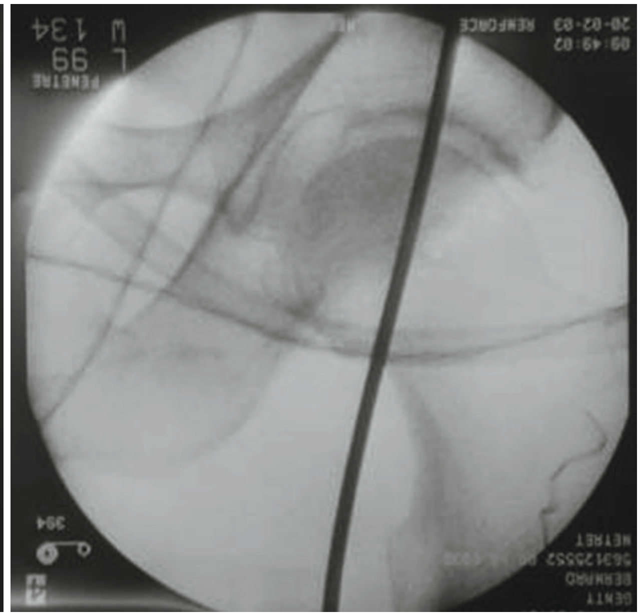
Fig. 16.17 Proximal cut of the closing wedge osteotomy using a cutting guide (6-8-10°)

Fig. 16.18 Bone wedge removal





Figs. 16.19 and 16.20 Wedge closing using the reduction clamp

Figs. 16.21 and 16.22 Preoperative fluoroscopic control using a long metal rod

Fig. 16.23 Fixation of the osteotomy

Fig. 16.24 Postoperative X-ray

Medial Opening Wedge High Tibial Osteotomy (HTO)

Setup

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. 16.25). The pes anserinus tendons are retracted. The superficial medial collateral ligament is incised at the level of the osteotomy (Fig. 16.26). 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.

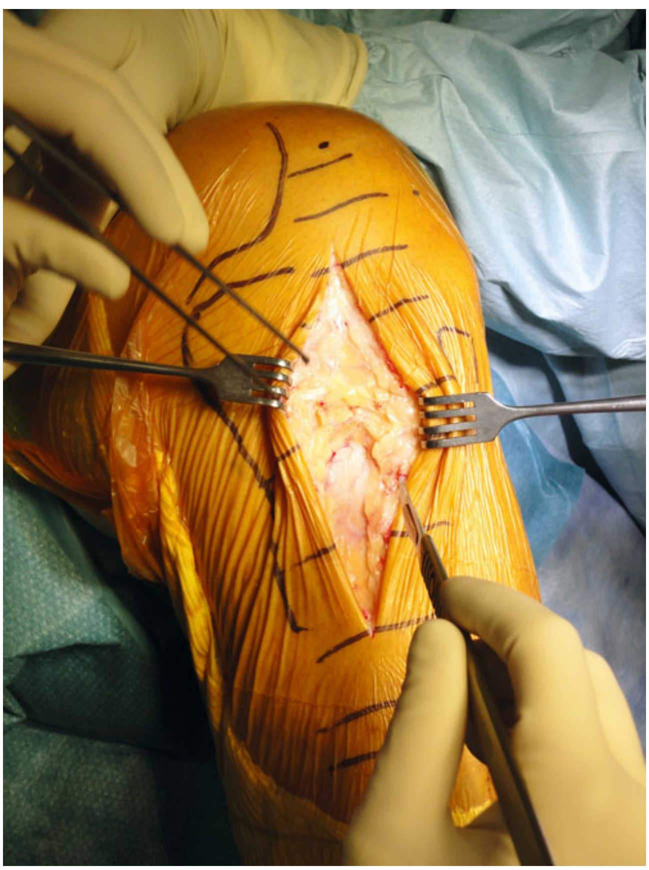


Fig. 16.25 Skin incision

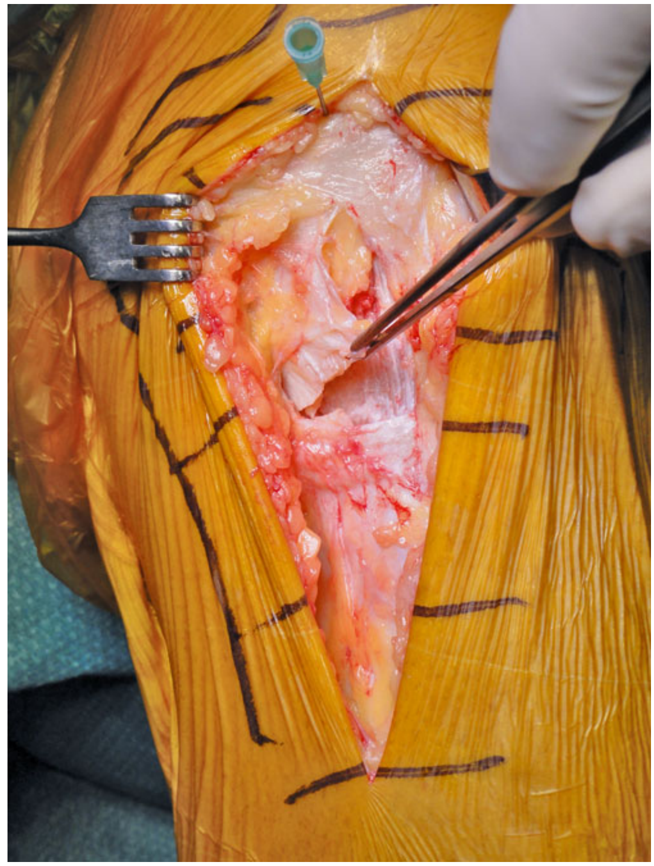


Fig. 16.26 Incision of the superficial medial collateral ligament

High Tibial Osteotomy (HTO)

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 horizontal (slightly different from the closing wedge medial high tibial osteotomy which is more oblique). First, 2 Kirschner 20/10 guide pins are introduced medially. Laterally, these guide pins should be just superior to the head of the fibula. An image intensifier is used to correctly position the guide pins. The direction can be adjusted, if necessary (Fig. 16.27). Using an oscillating saw, the tibial cut is now performed underneath these guide pins, but always staying in contact with them. The center of the tibia is cut first followed by the anterior and posterior cortices. The cuts are completed using an osteotome (Fig. 16.28), especially on the anterior cortex where the patellar tendon can be damaged. It is necessary to have an intact lateral hinge for this type of osteotomy. We preserve this hinge by first weakening it with a number of 3.2 mm drill holes (Fig. 16.29).

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 up the osteotomy, several more osteotomes are introduced between the first two (Fig. 16.30):

The first osteotome should be impacted against the lateral cortex and the second nearly as far. The third osteotome is then introduced in between the previous 2. If necessary a fourth and fifth osteotome are introduced between the first two. These osteotomes should not be impacted too deep, since they could break the lateral hinge.

If an insufficient opening of the osteotomy is obtained, the bony corticals anteriorly and posteriorly should be carefully broken using an additional osteotome.

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

- Fracture of the lateral hinge – frequently observed in significant corrections. This results in a surgical undercorrection of the deformity.
- Fracture of the lateral tibial plateau – this complication can occur if the lateral hinge has been insufficiently weakened or if one forcefully tries to open the osteotomy with a valgus maneuver or if the osteotomes are not placed deep enough. Usually, plate and screw fixation would suffice to overcome this complication.

The obtained angle of correction is systematically evaluated using a long metal rod centered on the hip and ankle (Figs. 16.31 and 16.32). The angular correction is evaluated at the level of the joint line (Fig. 16.33). If necessary, an additional osteotome is introduced or removed.

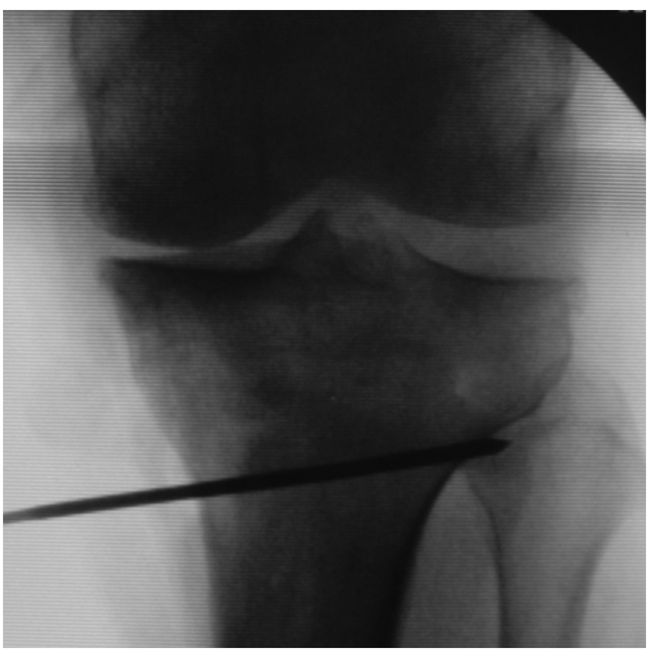


Fig. 16.27 Preoperative fluoroscopic control

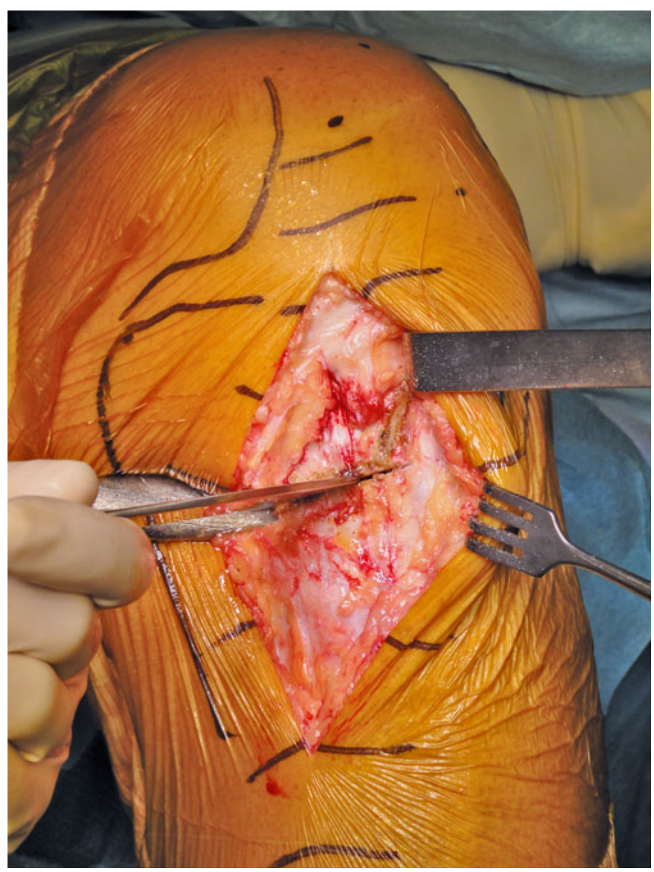


Fig. 16.28 The tibial cut is completed using an osteotome

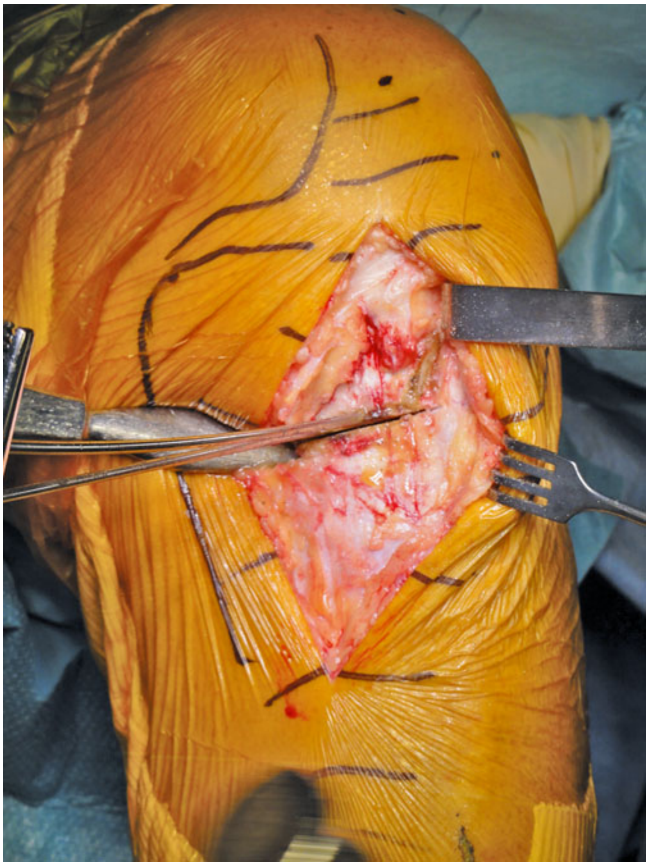


Fig. 16.29 The hinge is weakened using a 3.2 mm drill holes

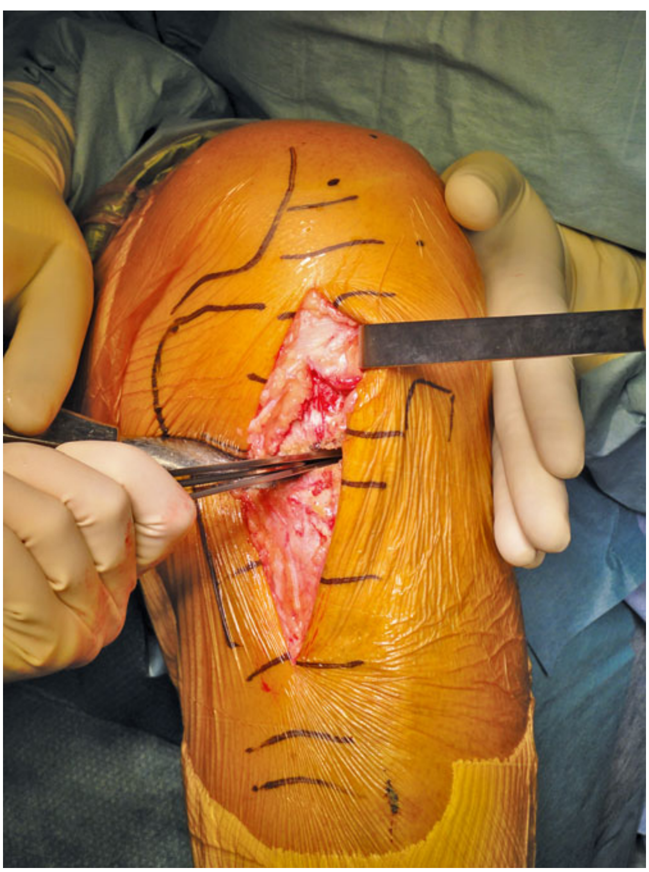
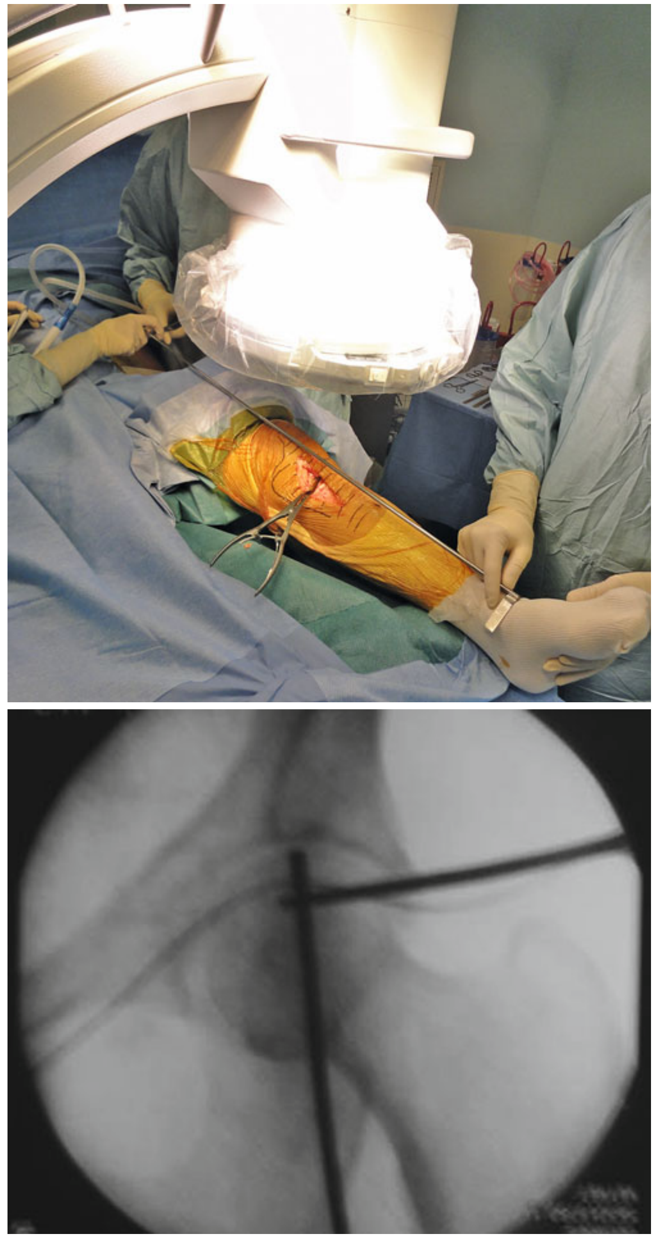


Fig. 16.30 To gently open up the osteotomy several more osteotomes are introduced between the first two



Figs. 16.31 and 16.32 Preoperative evaluation of correction using a long metal rod

Fig. 16.33 The femorotibial mechanical axis is lateral to the lateral tibial spine

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. 16.34). Other types of fixation are also possible (Staples, Surfix Plate, Chambat Plate, etc.). 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 to 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 is taken to check screw lengths and plate position.

The osteotomy site is filled with tricortical bone graft harvested from the ipsilateral anterior iliac crest (Fig. 16.35) in cases of large correction (over 10°). 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.

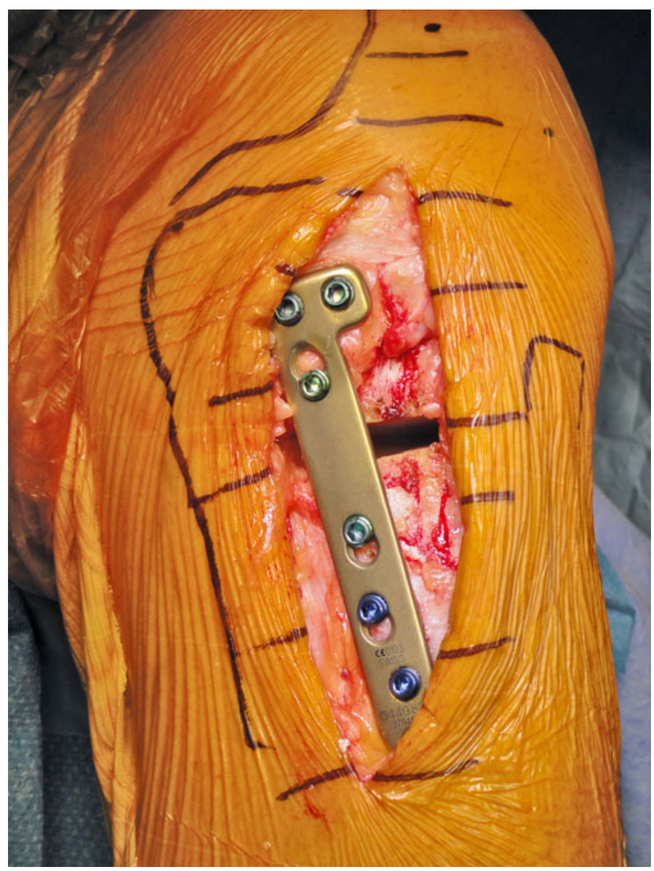


Fig. 16.34 Fixation of the osteotomy with a locking plate

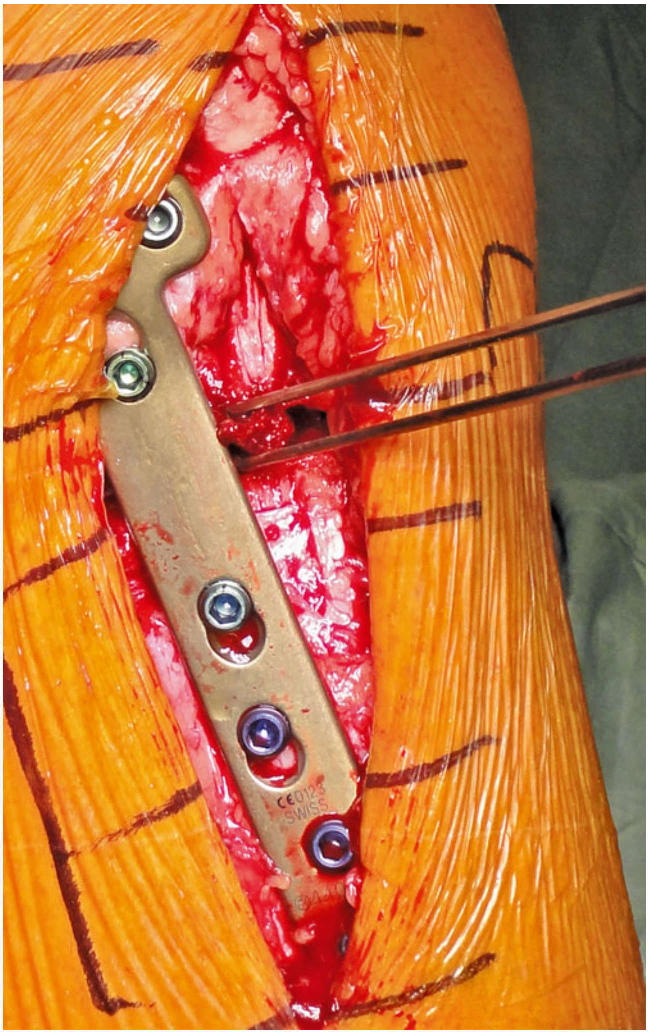


Fig. 16.35 Osteotomy site filled with bone graft in case of correction over 10°

Postoperative Guidelines

The postoperative guidelines are identical for the closing wedge as well as the opening wedge high tibial osteotomy (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 6 weeks depending on evidence of radiological union.
  - Walking protected by two crutches.
  - Thromboprophylaxis for 1 month.
  - Bracing in extension for 2 months.
  - Flexion is limited to 120° the first 15 days. After that date flexion can be progressively augmented.
  - Skin sutures are removed around day 12.
  - Driving a car is not allowed for 10 weeks.
  - Physical work is not allowed for 3–4 months.
  - Sports are allowed after 6 months after bony union has been achieved.

  Note:

Two specific complications can be observed after a closing wedge high tibial osteotomy (HTO):

- Peroneal nerve lesion
- Compartment syndrome

Radiographs should be taken 2 months after the intervention. If bony healing is observed, weight bearing can begin. If delayed union is suspected, weight bearing is delayed and the patient is invited to come back in 1 month.

Future Improvements

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

High Tibial Varus Osteotomy

17

R. Debarge and P. Archbold

Introduction

The varus high tibial osteotomy is indicated in the young active patient with lateral arthritis of the knee and a moderately valgus knee. This surgical procedure results in a durable and satisfying clinical outcome up to 8–12 years if the lower limb has been corrected to neutral alignment. This procedure addresses the valgus both in extension and in flexion. It results frequently in an obliquity of the joint line. This surgery should be used as an alternative to a knee prosthesis (TKA or UKA). The surgical technique consists of a closing wedge osteotomy on the medial side of the tibia. Exceptionally, a lateral opening wedge osteotomy is done to correct a deformity resulting from an excessive lateral closing wedge high tibial osteotomy.

Radiological Workout

Cf chapter surgical indications in arthritis of the knee.

The amount of correction needed to obtain a mechanical femorotibial axis of approximately 180° is calculated with respect to the width of the metaphyseal area of the tibia (Fig. 17.1).

The evaluation of the valgus deformity remains more difficult than the evaluation of a varus deformity.

Fig. 17.1 Femorotibial mechanical angle of 186°: a correction of 6° is planned. This evaluation is more difficult than in case of varus deformity

R. Debarge, MD
Clinique Jean Causse,
Traverse de Béziers, 34440 Colombiers, France
e-mail: r_debarge@hotmail.com

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_17, © Springer-Verlag London 2014

Surgical Technique: Medial Closing Wedge High Tibial Osteotomy

Patient Setup

The patient is placed in the supine position, and a tourniquet is used. The lower limb is covered with an extremity sheet (Fig. 17.2)

The image intensifier should be available.

The surgical approach is identical to the surgical approach for an opening wedge high tibial osteotomy. An anteromedial, slightly oblique, almost horizontal skin incision starts 1 cm proximal to the tibial tubercle and continues medially over a distance of 8 cm (Fig. 17.3).

The hamstring tendons are identified and retracted. The superficial medial collateral ligament is incised horizontally at the level of the osteotomy (Fig. 17.4). The proximal fibers of the superficial medial collateral ligament are elevated proximal and distal to the incision over distance of a couple of mm (uncovering the area of the wedge that will be resected).

A periosteal elevator is introduced posterior to the metaphyseal area of the tibia always staying in contact with the bone. The periosteal elevator is kept in place once the lateral side of the posterior tibia is reached. It will protect the posterior structures during the osteotomy.

A Farabeuf retractor is introduced underneath the patellar tendon to retract and protect it during the osteotomy.

Fig. 17.2 Patient setup

Fig. 17.3 Skin incision

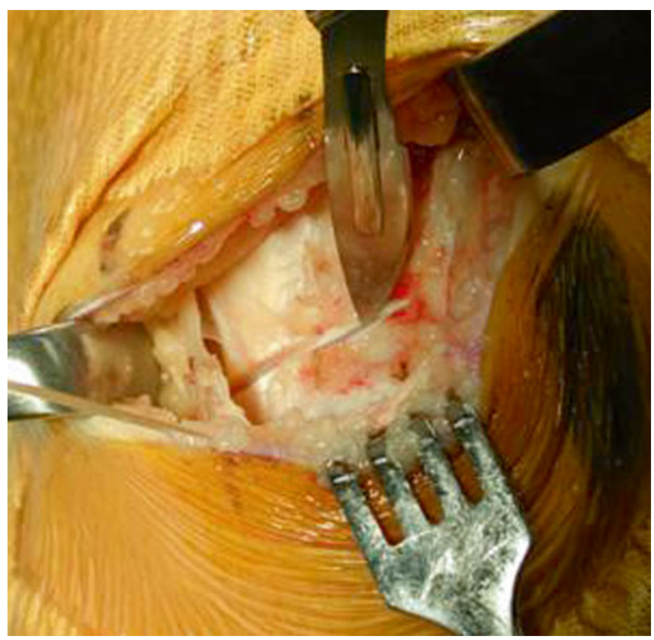


Fig. 17.4 The superficial medial collateral ligament is incised horizontally

The Tibial Osteotomy

The tibial osteotomy is performed just proximal to the level of the tibial tubercle. It is almost horizontal in the coronal plan, slightly oblique and upsloped from medial to lateral. Two Kirschner wires will serve as guide pins for the proximal cut of the osteotomy. The pins are introduced medially and will emerge laterally just proximal to the tibiofibular joint. After the introduction of two guide pins, their correct position is verified using an image intensifier (Figs. 17.5 and 17.6). The proximal cut of the osteotomy is done with an oscillating saw under the two guide pins (Fig. 17.7). First the mid part of the tibial is done and then the anterior and posterior cortex; the lateral cortex should not be transected. As Henri Dejour uses to say, you should only "knock at the door." The lateral cortex will serve as a hinge during the procedure. Subsequently, the distal cut is performed. In the sagittal plane, it should be parallel to the proximal cut, and in the frontal plan, it should converge on the lateral side. The distance between both cuts at the level of the medial cortex has been defined during the surgical planning. The wedge is removed using a large grasper. The lateral hinge is now gently perforated with a 3.2 drill to weaken it. Subsequently, the osteotomy will progressively close by introducing an osteotome into the osteotomy and gently further weakening the lateral hinge (Fig. 17.8). An intraoperative evaluation of the correction is mandatory. A long metal rod is placed from directly over the middle of the femoral head to the middle of the ankle joint (Figs. 17.9 and 17.10). At the level of the knee, this rod should be in the center of the knee following correction (Fig. 17.11).

An overcorrection should be avoided. Therefore the height of the resected wedge should not be excessive. A frequent error of overcorrection is the fact that the surgeon did not consider the thickness of the saw blade when making the resection. The osteotomy is fixed using two to three Blount or Orthomed staples on the medial side (Figs. 17.12 and 17.13). The use of other fixation devices such as plate and screw fixation is of course possible, but we prefer to use less prominent types of fixation in this area of the knee. The pes anserinus is closed over the staples. A drain is positioned in proximity to the osteotomy and the skin is closed using interrupted sutures.

Figs. 17.5 and 17.6 Intraoperative fluoroscopic control

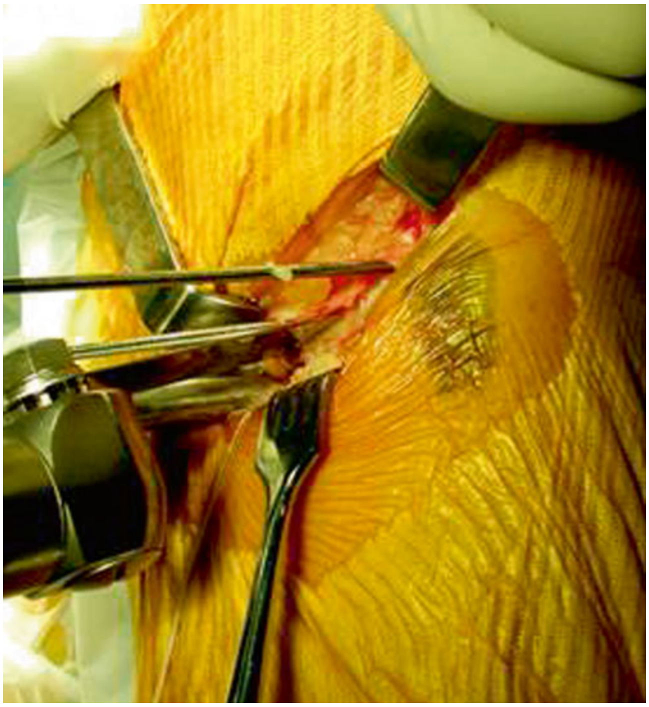


Fig. 17.7 Osteotomy with an oscillating saw under the two guide pins

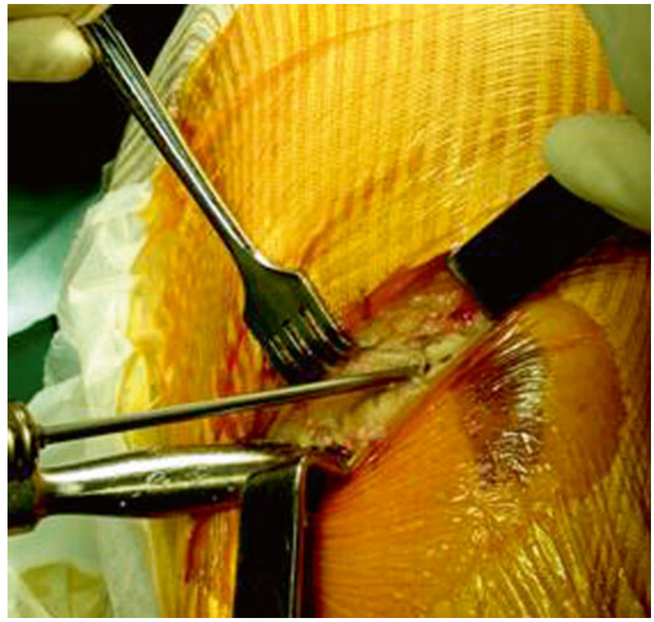
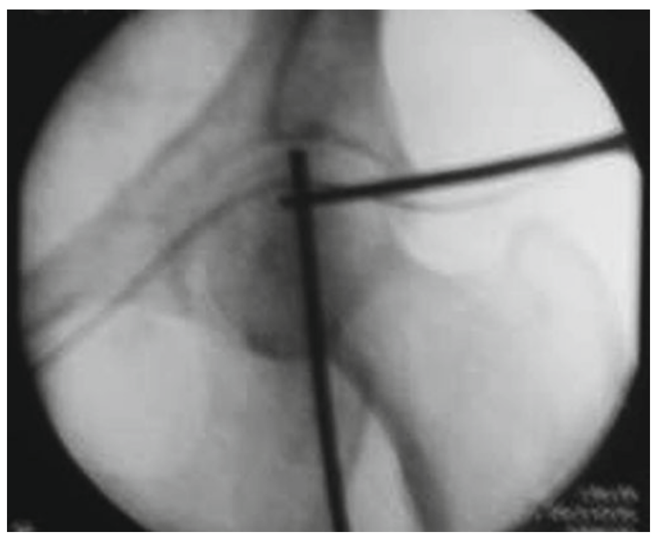
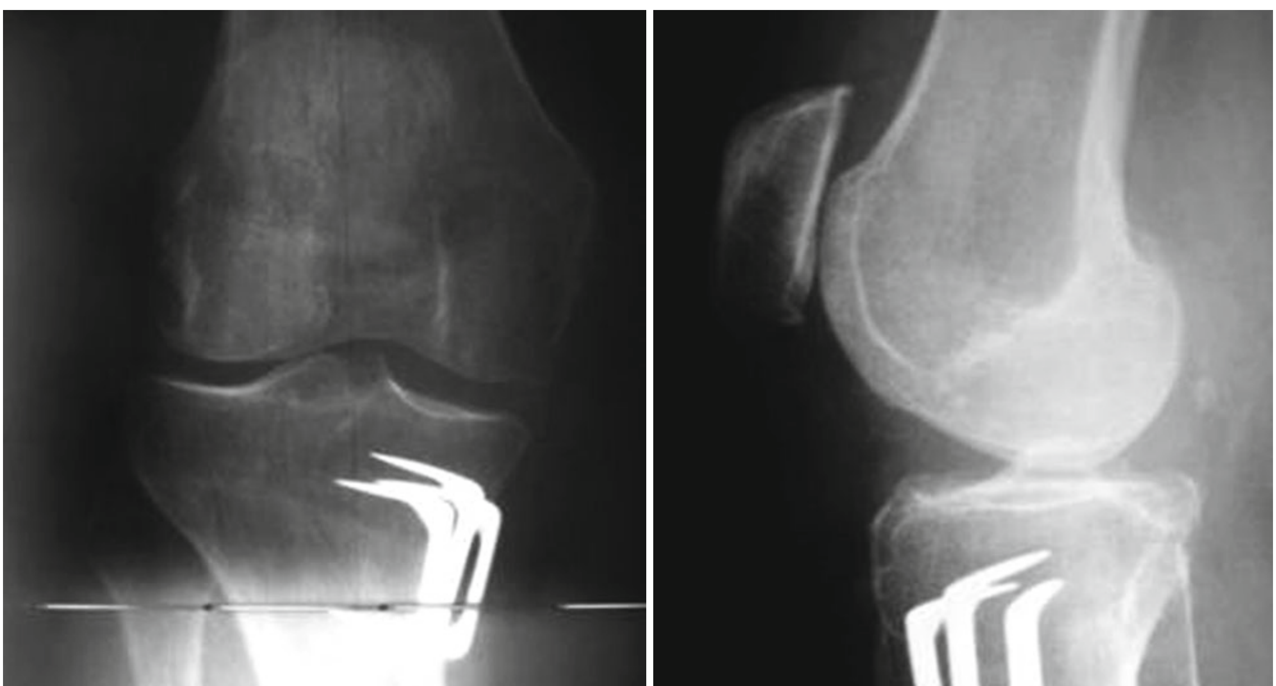


Fig. 17.8 Weakening the lateral hinge with 3.2 mm drill holes



Figs. 17.9 and 17.10 Intraoperative evaluation of the correction using a long metal rod

Fig. 17.11 The rod should be in the center of the knee following correction. In this case, the axis is slightly in varus



Figs. 17.12 and 17.13 Postoperative x-rays

Postoperative Guidelines

The patient should receive information on the postoperative guidelines prior to the surgery.

These postoperative guidelines are identical to those for an opening wedge osteotomy.

Complications

- Errors of correction: undercorrection is more frequent than overcorrection.
- Nonunion and fixation failures are rare.
- Delayed union can be observed in case of an imperfect fit between the osteotomy cuts.
- The osteosynthesis material can cause pain or discomfort. Removal of it is in many cases sufficient for pain relief.
- The clinical outcome of a medial closing wedge high tibial osteotomy can decline after approximately 7–20 years. In those cases, a total knee arthroplasty can be performed without any major difficulties.

Future Improvements

- Improvement in the calculation of the desired correction.
- Improvements in the reproducibility of the desired correction: computer-assisted surgery and navigation could result in a more precise evaluation of the mechanical femorotibial axis.
- Improvement in the fixation of the osteotomy allowing earlier weight bearing.
- Applications of specific growth factors or other biologic agents to improve early consolidation.

Anterior Opening Wedge Osteotomy of the Tibia for the Treatment of Genu Recurvatum

18

R. Debarge and P. Archbold

Introduction

The surgical management of a genu recurvatum (hyperextension of the knee) is rare. It should be considered for symptomatic patients who suffer from significant asymmetrical genu recurvatum (more than 20°). Distinction should be made between an idiopathic symmetric genu recurvatum and a secondary genu recurvatum due to a bony or ligamentous lesion.

It is of major importance to evaluate the recurvatum clinically as well as radiographically. The evaluation should be compared to the contralateral side (Fig. 18.1).

Fig. 18.1 Asymmetrical genu recurvatum

R. Debarge, MD
Clinique Jean Causse,
Traverse de Béziers, 34440 Colombiers, France
e-mail: r_debarge@hotmail.com

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_18, © Springer-Verlag London 2014

Radiological Workup

(Cf chapter on surgical indications for arthritis.) The aim of this workup is to quantify the overall recurvatum in both knees and to calculate the amount of recurvatum residing in the femur or/and tibia (Fig. 18.2).

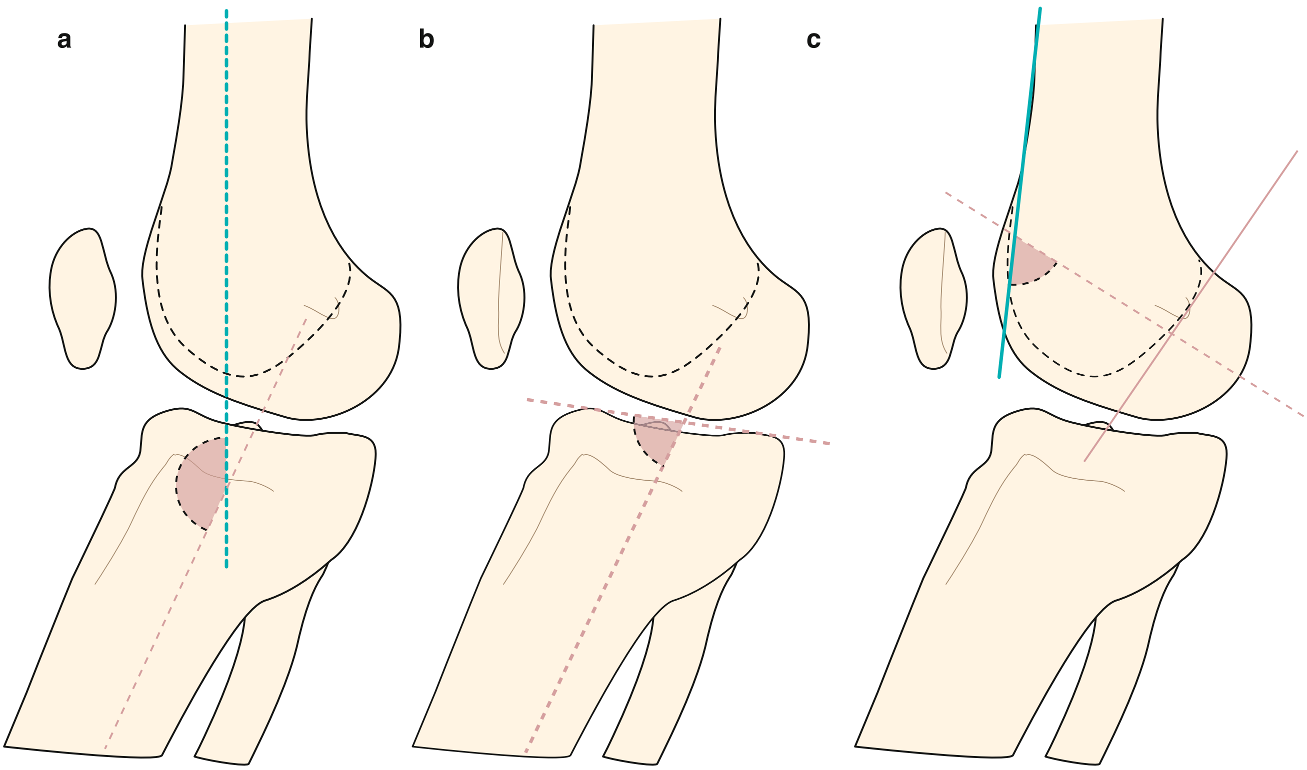


Fig. 18.2 Radiological measurements of femoral and tibial recurvatum. (**a**) Global recurvatum (angle between anatomical femoral and tibial axes). (**b**) Tibial slope. (**c**) Epiphyseal femoral angle between the femoral anterior tangent line and the Blumensaat line perpendicular

Anterior Opening Wedge Tibial Osteotomy

Indications

- Deformity secondary to poliomyelitis: the recurvatum should not be corrected completely since it has a stabilizing effect on the lower limb. This effect on stability is important in these patients who frequently lack a functional quadriceps muscle.
- Chronic posterior laxity: reducing the posterior tibial translation.
- Bony recurvatum at the level of the tibia (negative tibial slope) due to a fracture malunion or secondary to growth plate arrest of the anterior aspect of the proximal tibial physis (Fig. 18.3).

Fig. 18.3 Negative tibial slope

Technique

This technique has been described by Henri Dejour and F. Lecuire (Fig. 18.4). The anterior opening wedge osteotomy is performed at the level of the tibial tubercle (TT) with a posterior hinge. The hinge is situated at a level of the insertion of the fibers of the posterior cruciate ligament and the attachment of posterior knee joint capsule on the tibia.

The anteromedial skin incision is made in line with the medial border of the patellar tendon (Fig. 18.5). An osteotomy of the tibial tubercle is performed. The bone block should be 6–8 cm long and should reach into the metaphyseal bone (cf Fig. 18.6 and chapter on episodic patellar dislocation). Guide pins are introduced anteriorly approximately 4 cm below the joint line directed posteriorly and aimed at the level of the insertion of the posterior cruciate ligament fibers and proximal to the insertion of the posterior capsule (Fig. 18.7). Medially, a large periosteal elevator is inserted underneath the fibers of the superficial medial collateral ligament. Laterally the tibialis anterior muscle insertion is partially released.

The osteotomy is completed with an oscillating saw underneath the guide pins and always staying in contact with the guide pins. The osteotomy should be situated proximal to the tibiofibular joint (Fig. 18.8). Opening of the osteotomy is achieved by the sequential introduction of several osteotomes (cf surgical technique for opening wedge high tibial osteotomy).

Generally, each osteotome or 1 mm of opening achieves a correction of about 2°. The final correction should take into account not only the bony genu recurvatum measured radiologically but also the clinical genu recurvatum. A bony recurvatum of 20° but with only a clinical recurvatum of 10° should not be corrected by 20°. This degree of correction could result in a clinical flexion deformity that is poorly tolerated by the patient.

Remark: *An anterior tibial osteotomy frequently increases varus of the tibia. Therefore, the osteotomes should be inserted from the medial side during opening to minimize this effect.*

The posterior cortex is weakened with the 3.2 mm drill (cf technique HTO). The final correction should be controlled clinically to avoid a hypercorrection in flexion. The osteotomy is fixed by two Blount staples on either side of the tibial tubercle (Fig. 18.9).

Cortical and cancellous iliac crest bone grafts are needed to fill the osteotomy (Fig. 18.10). The tibial tubercle osteotomy is fixed using two 4.5 AO screws introduced anteroposteriorly. The patellar height should not be modified. In other words, the osteotomy bone block is proximalized by the same amount as the opening wedge osteotomy in order to avoid a patella infera (Figs. 18.11 and 18.12).

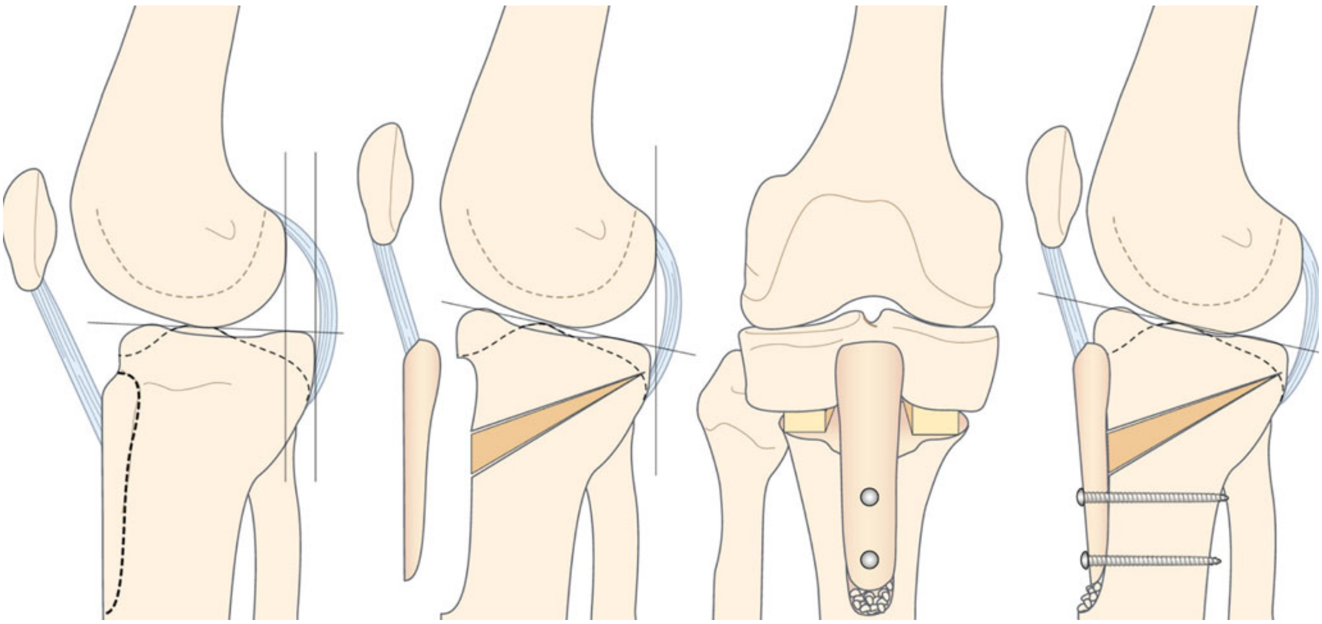


Fig. 18.4 Surgical technique for anterior opening wedge osteotomy

Fig. 18.5 Skin incision

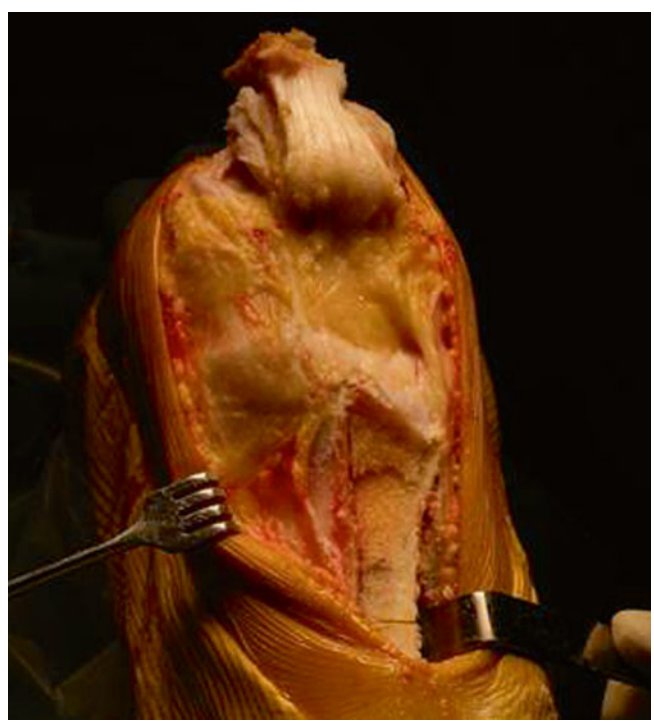


Fig. 18.6 Tibial tubercle osteotomy

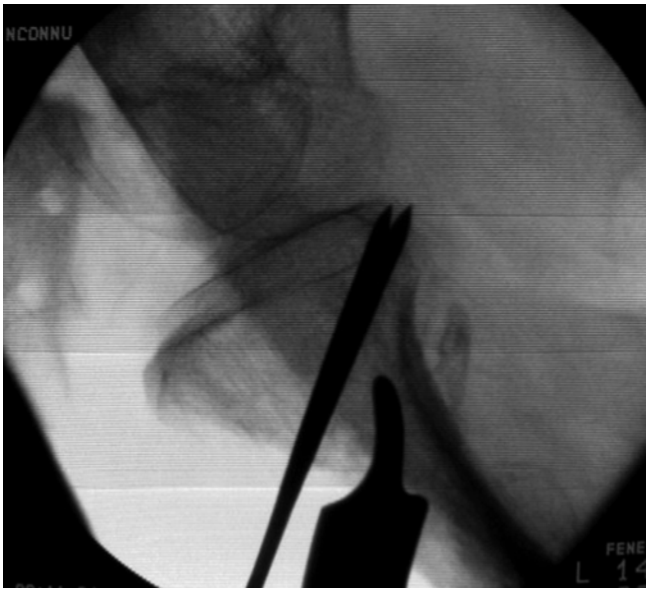


Fig. 18.7 Intraoperative fluoroscopic control of guide pin positioning

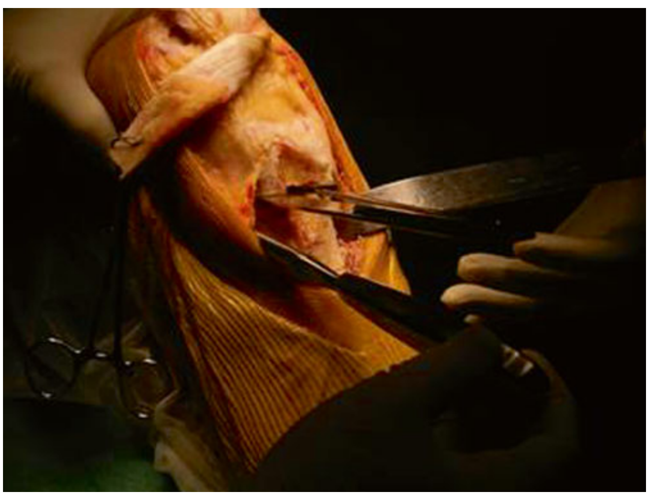


Fig. 18.8 Tibial osteotomy underneath the guide pins to avoid epiphyseal fracture

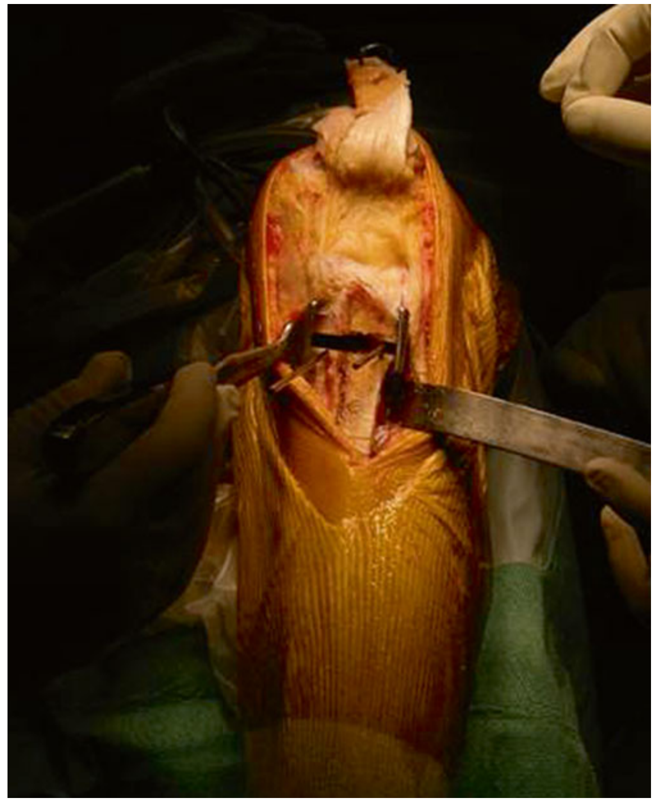


Fig. 18.9 Fixation by two Blount staples

Fig. 18.10 Bone grafts to fill the osteotomy

Fig. 18.11 Tibial tubercle fixation

Fig. 18.12 Postoperative x-rays

Postoperative Guidelines

- Non-weight bearing for 2 months and walking with crutches.
- Progressive mobilization of the knee, limited to 90° for 60 days (to ensure consolidation of the tibial tubercle osteotomy).
- Bracing at 10° of flexion.
- Postoperative radiographs should include a lateral radiograph of the knee to measure the obtained correction.

19 Surgical Technique for a Double Osteotomy

P. Archbold, P. Verdonk, and E. Servien

Introduction

A double osteotomy is indicated in the following situations:

- A situation in which an isolated osteotomy (on the femur or on the tibia) to correct a major angular deformity (>to 10°) in the frontal plane in valgus (Fig. 19.1) or in varus (Figs. 19.2 and 19.3a) would result in an oblique joint line (Fig. 19.3b). This obliquity would create shear forces across the knee joint that can lead to early failure of the intervention. A distal femoral osteotomy combined with a proximal tibial osteotomy is able to correct the axis of the lower limb while maintaining an acceptable obliquity of the joint line (Fig. 19.3c).
- A situation in which an attempted single site correction with an opening wedge osteotomy results in too much opening, compromising the stability of the osteotomy.
- A situation in which correction with a single closing wedge osteotomy would be too large and result in poor coaptation of the proximal and distal bone segments, which can cause problems for future total knee arthroplasty.
- The treatment of osteoarthritis secondary to malunion of the femur. In these cases, the aim of the procedure is to address the frontal or torsional malunion on the femur by a femoral osteotomy and to address the arthritis with a tibial osteotomy (Fig. 19.4). It is of major importance to know that femoral malunions situated close to the knee joint are more significant than those situated at a greater distance from the joint. A femoral osteotomy can only correct a deformity in extension and not in flexion.

Certain difficulties and complications are inherent to a double osteotomy:

1. The risk for a delayed union or malunion is increased compared to an isolated osteotomy.
2. Calculation of the correction remains difficult and complicated. In the case of a femoral malunion, one can perform both interventions separately starting with the femoral derotation osteotomy and then the tibial osteotomy at a later stage. If a computer-assisted navigation is available, both corrections in the frontal and horizontal plane can be combined during the same intervention.

Nevertheless, indications for a double osteotomy remain rare, and in this chapter we will not discuss proximal or diaphyseal femoral osteotomies that are indicated in isolated torsional problems.

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis Road, BT95JH Belfast, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

P. Verdonk, MD, PhD
Orthopedisch Centrum Antwerpen,
Stevenslei 20, 2100 Deurne, Belgium
e-mail: pverdonk@yahoo.com

E. Servien, MD, PhD
Albert Trillat Center, Croix Rousse Hospital, 69004 Lyon, France
e-mail: elvire.servien@chu-lyon.fr

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_19, © Springer-Verlag London 2014

Fig. 19.1 Major angular deformity in the frontal plane in valgus (right knee)

Fig. 19.2 Major angular deformity in the frontal plane in varus (both knees)

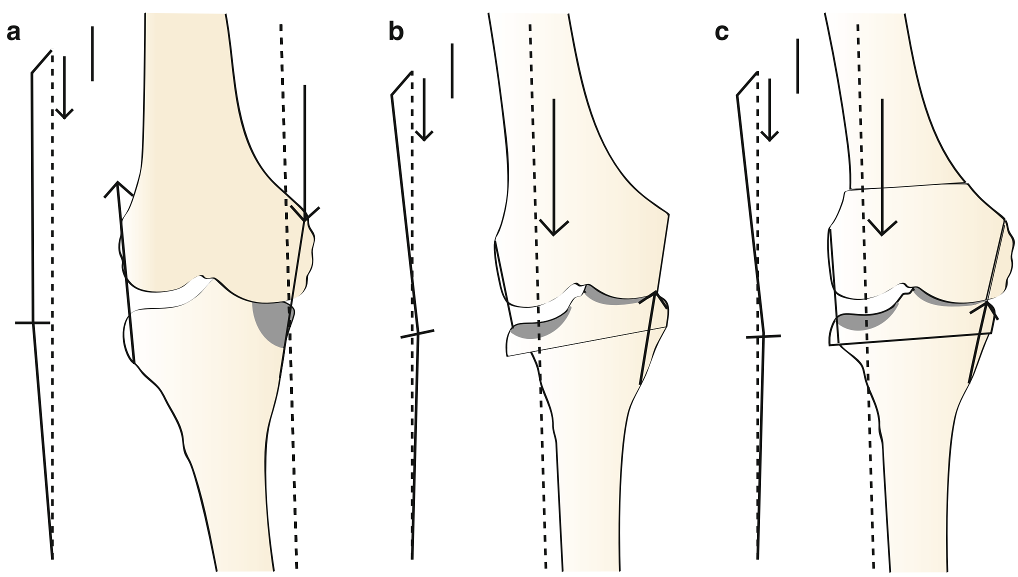


Fig. 19.3 (**a**) Case of major angular deformity in varus. (**b**) An isolated tibial osteotomy to correct a major angular deformity would create an oblique joint line. (**c**) A normal or acceptable joint line obliquity after correction of a major angular deformity becomes possible using a distal femoral osteotomy associated with the proximal tibial osteotomy

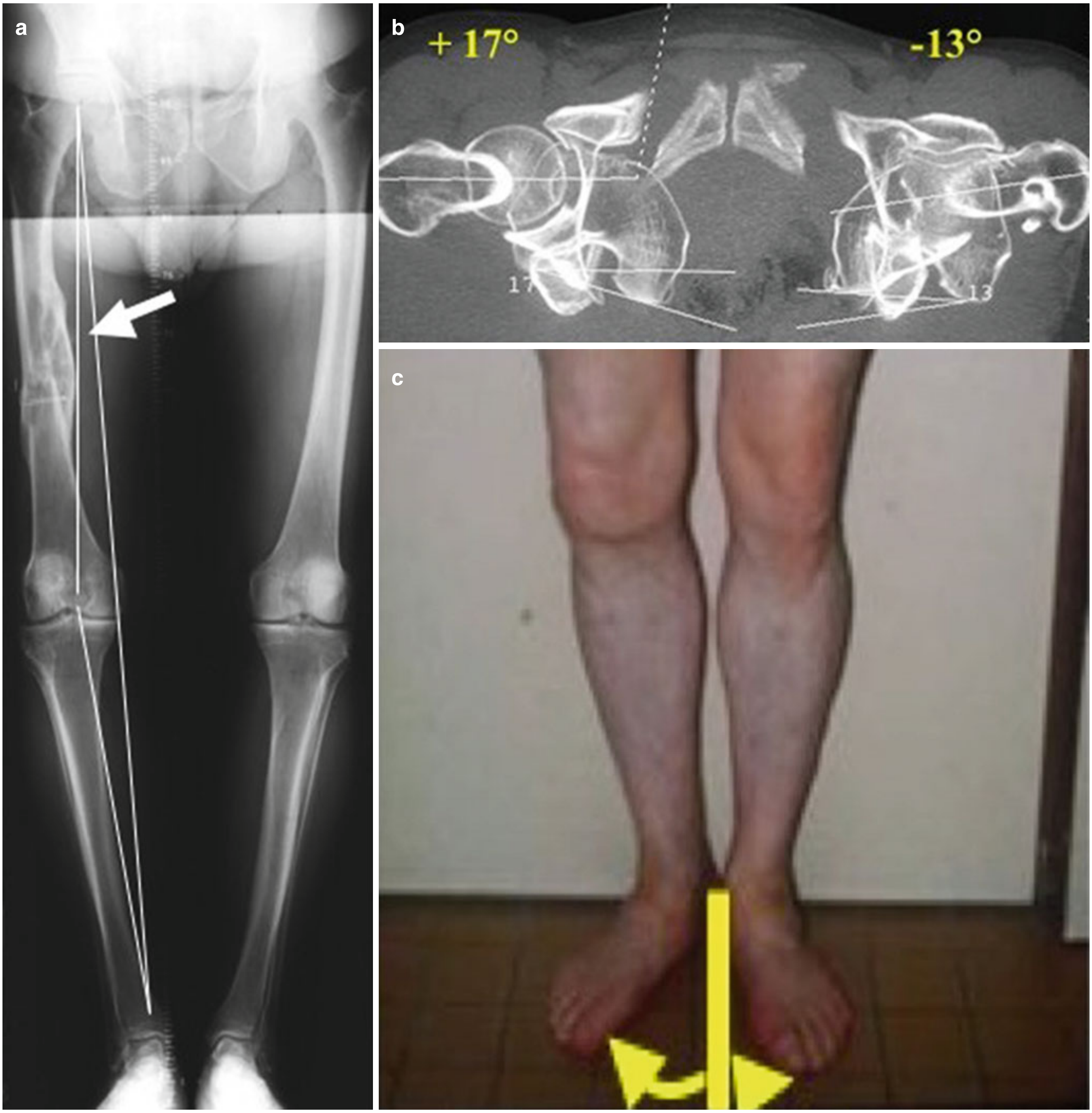


Fig. 19.4 (**a**) Medial femorotibial osteoarthritis caused by rotational malunion after femoral fracture (external rotation of the right limb). (**b**) External rotational deformity measured by CT scan. (**c**) Clinical deformity

The Principles

Varus Knee

In a varus knee with a mechanical axis less than 165°, the combination of a lateral closing wedge distal femoral osteotomy with a lateral closing wedge high tibial osteotomy or medial opening wedge high tibial osteotomy is indicated. The advantage of an opening wedge high tibial osteotomy is preservation of the length of the lower limb. The skin incision is placed laterally on the femur and crosses the midline at the level of the tibial tubercle to continue medially on the tibia. Alternatively, an isolated lateral femoral incision can be combined with an isolated medial tibial incision. In cases of a closing wedge high tibial osteotomy, a laterally based long skin incision is typically used (Fig. 19.5).

Fig. 19.5 Postoperative x-rays (see case Fig. 19.2)

Valgus Knee

In a valgus knee with a mechanical axis greater than 190°, a combination of an opening wedge lateral distal femoral osteotomy with a closing wedge medial high tibial osteotomy is indicated (Fig. 19.6). This combination results in an acceptable orientation of the joint line while lowering the risk of injury to the peroneal nerve.

Fig. 19.6 Postoperative long leg films after correction of a major valgus deformity

Malunion with Torsional Problem

In cases of osteoarthritis secondary to a femoral malunion in combination with a torsional problem greater than 15° and a frontal deviation greater than 10°, we advise the combination of a derotation osteotomy on the femur and a tibial osteotomy to address the frontal plane deformity (Fig. 19.7).

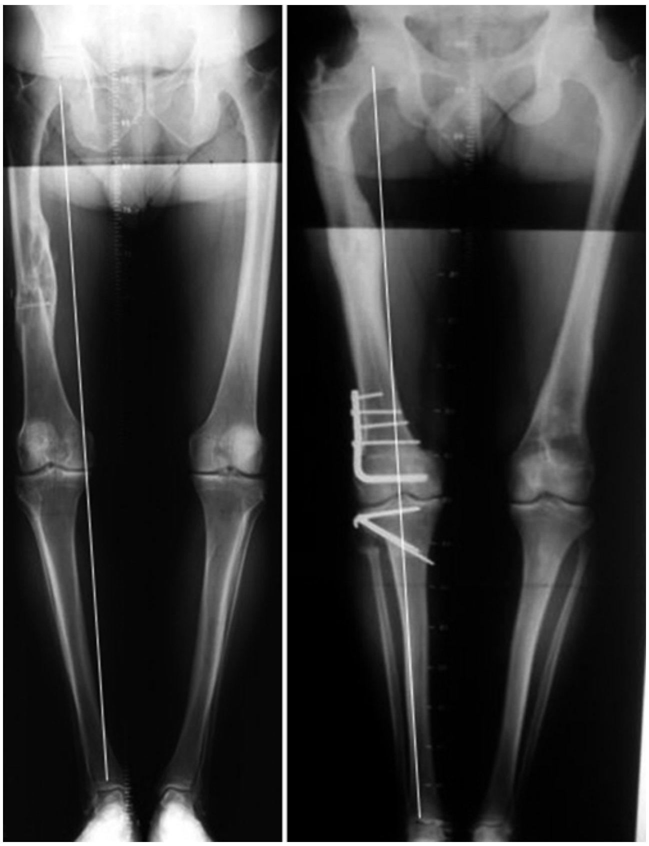


Fig. 19.7 Pre- and postoperative x-rays after correction of an external rotational malunion associated with a medial compartment osteoarthritis (see case Fig. 19.4)

Surgical Technique

On the Femur

The approach has been described in detail in the chapter on femoral osteotomy for varization.

1. Lateral opening wedge osteotomy for valgus knee (see chapter on femoral osteotomy for varization)
2. Closing wedge osteotomy for the varus knee
   The area for the osteotomy is prepared. Two additional Kirschner guide pins are introduced in the femur as guide pins for the future osteotomy. One pin is introduced parallel to the joint line approximately 50 mm proximal to the joint line. The second pin is introduced proximally to the first on the lateral cortex but converging with the first medially. This represents the angle and the wedge that will be resected. The quadriceps muscle is retracted at a level proximal to the trochlea with the knee in extension; the posterior side of the knee is cleared. A superficial longitudinal mark on the lateral cortex of the femur with the oscillating saw can serve as a landmark to determine the rotation (Fig. 19.8). The blade plate has to be introduced in the epiphyseal area approximately 30 mm proximal to the joint line. The blade is 5.6 mm thick and 16 mm in width, and the distance between the holes is 16 mm. Its entry point is anterior and proximal to the lateral collateral ligament. The entry angle has been determined by preoperative planning and a specific reamer is used. For a calculated valgus correction of 8°, the guide instrument is set at 93° (85° + 8°; this is the complementary angle to the desired anatomical angle of 95°, plus the angle of correction). The blade is subsequently introduced into the femur. The correct angulations are again checked using the image intensifier.
3. Derotation osteotomy in the case of femoral malrotation
   The area of the osteotomy is prepared in the same manner. Two superficial saw marks are made on the lateral cortex indicating the desired angle of the derotation (Fig. 19.8). By doing this, an isolated derotation osteotomy can be performed as well as a derotation osteotomy in combination with an opening wedge or a closing wedge femoral osteotomy. The derotation osteotomy should not interfere with the patellar tracking or create a step on the anterior cortex.

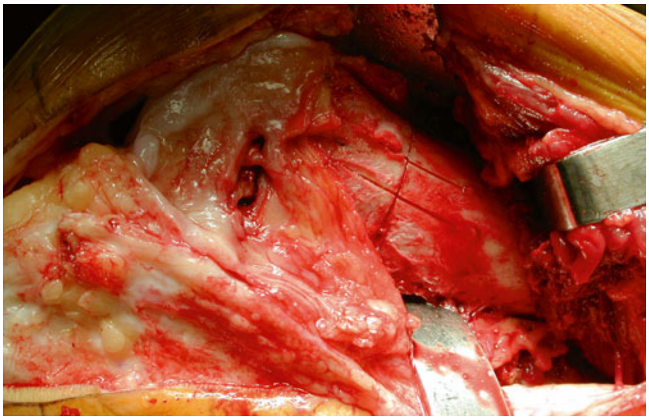


Fig. 19.8 Two rotational landmarks are superficially done on the femoral cortex using the saw

On the Tibia

For these surgical techniques, please see chapter on tibial osteotomy.

The bone graft obtained in case of a closing wedge femoral osteotomy is used to fill the opening wedge tibial osteotomy.

Postoperative Guidelines

The postoperative guidelines are identical as for a high tibial osteotomy.

20 Lateral Opening Wedge Tibial Osteotomy

S. Lustig, Maad F. AlSaati, and Robert A. Magnussen

Introduction

Indications for a lateral opening wedge tibial osteotomy include cases where an overcorrection has been made following a valgus-producing lateral closing wedge high tibial osteotomy (Fig. 20.1a, b) or in valgus malunions following a tibial plateau fracture (Fig. 20.2).

It aims to compensate for a valgus malunion by raising the joint line laterally. Its advantage over a closing medial osteotomy is that it does not lower the joint line. It requires an autologous bone graft harvested from the ipsilateral anterior iliac crest and an osteotomy of the fibula neck. This technique is commonly practiced in pediatric surgery but continues to have a bad reputation when used in adults due to the risk of injury to the common peroneal nerve.

The thickness of the opening wedge to obtain a normocorrection is calculated based on the width of the tibial epiphysis and the desired angle of correction. In the cases of an iatrogenic overcorrection, one should aim to leave a discrete valgus.

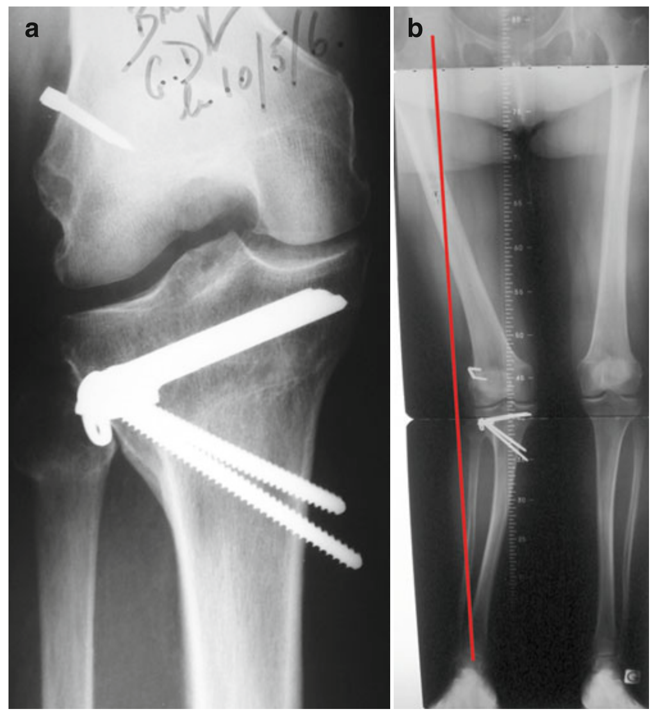


Fig. 20.1 (**a**, **b**) X-rays showing significant overcorrection after closing wedge HTO

S. Lustig, MD, PhD (✉)
Albert Trillat Center, Croix Rousse Hospital,
103 grande rue de la Croix Rousse, 69004 Lyon, France
e-mail: sebastien.lustig@gmail.com

M.F. AlSaati, MD
Saati Medical Center,
88591, 11672 Riyadh, Saudi Arabia
e-mail: maad.saati@gmail.com

R.A Magnussen, MD
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
2050 Kenny Rd, Suite 3100, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_20, © Springer-Verlag London 2014

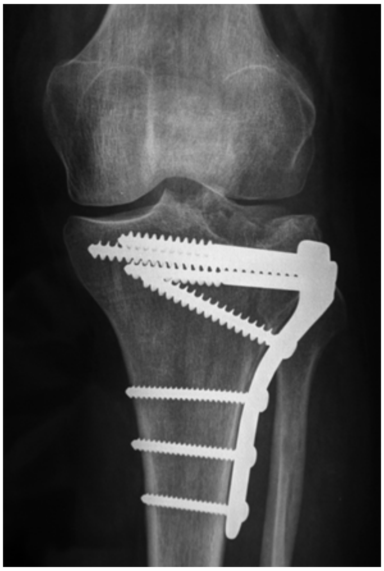


Fig. 20.2 X-rays showing sequelae of lateral tibial plateau fracture

Surgical Technique

Setup

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 on the ipsilateral iliac crest. A small bump is positioned underneath the ipsilateral buttocks to obtain a better exposure of the iliac crest. An image intensifier is required. This technique has similarities to that used for a lateral closing valgus tibial osteotomy as described previously.

Incision

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 (if the procedure is required due to the result of trauma or a previous osteotomy, we use the scar that is already present) (Fig. 20.3). The fascia of the tibialis anterior is released as a Z-plasty. Subsequently, the tibialis anterior muscle and the long toe extensor muscle are elevated from the tibial metaphysis using a large periosteal elevator. In order to mobilize the common peroneal nerve, these muscles must be released more distally than in a lateral closing wedge osteotomy. In cases of revision surgery, more care must be taken as the tissues are often scarred.

Fig. 20.3 The skin incision must take into consideration previous scars

Osteotomy of the Neck of the Fibula

The neck of the fibula is identified and exposed. A periosteal elevator is placed around the neck, always staying in contact with the bone. This maneuver protects the peroneal nerve (Fig. 20.4).

Two holes are now drilled in the neck using a 3.2 mm drill (Fig. 20.5). With the use of an osteotome, the two holes are interconnected (Fig. 20.6). The fibular shaft should be mobile. Care is taken so that the peroneal nerve is not in contact with the osteotomy. In the absence of a malunion and if local conditions (dissection) permit, we prefer to perform the osteotomy at the neck of the fibula; otherwise, it is possible to perform the osteotomy in the distal third of the tibial shaft.

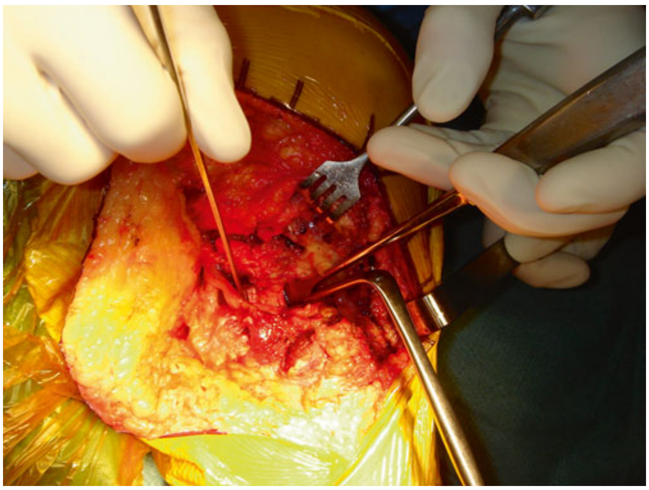


Fig. 20.4 Fibular neck exposure and protection of the peroneal nerve

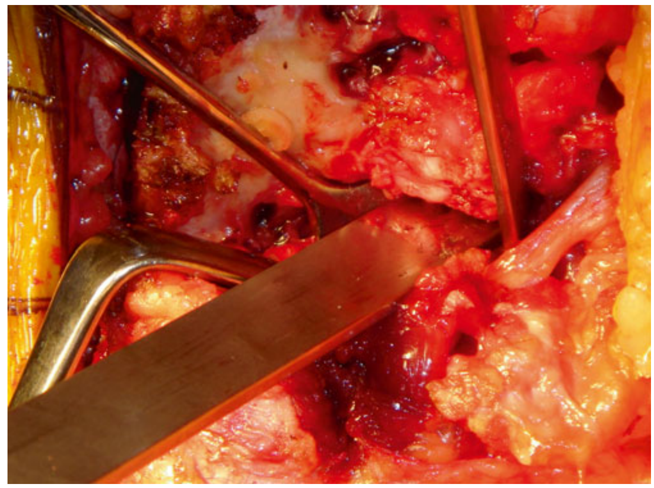


Fig. 20.6 Fibular neck osteotomy with the use of an osteotome

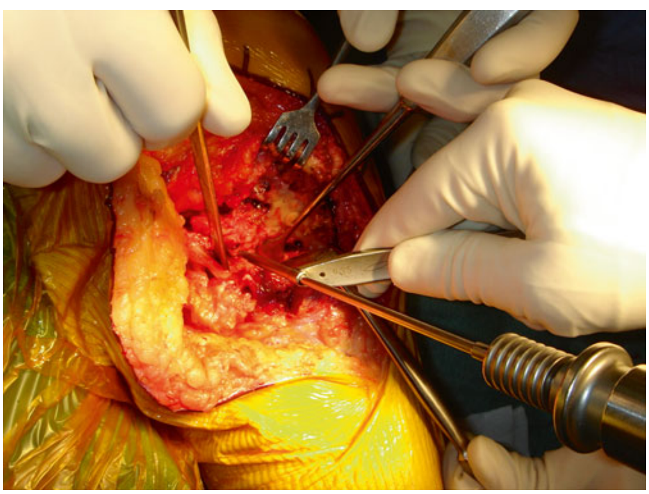


Fig. 20.5 Two holes are drilled in the fibular neck using a 3.2 mm drill

Osteotomy of the Tibia

A large raspatory is positioned behind the posterior cortex of the tibia. The patellar tendon is anteriorly retracted by a Farabeuf (Figs. 20.7 and 20.8). The osteotomy is performed proximal to the tibial tubercle in an almost horizontal direction. The direction of the osteotomy in the frontal plane is marked with two 2.5 mm threaded K-wires under fluoroscopic control. The wires are passed parallel to each other in a slightly upward trajectory ending about 1 cm below the medial tibial plateau (Fig. 20.9). The line of the osteotomy should be flushed with the top edge of the tibial tuberosity. If necessary a coronal plane cut behind the TTA can be done to allow more horizontal osteotomy (Fig. 20.10).

Using an oscillating saw, the osteotomy is now performed underneath these guide pins, but always staying in contact with them. 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 patellar tendon can be damaged. It is necessary to have an intact medial hinge for this type of osteotomy. We mobilize this hinge by weakening it with a number of 3.2 mm drill holes (Fig. 20.11). Subsequently, a Lambotte osteotome (thickness 2 mm, corresponding with approximately 2° of angular correction) is introduced into the osteotomy. A second osteotome is now introduced below the first. Depending on the desired correction, more osteotomes are then introduced between the first two (Fig. 20.12a, b). It is important not to drive the third osteotome too far in order to avoid fracturing the medial cortex.

The natural tendency is to open the osteotomy site more anteriorly and posteriorly, with potentially negative effects on tibial slope. One must be careful to avoid this mistake. Placing the osteotomes more posteriorly can minimize this risk.

The degree of correction is monitored by checking the amount of opening at the fibular osteotomy site. The correction is maintained with Méary retractor (Fig. 20.13).

Two complications can be encountered during this type of osteotomy:

- Fracture of the medial hinge. Frequently observed in larger corrections, this complication results in undercorrection of the deformity. If this problem occurs, it should be fixed by placing a staple over the medial hinge via a direct medial approach.
- Fracture of the medial tibial plateau. This problem is observed if the medial hinge has been insufficiently weakened, if one forcefully tries to open the osteotomy with a varus maneuver, or if the osteotomes are not placed sufficiently deep. Usually medial-sided fixation suffices to overcome this complication.

The obtained angle of correction is systematically evaluated using a long metal rod centered on the femoral head and center of the ankle mortise (Fig. 20.14a, b). The angular correction is evaluated at the level of the knee joint line. If necessary an additional osteotome is introduced or removed to dial in the appropriate correction.

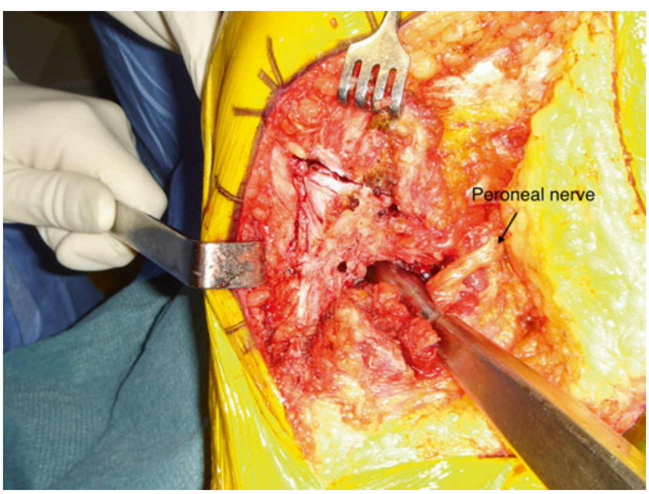


Fig. 20.7 A retractor is positioned behind the posterior cortex of the tibia to prevent vascular lesions. The peroneal nerve is also protected by the the retractor (*arrow*)

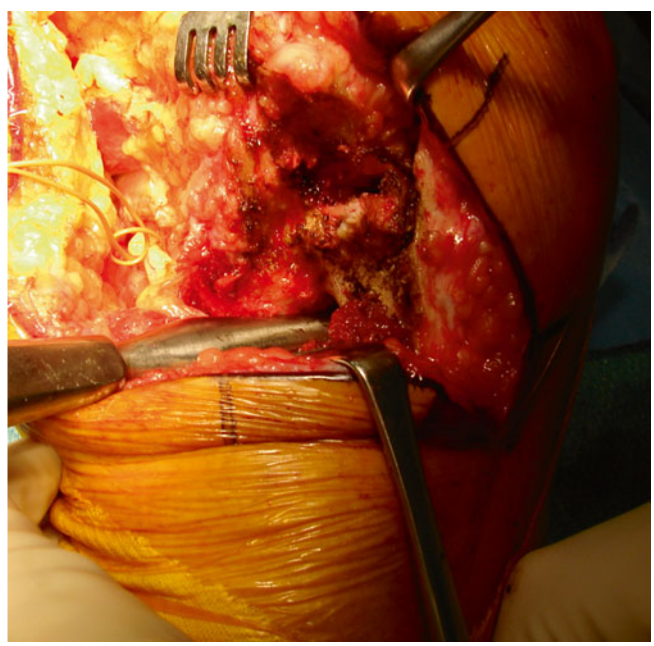


Fig. 20.8 A Farabeuf retractor retracts the patellar tendon

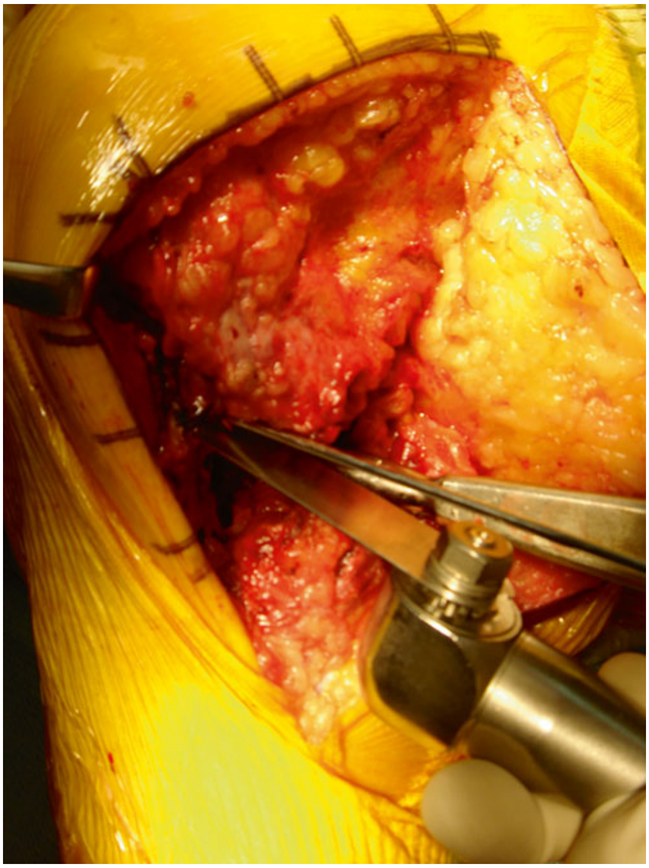


Fig. 20.9 Tibial cut using the oscillating saw

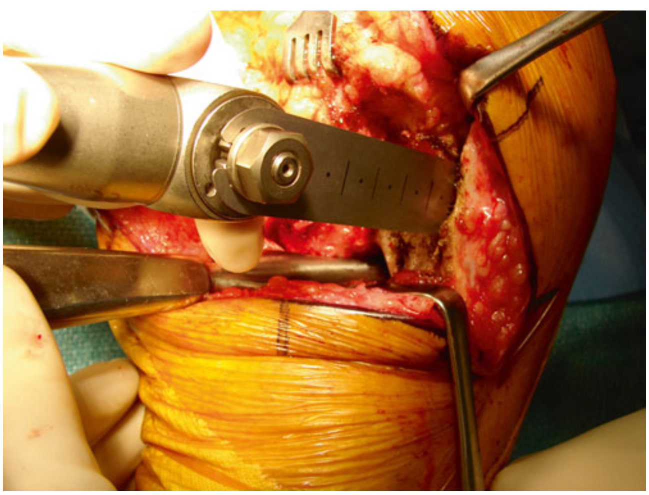


Fig. 20.10 A coronal plane cut behind the tibial tubercle can be done to allow more horizontal osteotomy

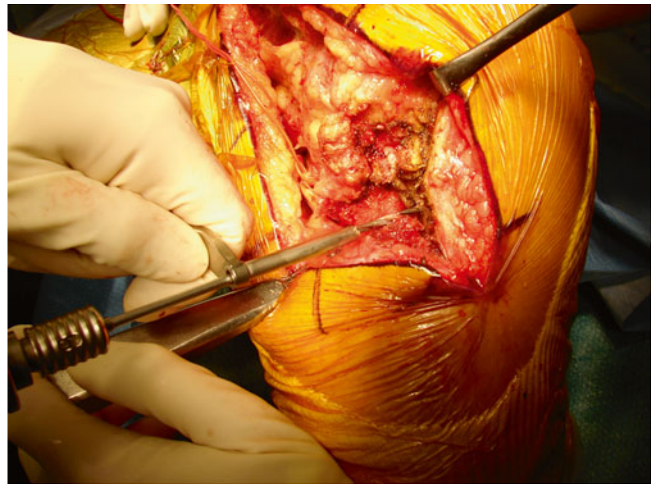


Fig. 20.11 The hinge is weakened with 3.2 mm drill holes

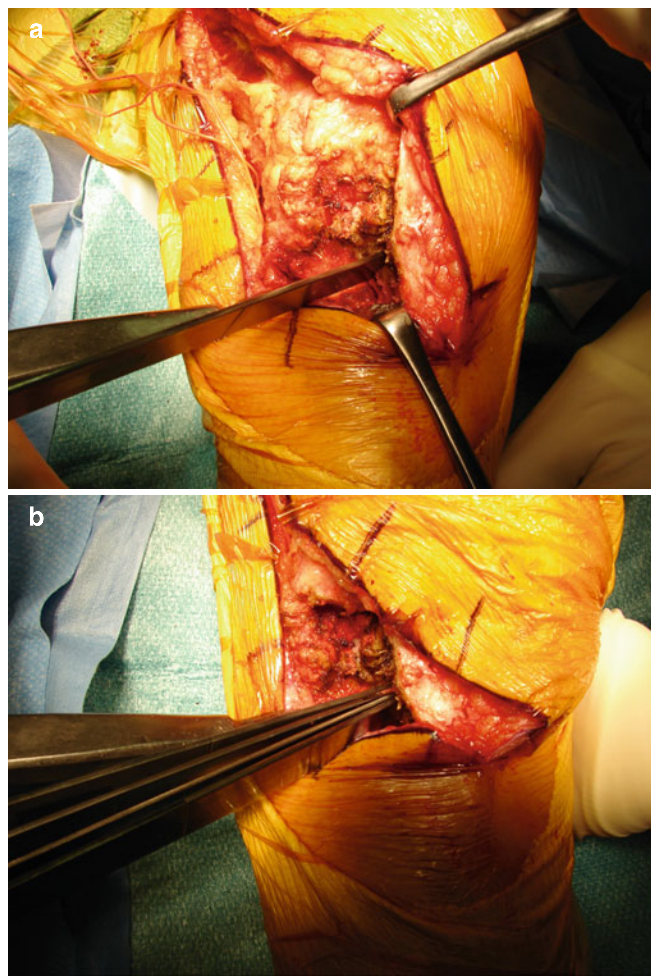


Fig. 20.12 (**a**, **b**) The wedge is progressively opened using osteotomes

Fig. 20.13 The correction is maintained with a Méary retractor

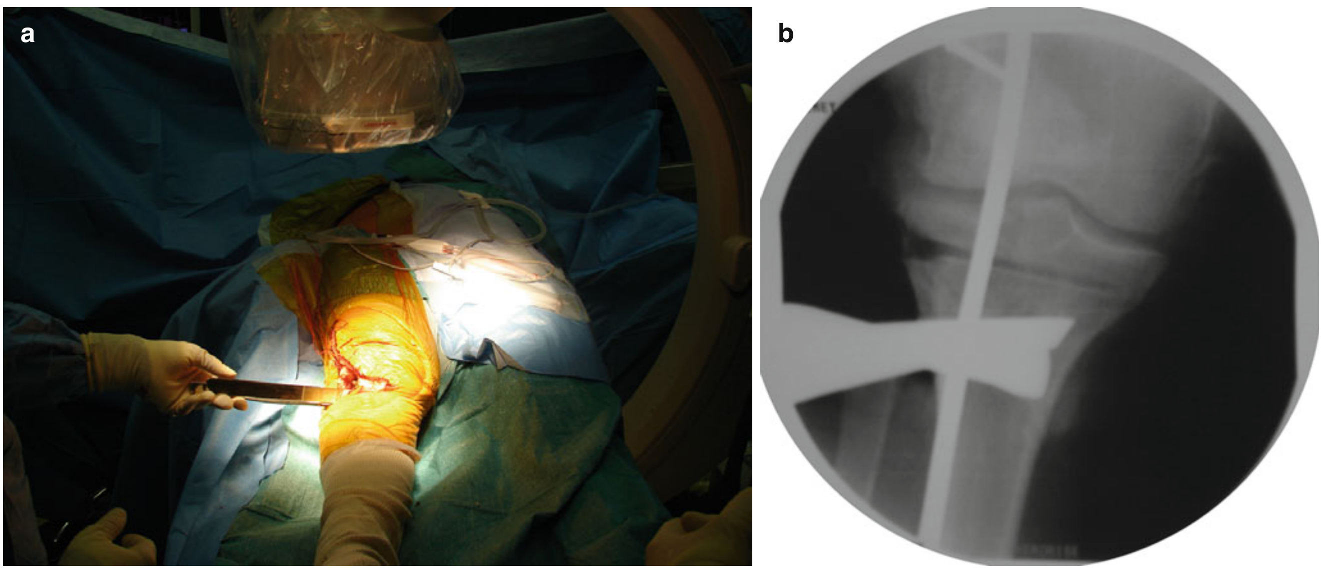


Fig. 20.14 (**a**, **b**) Intraoperative fluoroscopic control using a long metal rod centered on the femoral head and center of the ankle mortise

Osteosynthesis

In order to avoid loss of correction in the postoperative period, the fixation should be strong and stable. We use two Orthomed staples: one placed between Gerdy's tubercle and the TTA and the other placed between the epiphysis and diaphysis. The staples converge toward the center of the shaft. Staple fixation is rarly used for osteotomies currently in our practice, but it is our preference in this rare situation (Fig. 20.15).

A locking plate can be used for fixation; however, it can be difficult to place due to the proximity of the osteotomy to the joint line. The osteotomy site is filled with tricortical bone graft harvested from the ipsilateral anterior iliac crest (Fig. 20.16a, b). These grafts are impacted, taking care not to overcorrect. The wound is closed by repairing the tibialis anterior and extensor digitorum muscle bellies over the anterolateral staples. A suction drain is placed and the wound is close in layers.

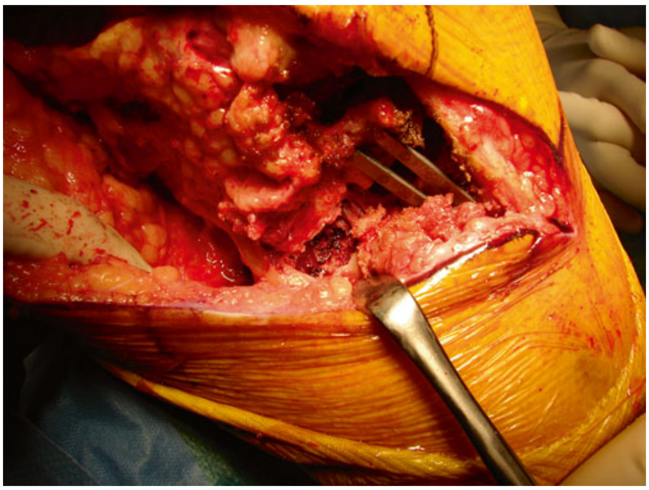


Fig. 20.15 Fixation using staples. The osteotomy site is filled with bone graft

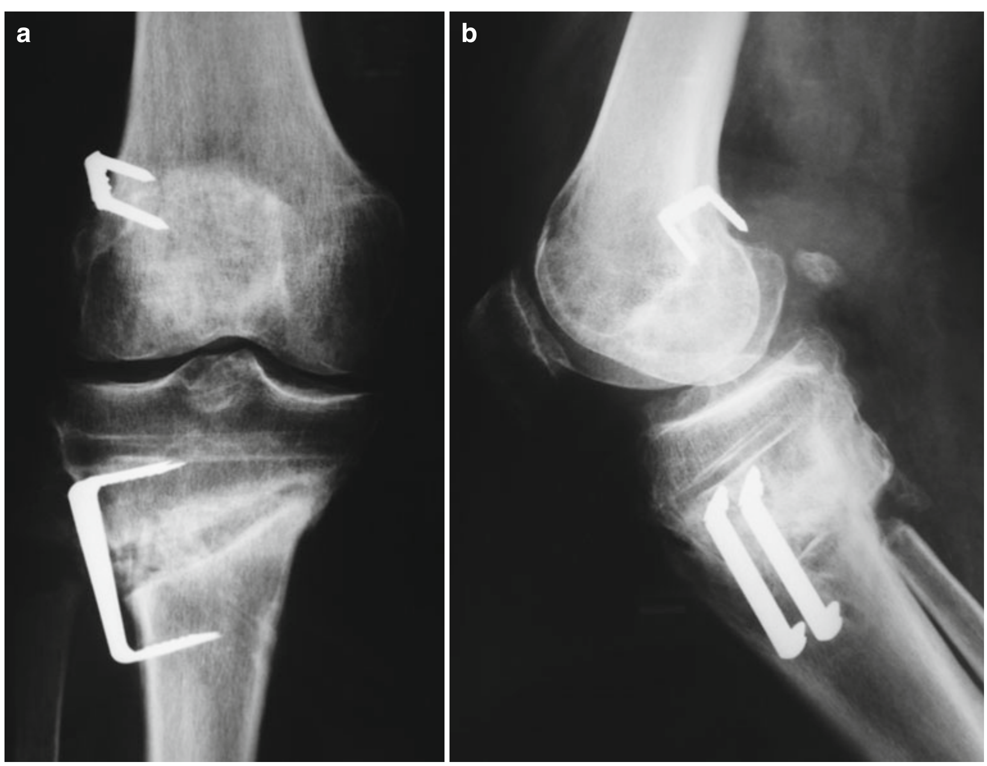


Fig. 20.16 (**a**, **b**) Postoperative X-rays

Postoperative Guidelines

- No weight bearing for 2 months.
- Walking protected by two crutches.
- Thromboprophylaxis for 1 month.
- Bracing in extension for 2 months.
- Flexion is limited to 120° for the first 15 days. After that date flexion can be progressively advanced.
- The drain is removed between day 2 and day 4.
- Hospital stay is between 4 and 7 days.
- Skin sutures are removed around day 12.
- Driving a car is not allowed for 10 weeks.
- Physical work is not allowed for 3–4 months.
- Sports are allowed after 6 months after bony union has been achieved.

Warning!

Two specific complications can be observed after a closing wedge high tibial osteotomy (HTO):

- Peroneal nerve lesion – particularly in large corrections or in revision surgery
- Compartment syndrome

The patient is reviewed 2 months after the intervention. Radiographs should be taken. If bony healing is observed, weight bearing can be started. If delayed union is suspected, partial weight bearing is allowed and the patient is invited to come back in 1 month.

21 Patellofemoral Arthritis and the Lateral Vertical Partial Patellectomy

S. Lustig, L.N. Favaro Lourenço Francisco, and Robert A. Magnussen

Introduction

Isolated patellofemoral arthritis (PFA) is a relatively rare condition. Above the age of 55, the incidence is estimated at 8 % in females and 2 % in males. In 90 % of the patients, lateral patellofemoral arthritis is observed. The condition is bilateral in over 70 % of the patients, and in 80 % of cases trochlear dysplasia can be identified as the major etiological factor.

Clinical Evaluation

Anterior knee pain is typically observed in patients with lateral patellofemoral arthritis. Ascending and descending stairs generally increase the pain. These patients are often unable to rise from a chair or squat without using their hands without significant pain. The nature of the pain is never excessive and generally does not interfere with activities of daily life. Walking on flat ground is usually not limited, which helps to differentiate between patellofemoral arthritis and tibiofemoral arthritis. Swelling of the knee is intermittently present. Manual pressure and manipulation of the lateral or medial facets usually evoke this specific pain. Range of motion of the knee is normal or near normal. Signs of patellar instability are generally absent.

Radiographic Workup

The radiographic workup includes the following plain radiographs: anteroposterior weight bearing, lateral weight bearing, and 45° flexed and patellar axial skyline views. Primary etiological factors for lateral patellofemoral arthritis include trochlear dysplasia, patella alta, and trauma. One should always exclude inflammatory joint disease, tibiofemoral arthritis, and the sequelae of complex regional pain syndrome. The differential diagnosis should include chondrocalcinosis. In our opinion, meniscal calcifications, which are frequently observed on plain radiographs, are not indicative of chondrocalcinosis but indicate small calcifications secondary to a prior hemarthrosis. Chondrocalcinosis is characterized by the typical recess above the trochlea and the typical radiographic sign of the patellofemoral joint shaped like a "saw." Patellofemoral degenerative lesions can be classified according to Iwano, in four stages (Fig. 21.1a–d):

Stage 1: Presence of osteophytes, joint space width narrowing, and remodeling of the subchondral bone.
Stage 2: Joint space width narrowing less than 3 mm.
Stage 3: Joint space width narrowing more than 3 mm.
Stage 4: Absence of joint space. The patella can have the shape of a beret (Fig. 21.2).

CT imaging can help determine possible indicators for patellofemoral instability. An MRI is useful to evaluate the tibiofemoral compartment.

S. Lustig, MD, PhD (✉)
Albert Trillat Center, Croix Rousse Hospital,
103 grande rue de la Croix Rousse, 69004 Lyon, France
e-mail: sebastien.lustig@gmail.com

L.N. Favaro Lourenço Francisco, MD
São Paulo, Brazil
e-mail: lucionuno@hotmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_21, © Springer-Verlag London 2014

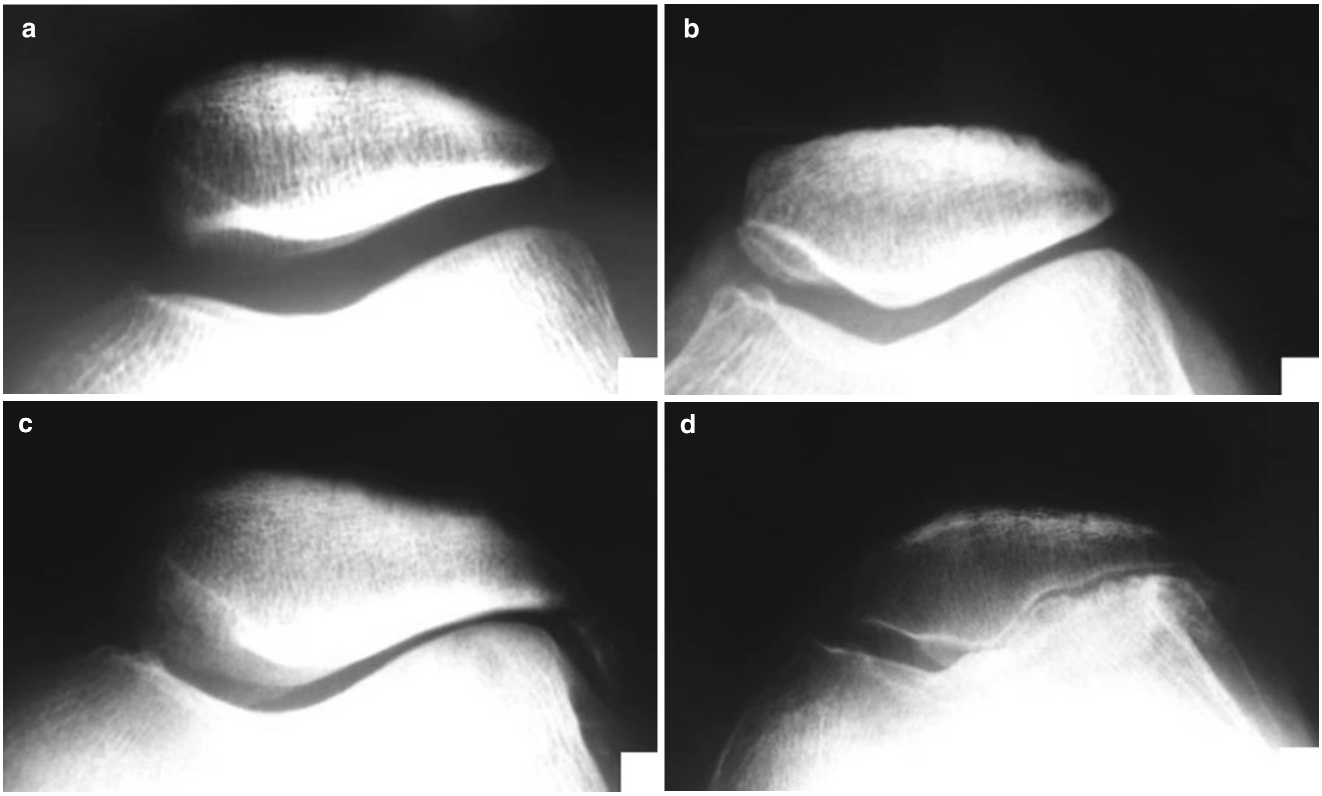


Fig. 21.1 Iwano classification of isolated patellofemoral osteoarthritis. (**a**) Stage 1, slight; (**b**) Stage 2, joint space width narrowing less than 3 mm; (**c**) Stage 3, joint space width narrowing more than 3 mm; (**d**) Stage 4, absence of joint space

Fig. 21.2 Béret Basque

Treatment

Options:

Treatment options for lateral patellofemoral arthritis are numerous. Conservative therapy is generally prescribed for the early stages of patellofemoral arthritis (modifications of ADLs, NSAIDs, physiotherapy, and injections of corticosteroids or hyaluronic acid). Nevertheless, surgery can be indicated if the symptoms are severe or if they fail to respond to conservative therapy. Surgical treatment is determined by several factors: the age of the patient, the patient's profession, the patient's function in activities of daily living, and the clinical symptoms.

Non-arthroplasty Surgery

Arthroscopic Lavage

The efficacy of articular lavage is disputed. Clinical improvement is not reproducible and often of short duration. Therefore, we do not recommend or perform this procedure.

Lateral Patellar Release

Isolated lateral patellar release is controversial and therefore not generally indicated for anterior knee pain. We do consider this procedure in cases of lateral facet overload characterized by pain over the lateral patellar facet and increased patellar tilt (indicative of a pathologically tight lateral retinaculum) in patients without significant patellofemoral arthritis on radiographs. Some authors have described Z-lengthening of the lateral retinaculum in such cases with good results.

Tibial Tubercle Osteotomy

The principles of this technique are to decrease patellofemoral contact pressure and transfer the weight bearing area from the area of wear to another region with intact articular cartilage. Therefore, this technique is contraindicated in cases of complex regional pain syndromes and generalized diffuse patellofemoral arthritis.

Anteriorization of the Tibial Tubercle

Introduced and popularized by Maquet, the aim of this procedure is to reduce the contact pressure of the patellofemoral articulation. This technique is fraught with complications, and therefore, it is not performed as a routine procedure. If we desire anteriorization of the tibial tubercle, we generally perform an anteromedialization of the tubercle as described by Fulkerson.

Medialization of the Tibial Tubercle

For lateral patellofemoral arthritis secondary to episodic dislocation of the patella, this technique is usually performed. A medialization of about 5 mm is usually desired. This technique can be combined with a partial lateral patellar facetectomy. We have abandoned the performance of a VMO advancement in such cases due to complications during rehabilitation. This technique is routinely combined with a lateral patellar release if the retinaculum is noted to be pathologically tight.

Distalization of the Tibial Tubercle

This technique is indicated in the cases of a patella alta. Although this technique seems logical, in terms of displacement of the contact zone, the postoperative period is long and characterized by a persistent swelling of the knee. Commonly, pain reduction is incomplete.

Lateral Vertical Partial Patellectomy (Lateral Facetectomy)

See complete description below.

Total Patellectomy

A total patellectomy is characterized by a subsequent weakness of the extensor apparatus. It also results in a large scar. Therefore, this technique should be used only in cases of severe posttraumatic arthritis. It should be noted however that resection of up to 25 % of the total width of the patella does not affect patellofemoral biomechanics.

Arthroplasty

Patellofemoral Arthroplasty

The success rate of patellofemoral arthroplasty varies from 44 to 90 %. The clinical outcome is superior to an isolated resurfacing of the patella. Reasons for failure include progressive tibiofemoral arthritis, implant malpositioning, and malalignment of the extensor apparatus (failure to correct an increase TT-TG). Due to the inconsistency in the results, we do not perform this procedure routinely.

Total Knee Arthroplasty

In the older patients, total knee arthroplasty remains the treatment of choice for lateral patellofemoral arthritis. Pain reduction and improvement of function are excellent. Patient satisfaction is especially high in patients with significant preoperative functional restrictions and limited expectations.

Partial Lateral Patellectomy or Lateral Facetectomy

This procedure is technically easy to perform; however, the indications are limited. Ideally, the patients should be between 40 and 65 years of age and limited during physical activities (ascending and descending stairs). Walking distance and flexion should be within normal limits. Conservative therapy should have been tried for at least 6 months. The patients should not be obese and should be normally aligned in the frontal plane. Palpation of the lateral border of the patella should evoke pain.

Plain radiographs, including the schuss view, should confirm absence of pathology in the tibiofemoral joint. The patellar skyline view should show an osteophyte or a typical "beret" aspect of the patella.

CT imaging allows evaluation of the TT-TG distance. It should be within normal limits. If an excessive TT-TG is measured, a medialization of the tibial tubercle may be indicated.

Surgical Technique

The patient is placed in the supine position with a tourniquet applied. An arthroscopy can be performed initially to evaluate the tibiofemoral joint as well as to remove potential loose bodies in the knee joint. In our experience, arthroscopy is rarely required (Fig. 21.3).

A lateral parapatellar skin incision is created, centered over the patella and measuring 5–6 cm in length. The lateral retinaculum is released (Fig. 21.4). The release should not involve the distal fibers of the vastus lateralis. The knee is now placed in extension and the articular surfaces of the patella and trochlea are inspected (Fig. 21.5).

The peripatellar soft tissues are carefully released from the anterior border of the patella over a distance of 1 cm using a 15 blade (Fig. 21.6). 1–1.5 cm of the lateral patellar facet, including its osteophyte, is then resected using an oscillating saw. The articular surface is protected by retractors or by placing a sponge into the patellofemoral joint (Figs. 21.7 and 21.8). The resected area generally goes from the lateral insertion of the patellar tendon to the lateral insertion of the vastus lateralis and must be sufficiently large. Very frequently, the inexperienced surgeon will be somewhat disappointed about the obtained resection on the postoperative radiograph (Fig. 21.9).

The capsule is not closed in the middle and distal portions of the patella. Hemostasis should be carefully performed (bone wax is applied to the resection area). An intra-articular drain is left for 24–48 h.

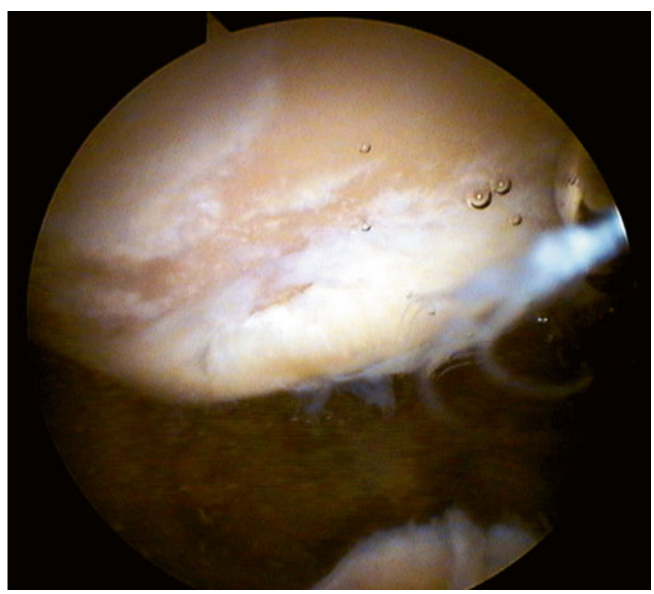


Fig. 21.3 Arthroscopic view: patellofemoral osteoarthritis with apparent subchondral bone

Fig. 21.4 Lateral parapatellar skin incision

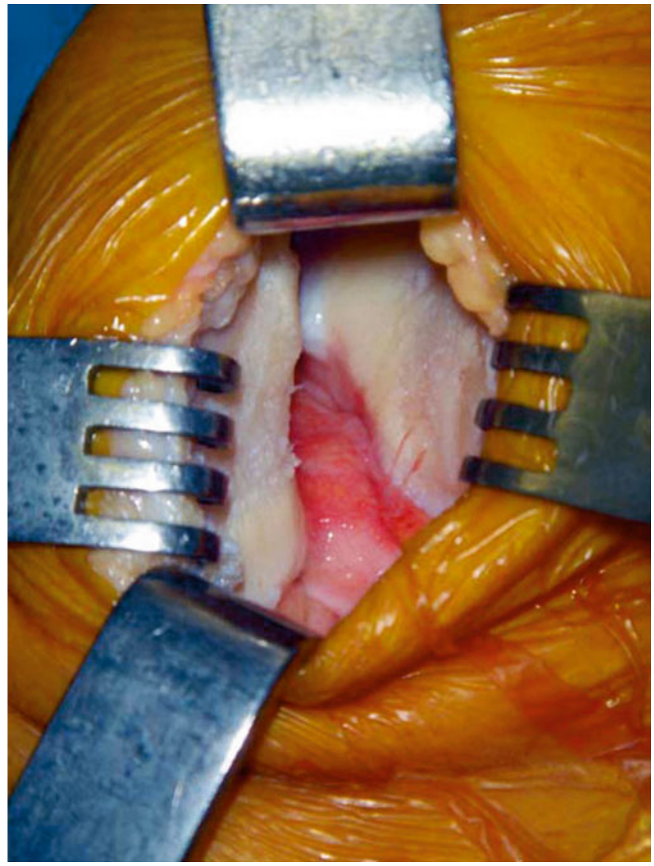


Fig. 21.5 Lateral retinaculum release and inspection of the patella and trochlea

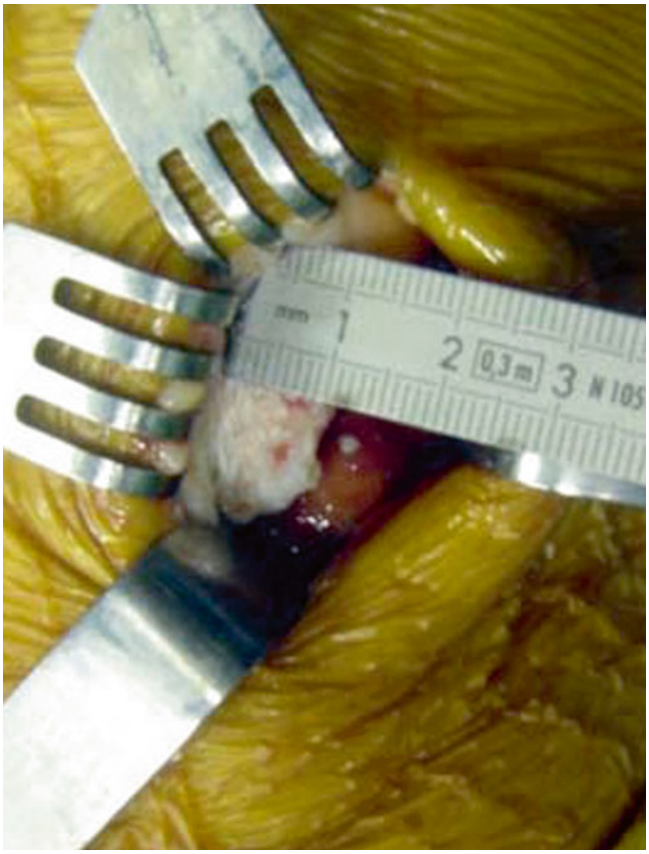


Fig. 21.6 Release of the peripatellar soft tissues from the anterior border of the patella

Fig. 21.7 Resection of the lateral patellar facet (1–1.5 cm)

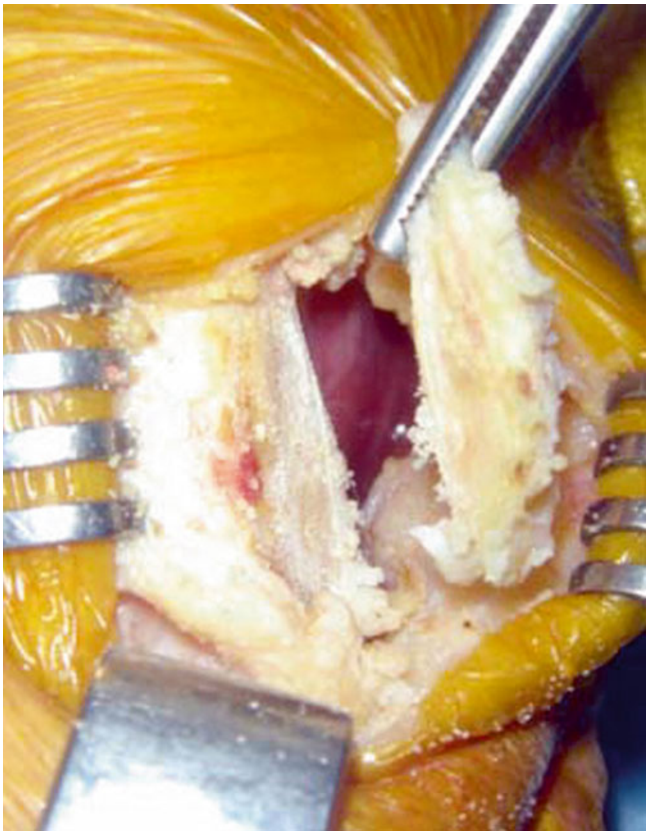


Fig. 21.8 Final view after resection

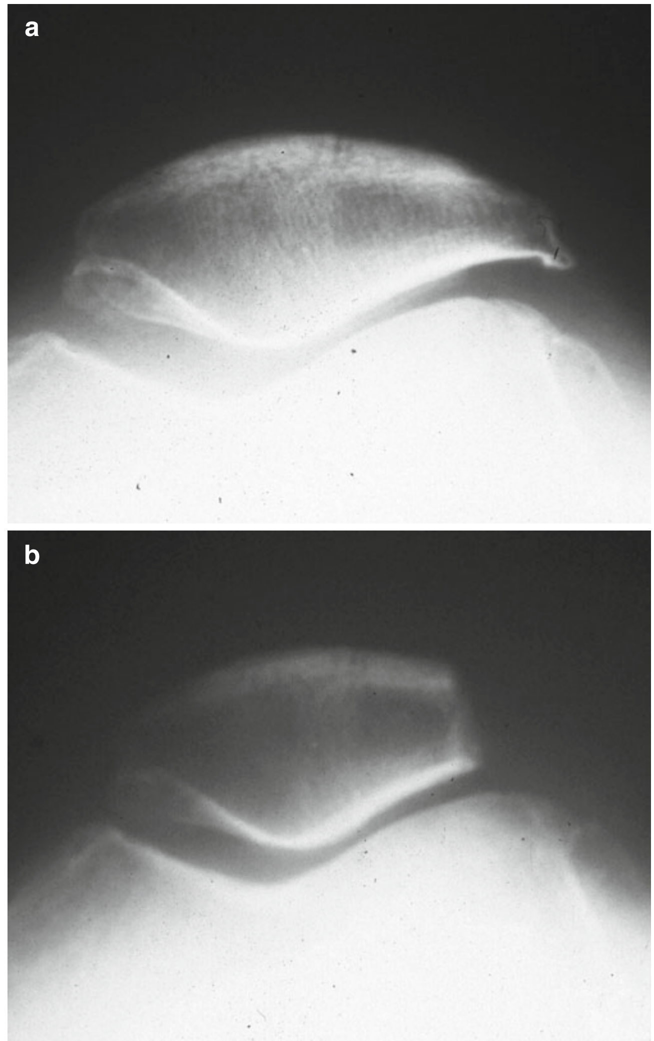


Fig. 21.9 Preoperative (**a**) and postoperative (**b**) x-rays (skyline views)

Postoperative Guidelines

Ice application should be limited to 3–4 days postoperatively.

Thromboprophylaxis is continued for 10 days.

As for all surgery on the patellofemoral joint, the brace should be in 20° of flexion at rest and in extension for walking. Walking with crutches is allowed for 3–5 days after which quadriceps training is started. Weight bearing is allowed immediately. Rehabilitation should be progressive and slow and should not provoke pain. Isometric quadriceps contractions and continuous passive motion should start of the first postoperative day. Return to normal activities of daily living is allowed after 1 or 2 months. Downhill walking is not allowed for 2–3 months and squatting for 6 months.

Complications

Complications include hematoma and pain because of an insufficiently large resection.

No specific complications were noted in our recently published series. Functional outcome is encouraging even if the radiological results are mediocre. With a mean follow-up of 8 years, no further surgery after facetectomy had to be performed in our series.

22 Unicompartmental Knee Arthroplasty

S. Lustig, A. Daher, and Robert A. Magnussen

Introduction

A unicompartmental prosthesis is indicated in unicompartmental arthritis. Patient selection and surgical technique are key factors for a successful outcome. In this chapter, we will detail the surgical technique for a medial UKA (Fig. 22.1). The surgical technique for a lateral UKA is comparable; therefore, we will only cover some specific points regarding a lateral UKA.

Radiological workup (cf. chapter on surgical indications for knee arthritis) (Figs. 22.2a, b, 22.3, and 22.4).

The stress radiograph is essential in the radiological workup. It will indicate whether the deformation is reducible but not overcorrectable (Figs. 22.4 and 22.5).

For UKA, the mechanical femorotibial axis (mFTA) of the lower limb should be within certain limits. The authors propose that they should not exceed 9° of varus or 14° of valgus. Outside these limits, a total knee arthroplasty (TKA) is generally preferred.

Fig. 22.1 U-KneeTec® prosthesis

S. Lustig, MD, PhD (✉)
Albert Trillat Center, Croix Rousse Hospital,
103 grande rue de la Croix Rousse, 69004 Lyon, France
e-mail: sebastien.lustig@gmail.com

A. Daher, MD
Centro Medico Dr Guerra mendez,
Torre D. Piso 5. Consultorio 504, calle rondón c/c 5 de julio,
Valencia, Venezuela
e-mail: alaindaher@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_22, © Springer-Verlag London 2014

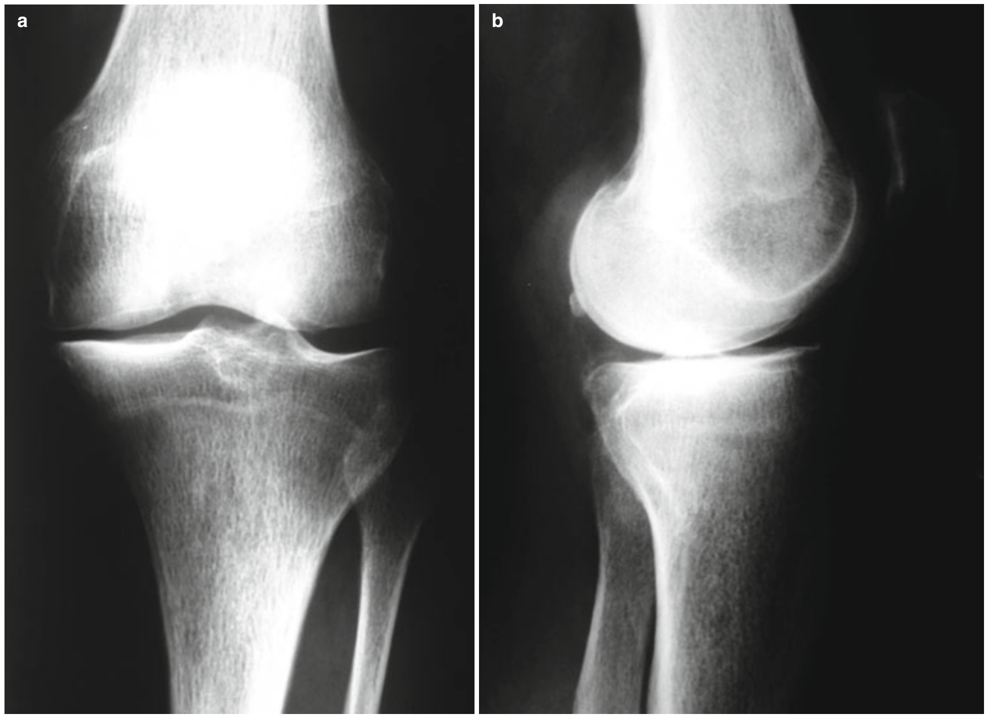


Fig. 22.2 AP (**a**) and lateral (**b**) 30° knee flexion X-rays

Fig. 22.3 Schuss views (45° knee flexion) are useful to detect mild narrowing of the medial compartment

Fig. 22.4 Stress radiograph in varus and valgus. In this case, the deformity is reducible and not overcorrectable (no medial laxity)

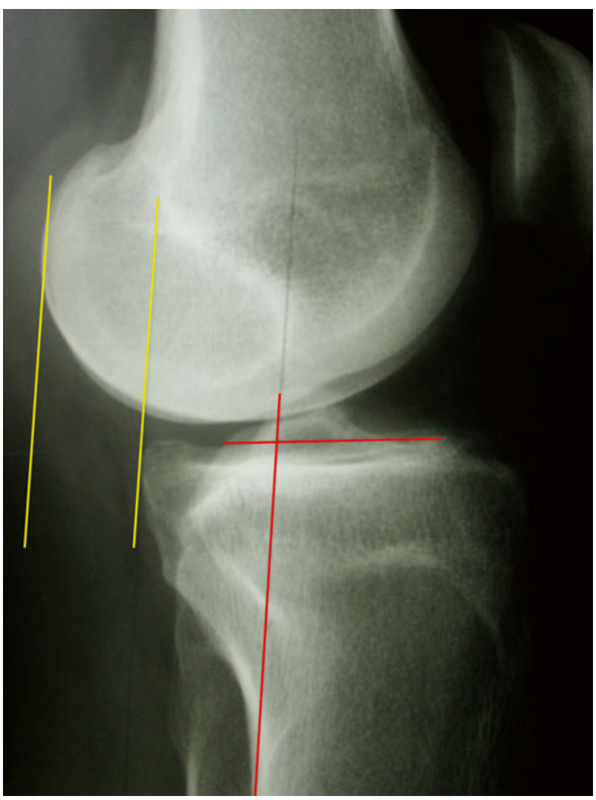


Fig. 22.5 Increased anterior tibial translation is a sign of osteoarthritis associated with ACL deficiency. UKS performed in such a population is prone to early failure

Surgical Technique for a Medial UKA

Setup

- cf. chapter on "Total Knee Arthroplasty"
- Tourniquet
- A vertical lateral support is placed at the level of the tourniquet and a distal horizontal support is placed to keep the knee flexed at 90°.

Approach

A paramedian medial skin incision of 8–10 cm begins at the superior pole of the patella and ends at the medial border of the tibial tubercle (Fig. 22.6). The vastus medialis and the medial border of the patellar tendon are identified. A medial midvastus arthrotomy of the knee is performed (Fig. 22.7). The anterior horn of the medial meniscus is incised and the anteromedial tibial plateau is exposed in a limited fashion. The "midvastus" approach can go 15 mm into the vastus medialis using the Metzenbaum scissors as proposed by Engh. This allows adequate exposure of the femoral condyle. The appropriate retractors are positioned. The articular cartilage and the status of the anterior cruciate ligament are examined.

The anteromedial joint capsule is released from the tibial metaphysis in a triangular fashion. The Trillat periosteal elevator is inserted between the medial border of the medial tibial plateau and the joint capsule. We do not perform any ligamentous release. Using the arthroscopic shaver, the articular cartilage on the distal femur is removed up to the level of the subchondral bone. This subchondral bone will serve as a reference for correct positioning of the UKA.

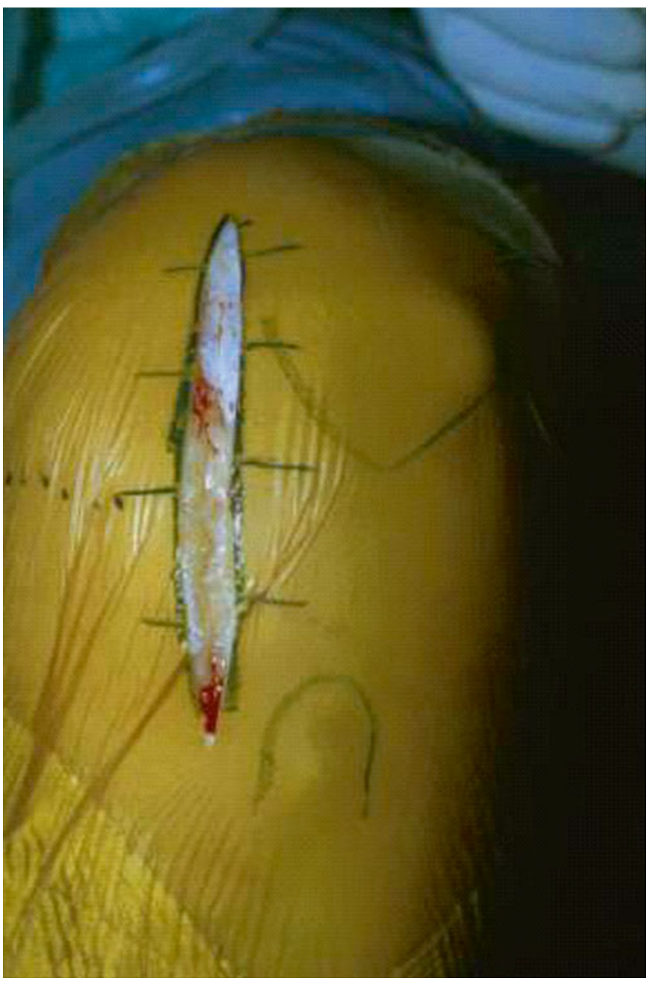


Fig. 22.6 Skin incision

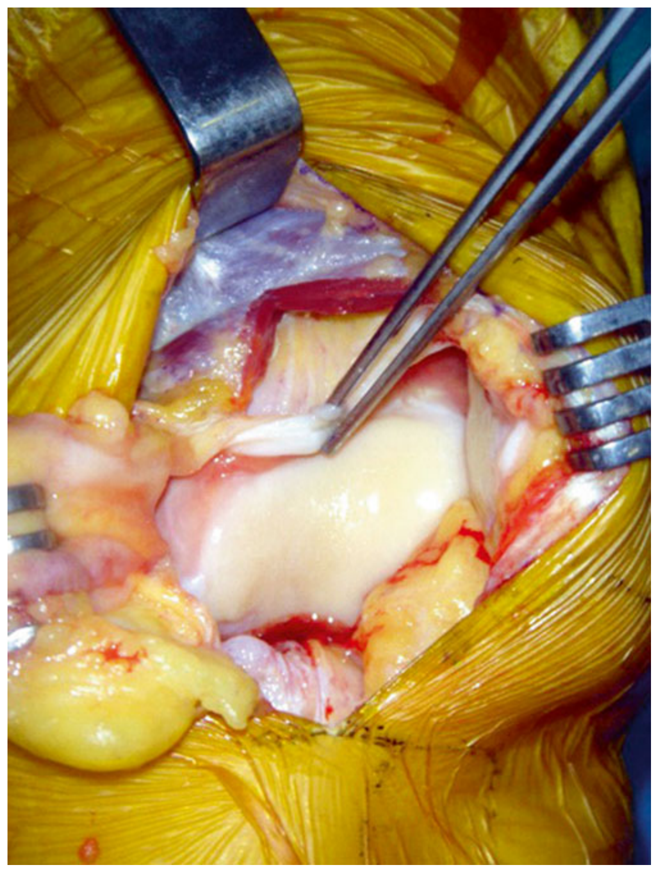


Fig. 22.7 Medial midvastus arthrotomy

The Tibia

The tibial alignment guide is positioned (Fig. 22.8). First coronal and subsequently sagittal plane alignment will determine the tibial cut. In a tibia with no extra-articular deformation, the cutting guide is centered over the midpoint of the mechanical access in the coronal plane. In the case of metaphyseal tibial bowing, the tibial cut should be performed perpendicularly to the proximal tibial epiphysis axis.

In the sagittal plane, a pin is placed into the medial joint space resting on the anterior and posterior margin of the tibial plateau. The extramedullary cutting guide is placed on this pin to reproduce the tibial slope. Once the cutting guide is correctly aligned in both the coronal and sagittal planes, the tibial resection height is determined. In extension, the level of the exposed subchondral bone of the distal femoral condyle is considered the joint line reference. A controlled valgus stress is now applied to reduce the deformity (Fig. 22.9). Generally, we aim to correct only the wear component taking care not to over correct the axial alignment.

Holding the knee in this correct position, the guide pin is now positioned in contact with the distal femoral subchondral bone. The tibial cutting guide is now lowered 13 mm below this reference. The technique of the tibial cut corresponds to the total thickness of the tibial component in extension (9 mm) + the distal femoral component (3 mm) + 1 mm for laxity. The extra millimeter is added to allow some "physiological" laxity. The cutting guide is then securely fixed by 3–4 guide pins through the appropriate holes.

The guide pins allow a perfect horizontal tibial cut while guiding the oscillating saw blade. Next, the vertical tibial cut is performed just lateral to the medial tibial plateau in the axial direction of the medial axis of the notch (Fig. 22.10). The posterior part of the vertical cut can be completed using an osteotome. The medial tibial plateau can now be removed carefully with a large grasper. The posterior meniscal horn can be accessed easily with the knee flexed to 90° and stressed in a valgus position. The cutting guide is removed and the appropriate mediolateral-sized trial tibial component size is selected. Overhang of the trial component is not accepted. The trial component should be easily introducible in flexion and stable during flexion/extension.

Primary assessment of the stability of the trial tibial component is mandatory at this point (Fig. 22.11a, b).

Fig. 22.8 Positioning of the tibial alignment guide

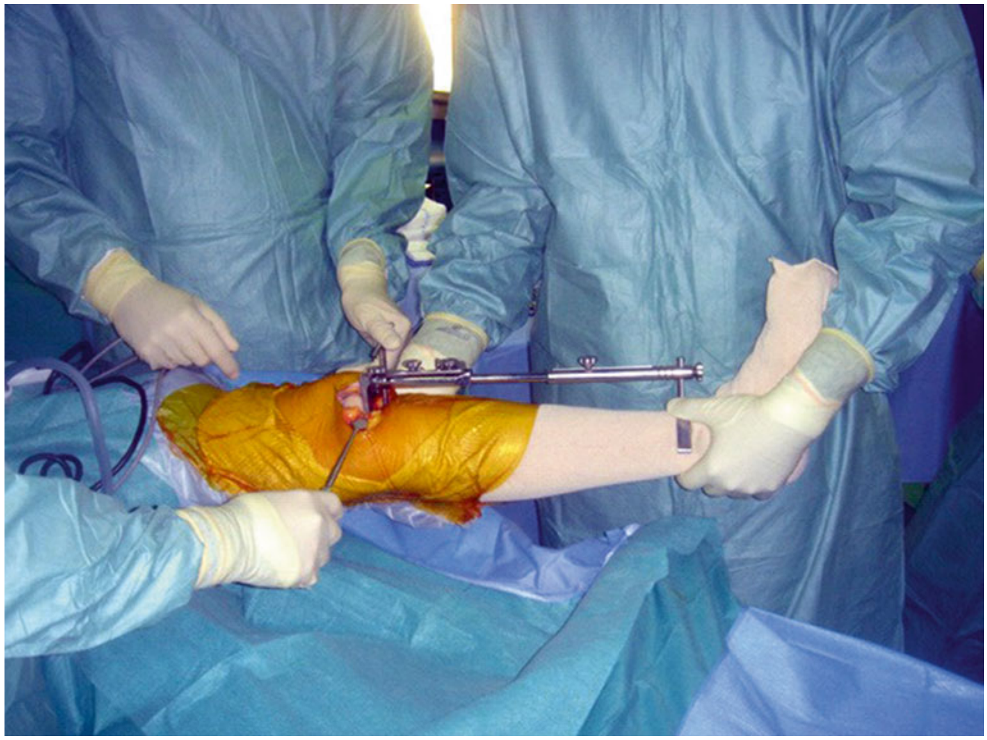


Fig. 22.9 Controlled valgus stress applied to reduce the deformity

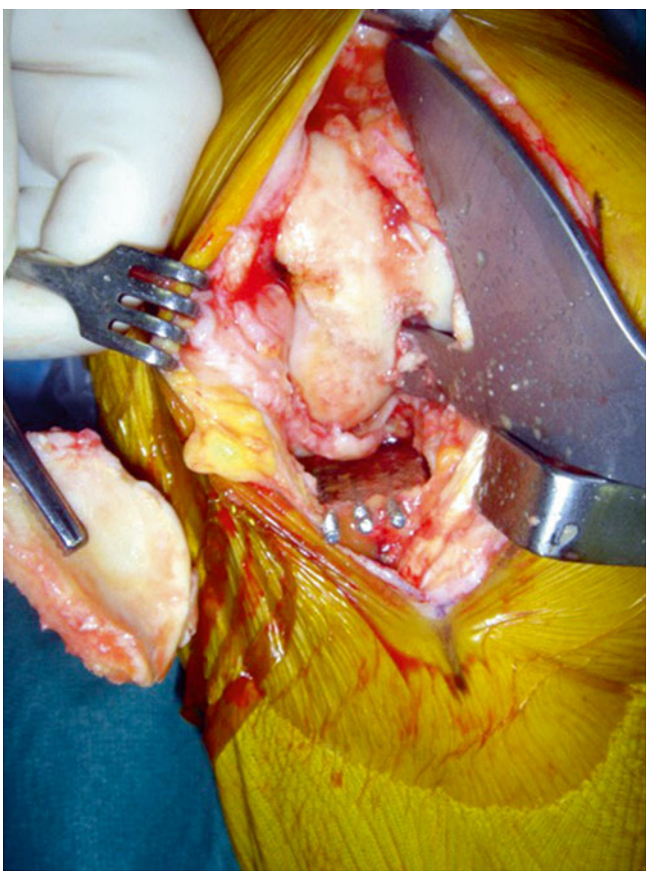


Fig. 22.10 Horizontal tibial cut on guide pins

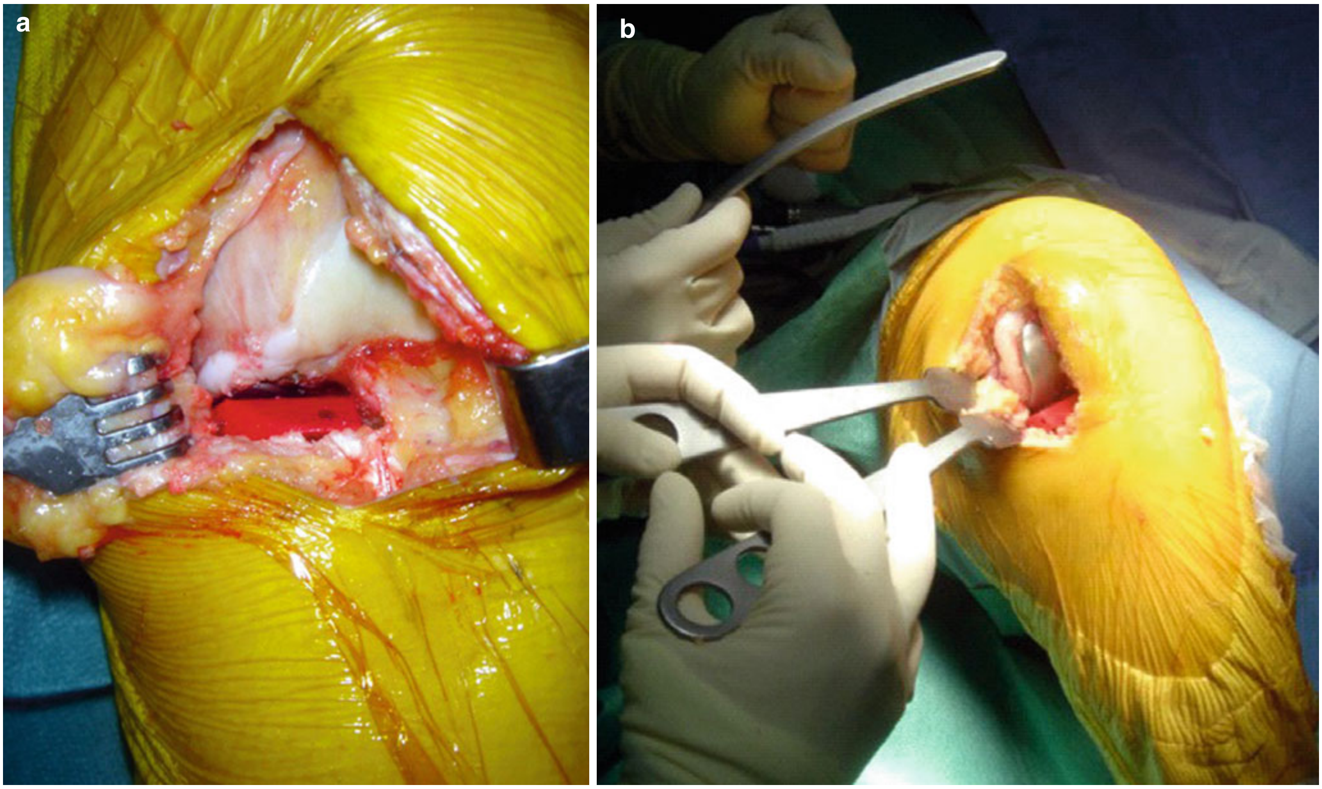


Fig. 22.11 (**a**, **b**) Primary assessment of the stability of the trial tibial component

Femoral Resurfacing

With the trial tibial component in place and the knee now in extension, a mark is made on the femoral condyle opposite the anterior limit of the tibial component. A special femoral guide (the crocodile guide) is vertically introduced and should lie flat on the tibial component with the knee still in full extension (Fig. 22.12a, b). This step is very important because the orientation determines the correct positioning of the femoral cutting guide and the femoral component in the coronal and horizontal planes. Two guide pins are inserted through the two holes of the crocodile guide. With the crocodile guide still in place, the knee is now flexed to 90°. The posterior border of the crocodile guide should be parallel to the tibial plateau. A small adjustment can be made at this point or during the next step. The crocodile guide is subsequently removed while the guide pins are left in place. These guide pins will accommodate the femoral drilling guide. In 90° of flexion, the femoral drilling guide is placed onto the two guide pins (Fig. 22.13). The correct position of this guide is perpendicular to the tibial cut. Although the design of the prosthesis accepts some freedom of alignment, this should not exceed 6°. In case of excessive malalignment of the drilling guide, the guide should be realigned. If necessary, realignment is performed by pinning the guide through the most central hole on the mediolateral axis of the lateral condyle including the lateral osteophyte. Next, the guide is removed and the femoral drilling guide is correctly aligned perpendicularly to the tibial cut with the knee in 90° of flexion. A third pin can ensure the correct alignment. All remaining holes are now predrilled. The guide is removed and the predrilled holes are now connected with each other by an oscillating saw to create the femoral recess. The femoral recess is subsequently enlarged and impacted. The appropriate femoral cutting block is chosen according to the size and the curvature of the femoral condyle (Fig. 22.14). The femoral cutting block size is assessed with a classic posterior femoral condyle reference system. Anteriorly it should be in between the femoral condylar mark and the two femoral guide pinholes. The curvature of the block should match that of the femoral condyle. The cutting block is fixed in place with pins. Finally, correct femoral alignment is double-checked. The posterior cut and the posterior chamfer are then performed. No distal femoral cut is performed.

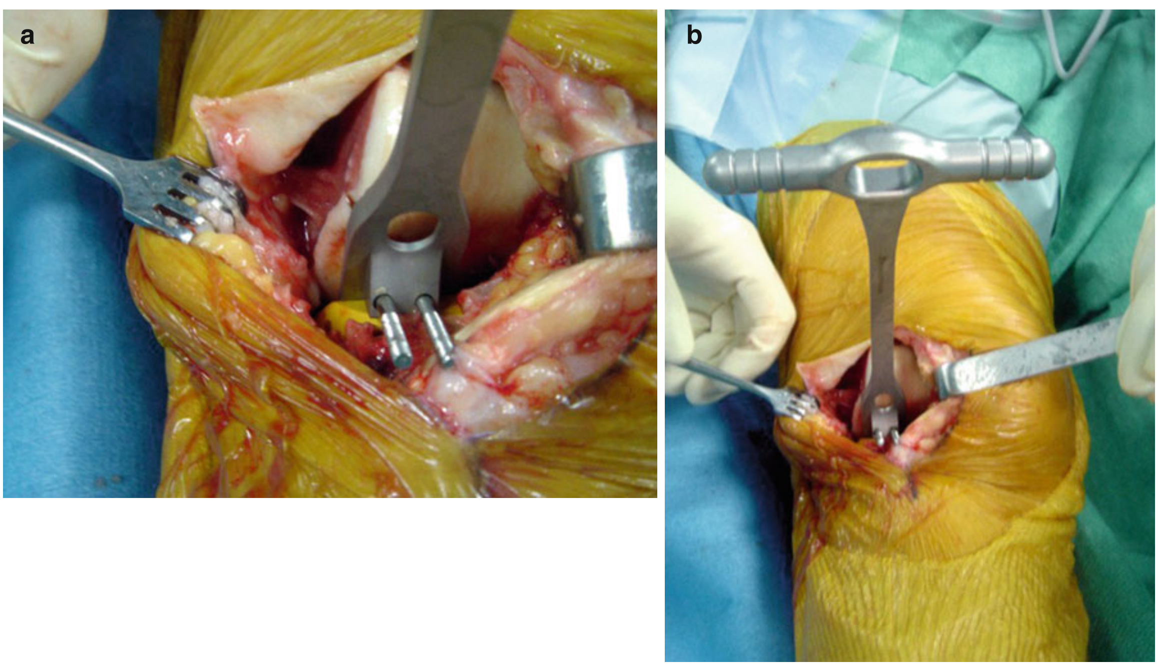


Fig. 22.12 (**a**, **b**) Femoral guide positioning in extension

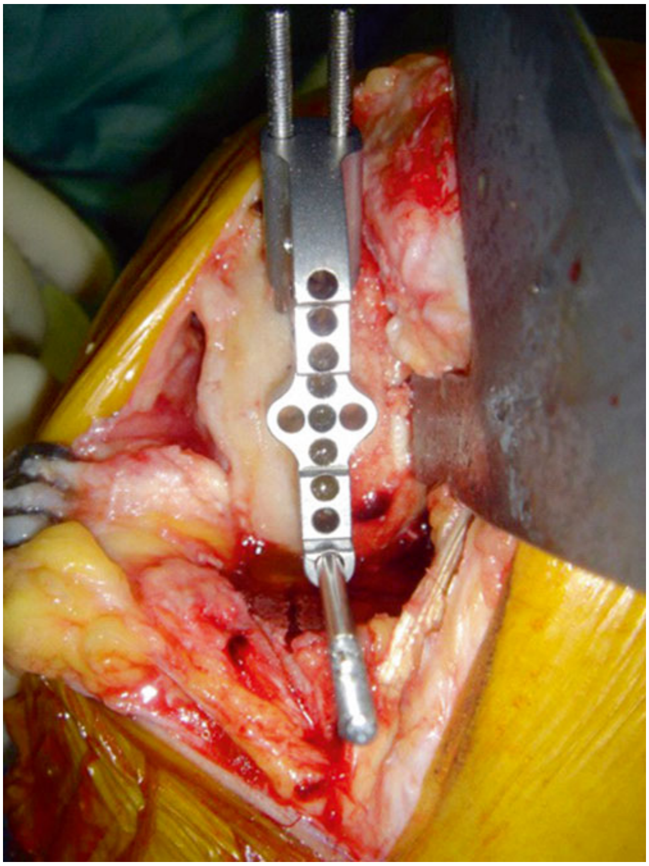


Fig. 22.13 Femoral drilling guide positioning in flexion. If necessary, the guide can be moved medially or laterally

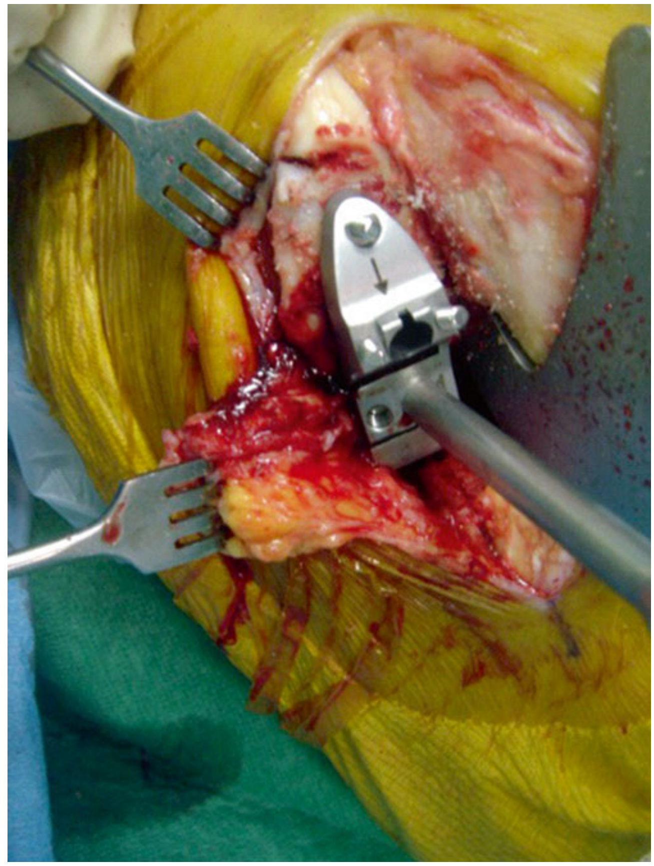


Fig. 22.14 Femoral cutting block positioning

Key Points

1. The cutting block size is determined by the shape and curvature of the femoral condyle.
2. It should be at a level of or cover the two previously performed two holes on the anterior border of the distal femur.
3. The cutting block should be in contact with the posterior condyle.
4. Rotation should not be modified in order to obtain a better cover of the condyle. Rotation of the femoral component is solely determined by the tibial cut.

The femorotibial components are introduced and primary stability is verified first in flexion and then in extension. If the tibial component has a tendency to advance in flexion, one should first suspect the remnant of a posterior meniscal horn pushing the tibial plateau anteriorly or an insufficient slope of the tibial plateau. A slight laxity should be accepted to guarantee undercorrection. If ligament tightness exists, the correct position of the femoral guide should be checked. It should be in contact with the subchondral bone. If the tightness is still present, one should proceed with an additional tibial cut of 1–2 mm. This cut can be done easily free hand using the oscillating saw: the tracts of the guide pins, which correspond with approximately 1–2 mm in thickness, should just be sawed away. Under no circumstances should one perform a ligamentous release to address the tightness. Again overhang of the trial tibial component is not accepted.

Implant Fixation

If alignment and laxity are satisfactory, the component can be cemented. Generally, we firstly cement the femoral component followed by the tibial component (Figs. 22.15, 22.16, and 22.17). A small bony recess is made underneath the tibial spine. The joint articulations are cleaned from debris and irrigated. The knee joint capsule and skin are closed. The tourniquet is not released for the closure. A drain is left intra-articularly.

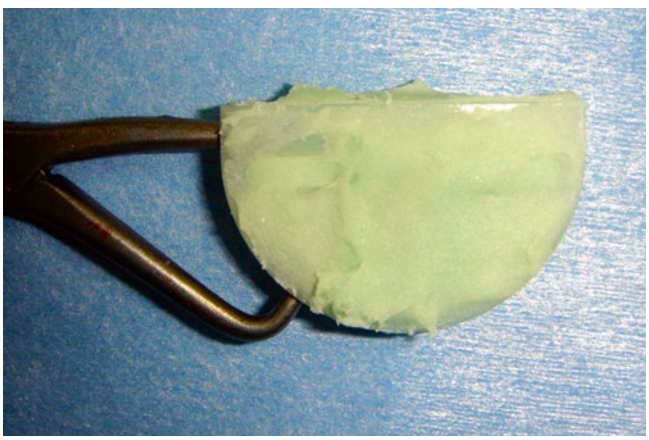


Fig. 22.15 Cemented tibial component

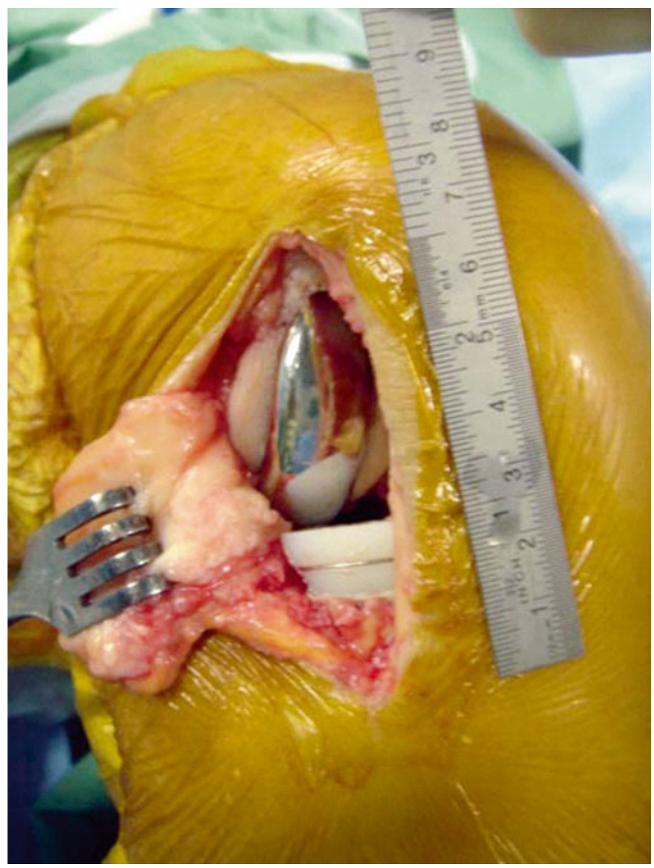


Fig. 22.16 Cemented components

Fig. 22.17 Fixation of the components

Postoperative Guidelines

- Postoperative radiographs (Fig. 22.18).
- Weight bearing is allowed on day 1; crutches are used for 1–3 weeks.
- Removal of the drain when production of less than 50 cc (maximum 1–3 days).
- Hospital stay for 3–5 days depending on the comorbidities and social circumstances.
- Flexion from 0 to 120° until day 45, unlimited afterwards.
- Thromboprophylaxis for 15 days.

Fig. 22.18 Postoperative X-rays

Specific Points for the Lateral Unicompartmental Arthroplasty

The surgical technique for a lateral unicompartmental knee arthroplasty is very comparable to the medial unicompartmental arthroplasty except for some specific points:

Approach

A lateral longitudinal parapatellar incision of approximately 8 cm is made with the knee in 90° of flexion to gain access to the lateral compartment of the knee joint. The joint capsule is opened using a lateral arthrotomy. The iliotibial band is NOT released from its distal attachment on Gerdy's tubercle (Fig. 22.19).

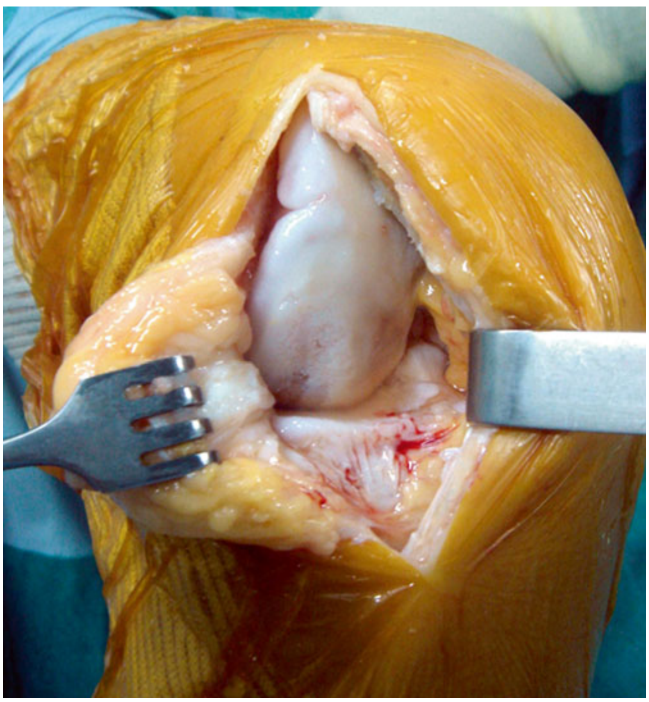


Fig. 22.19 The joint capsule is released but the iliotibial band stays intact

Tibial Cut

A common error in the lateral compartment is the overcorrection of the deformity by excessive varus stress, resulting in a tibial cut of insufficient thickness. Therefore, we generally opt to incompletely reduce the deformity in valgus. This will result in a thicker tibial cut (Fig. 22.20).

Fig. 22.20 Incomplete reduction of the deformity in valgus

Femoral Resurfacing

Generally, we place the femoral cutting guide on the most lateral part of the femoral condyle and, if present, on the lateral femoral osteophyte. This will eliminate a potential conflict between the femoral component and the tibial spines. As mentioned earlier, a general error is overcorrection in the coronal plane. This is due to the physiological laxity, which is present in the lateral compartment and should be preserved. In general, the surgical technique for a lateral unicompartmental knee arthroplasty is not more difficult than for the medial one using modern instruments. In fact, the lateral compartment is more tolerant than the medial one due to the extrinsic moment arm, which pushes the knee into varus. Therefore, the indications for the lateral unicompartmental knee arthroplasty can be pushed somewhat further going up to 12–15° of valgus alignment in the frontal plane.

Associated Procedures

In specific indications, a lateral facetectomy of the patella can be performed in associated with a UKA (Fig. 22.21).

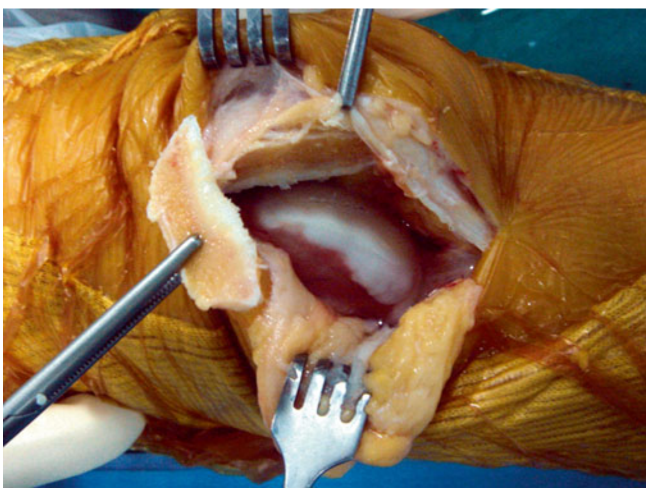


Fig. 22.21 Associate lateral facetectomy of the patella

Comments

Until 1996, an osteotomy of the anterior tibial tuberosity was routinely combined with a lateral unicompartmental knee arthroplasty. Due to the arrival of new and minimally invasive instruments, the osteotomy is no longer necessary to position the lateral unicompartmental knee prosthesis in a correct and reproducible manner. Therefore, this technique has been abandoned since 1996.

Complications

General complications are less frequent than for total knee arthroplasty: fat embolism and DVT are rarely observed. Septic arthritis remains an exception.

Axial malalignment: overcorrection is the most frequently observed error in our experience.

One should always take care of:

- An excessive tibial cut on the medial side for medial UKA
- Overcorrection in lateral UKA

Unicompartmental Knee Arthroplasty (UKA) After Unicompartmental Knee Arthroplasty (UKA) to the Other Compartments

23

Maad F. AlSaati, S. Lustig, and Robert A. Magnussen

Introduction

The concept of unicompartmental knee arthroplasty (UKA) has experienced an increase in interest in the last decade. The two main causes of failure are aseptic loosening and the occurrence of degenerative lesions in the opposite tibiofemoral compartment.

The UKA is known to be less invasive than the total knee arthroplasty (TKA) and has the added advantage of preserving both cruciate ligaments, which results in kinematics more similar to those of a normal knee. A UKA also has decreased morbidity and overall costs than a TKA. It allows a shorter hospital stay and faster return to normal function. Therefore, it may be tempting to preserve these benefits in case of progressive degenerative change of the opposite compartment after UKA. This goal can be achieved in selected cases by performing a second UKA (bicompartmental UKA) rather than revision to a TKA.

Patient Selection

The selection criteria for a bilateral UKA are summarized in Table 23.1. The typical patient is one who initially was happy with his first intervention but subsequently developed a degenerative change in the opposite compartment.

Table 23.1 Indications and contra-indications for UKA of a second tibiofemoral compartment

Indications
No wear or loosening of the original UKA with correct implant positioning
"Overcorrection" close to 5° of the first implant
Good initial result of the first UKA (initial painless period followed by appearance of secondary symptoms)
Localized pain in the opposite tibiofemoral compartment
Osteoarthritis stage C or D (IKDC) or osteonecrosis of the femoral condyle
Reducibility of the deformity in the frontal plane
Healthy cruciate ligaments
Normal or near normal range of motion
Contraindications
Absolutes
Inflammatory arthritis
History of infection
Ligament damage
Major bone loss
Extension deficit of greater than 10°
Relative
Patellofemoral compartment osteoarthritis
Weight greater than 80 kg

M.F. AlSaati, MD
Saati Medical Center,
88591, 11672 Riyadh, Saudi Arabia
e-mail: maad.saati@gmail.com

S. Lustig, MD, PhD (✉)
Albert Trillat Center, Croix Rousse Hospital,
103 grande rue de la Croix Rousse, Lyon 69004, France
e-mail: sebastien.lustig@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_23, © Springer-Verlag London 2014

Radiological Evaluation

Standard radiological assessment (anterior view, lateral view, "Schuss view," stress views, hip-ankle view bilaterally) can specify the stage of osteoarthritis (Fig. 23.1a, b), the reducibility of the deformity (Fig. 23.2a, b), and the mechanical axis. On a technical level, when performing bicompartmental UKA, the objective is not to obtain a 180° axis, but compensate for the intra-articular wear in the nonprosthetic compartment.

The axial view of the patella is also needed to assess the patellofemoral joint (Fig. 23.3). In case of lateral facet osteoarthritis, a vertical patellectomy can be performed in association with the UKA (see Chap. 22).

It is important to evaluate both the original prosthesis and the opposite compartment. In the prosthetic compartment, no signs of loosening or wear must be found. The prosthesis must be positioned well. There should not have been any degenerative changes in the opposite compartment at the time of the initial UKA—they should have appeared progressively over time.

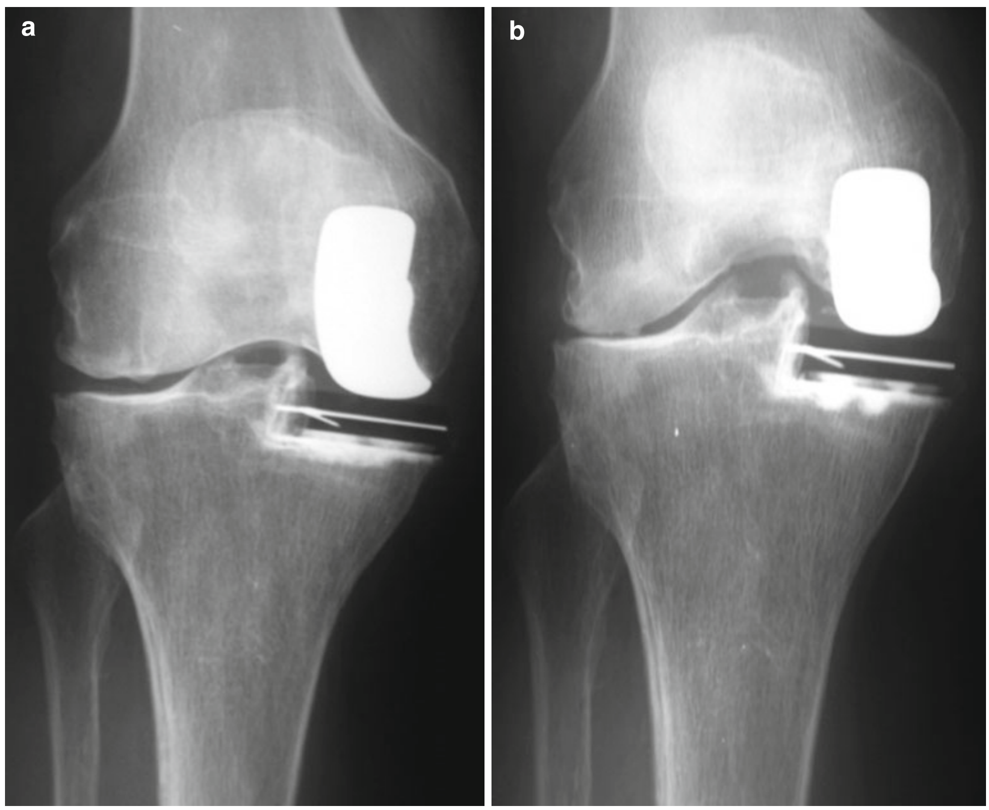


Fig. 23.1 (**a**, **b**) Standing AP view and "Schuss" view showing femorotibial osteoarthritis on the lateral compartment with a medial unicompartmental arthroplasty

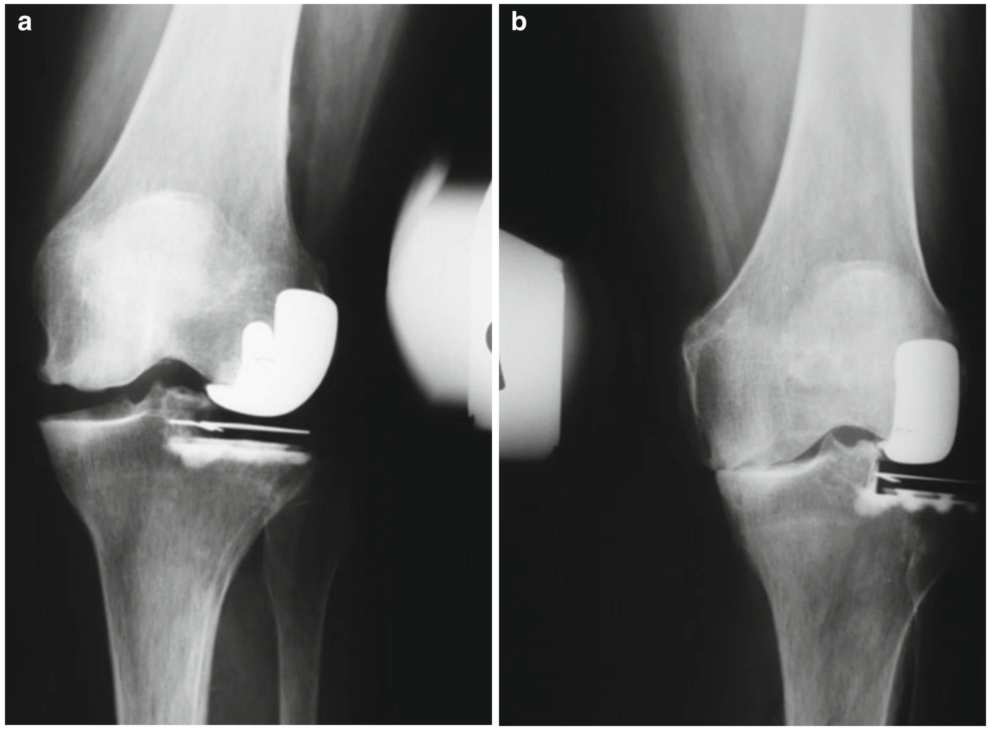


Fig. 23.2 (**a**, **b**) Views in stress showing a good reduction of the deformity and the absence of laxity of prosthetic compartment

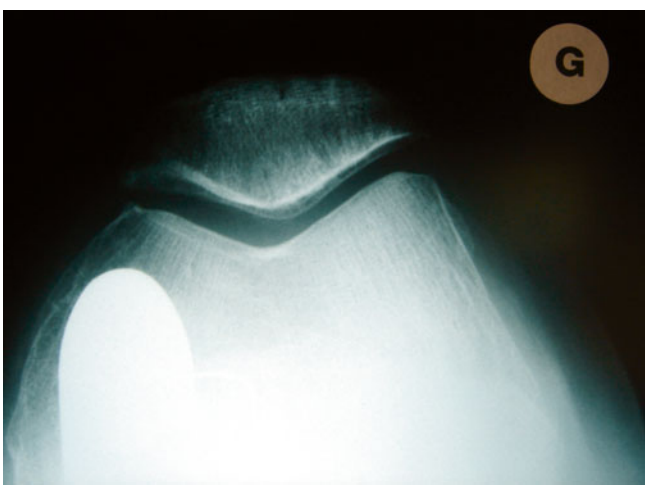


Fig. 23.3 Evaluation of the patellofemoral joint

Laboratory Tests

Infection must be excluded using a complete blood count (CBC) and assessment of inflammatory markers. A rheumatological workup should be performed if there is a concern for an inflammatory process.

Scintigraphy

Although not essential, this test can rule out subclinical implant loosening. It also verifies the absence of overload of the opposite tibiofemoral compartment.

CT Scan

A CT scan or CT arthrogram provides information on overhang or possible loosening of the initial UKA and can also help to identify the possible causes of complaints that are located in the opposite compartment (osteonecrosis, meniscal tear, cartilage damage, foreign body).

Arthroscopy

Arthroscopic evaluation of the joint can influence the decision between a second UKA and conversion to TKA. It is important to evaluate both the status of the polyethylene in the first UKA and the condition of the other two compartments. It can be performed at the beginning of the intervention.

Surgical Technique

Setup is the same as for all knee arthroplasty with the knee at 90° of flexion and a tourniquet at the upper part of the thigh. We use a cemented UKA with a cobalt-chrome resurfacing femoral implant and an all-polyethylene tibial component (HLS Uni Evolution, Tornier®). The approach is determined according to the old incision (that is used during the first UKA).

Medial Unicompartmental Arthroplasty After a Lateral Unicompartmental Arthroplasty

There are two options for performing the second UKA. The first is to create another separate incision (not less than 8 cm is recommended as a safety distance between the two incisions) between 8 and 10 cm long, extending from the upper pole of the patella to the medial border of the ATT (Fig. 23.4). The second option, in cases in which the first incision is sufficiently lateral, is to reuse the first incision by extending 5–6 cm proximally and 2 cm distally to mobilize it enough to perform a medial arthrotomy (Fig. 23.5). This second option is preferred.

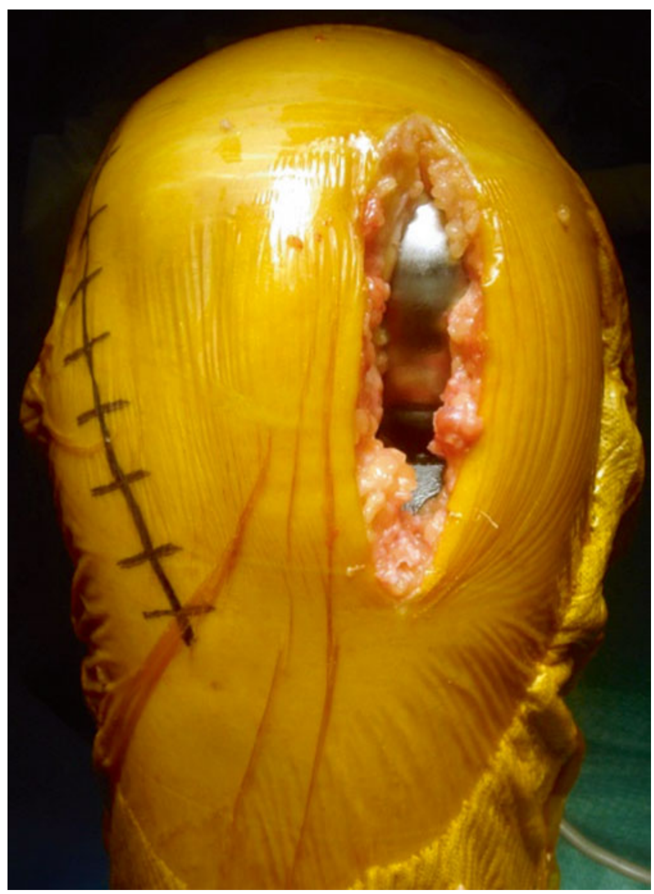


Fig. 23.4 Performing a separate incision away from the existing incision

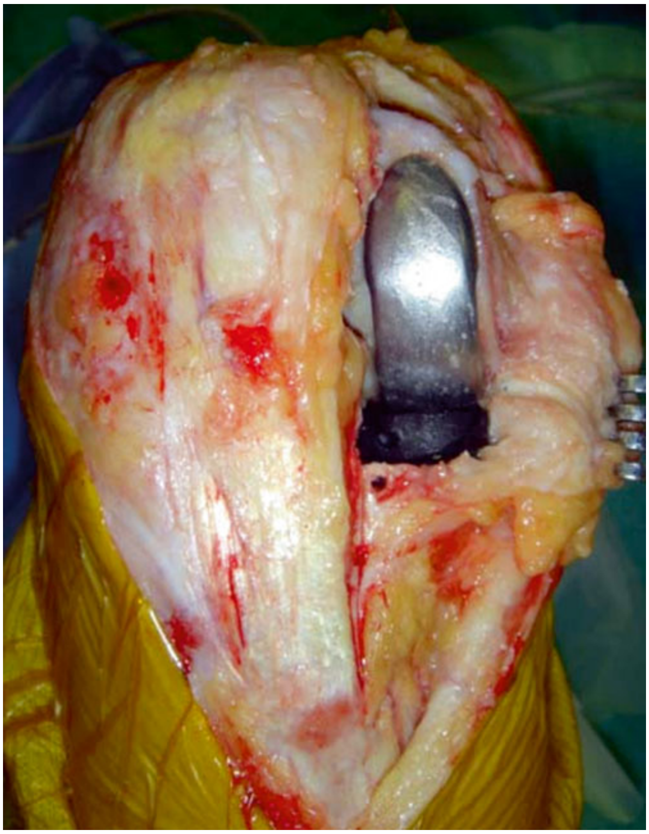


Fig. 23.5 The other option is preferred. Retaking the same incision with proximal extension and distal detachment of subaponeurotic and medial arthrotomy

Tibial Side

To position the cutting template, a pin is inserted through the tibial cutting guide and into the tibiofemoral joint. This pin gives the orientation of the tibial slope and establishes the level of the joint line. The tibial cutting guide is then secured by a pin to the tibia medially, approximately 5 mm below the joint line. This pin is parallel in the sagittal plane to the pin inserted into the joint. The extramedullary stem is then oriented to meet the extra-articular deformity.

The knee is placed in extension, and the surgeon makes a controlled valgus maneuver to compensate for the intra-articular wear without overcorrection. The tibial cutting guide is then lowered 13 mm (3 mm for the thickness of the prosthetic condyle, 9 mm corresponding to the thickness of the polyethylene plate, and 1 mm for security to avoid over-correction). The less valgus applied, the more we cut the tibia. This is the advantage of preoperative assessment with the stress radiograph, which allows anticipating of the degrees of valgus opening that will occur in the OR.

Two or three pins are inserted through the guide to secure it. The cut is made on the pins with the knee in flexion. The sagittal cut is oriented towards the center of the hip. It passes through the medial border of the insertion of the ACL and along the axial surface of the medial femoral condyle. The posterior aspect of the cut is completed with an osteotome (a 10 mm in width) while respecting the PCL. The medial tibial plateau is grasped with an alligator clamp, and all the menisco-capsular attachments are detached. The underside of the medial tibial plateau piece that is resected can measure reliably and accurately the size of the tibial trail piece.

Before the removal of the pins, verify the location of the tibial cut. It should be perfectly on the pins and it must be flat. We then introduce the tibial trial component to ensure its primary stability.

Femoral Side

The positioning of the femoral and tibial components is intimately linked. Indeed, the height of the tibial cut (but not its orientation) is determined relative to the joint line, while the orientation of the femoral cut is dependent on the position of the tibial trial component.

The tibial trial component is left in place. A special instrument, which we commonly call a crocodile (template of positioning), is placed between the abraded femoral condyle and the tibial trial piece (Fig. 23.6). While the knee is extended, we make sure it stays on the tibial trial piece and does not pass the medial border of the medial femoral condyle. This instrument has two functions: first, to determine the anterior limit of the femoral implant and, second, to eliminate the rotation of the femoral implant relative to the tibial component during flexion-extension. Two pin markers are introduced into the anterior part of the "crocodile."

While the knee is flexed to 120°, these pieces, the crocodile and the tibial trial piece, can be removed. On the two pins, the drill guide is positioned to prepare the femoral slot. Its location and orientation relative to the femoral condyle are checked (Figs. 23.7, 23.8, and 23.9).

After determining the appropriate position of the femoral component, the next step is to determine its size. The size is not selected according to the size of the tibial component, but by using anatomical criteria. The rotation should not be modified to look for better coverage of the condyle. This orientation must strictly follow that given by the slot made in the femur. The templated size is then fixed by pins to the condyle and we can drill the femoral block and make the cut on the posterior condyle.

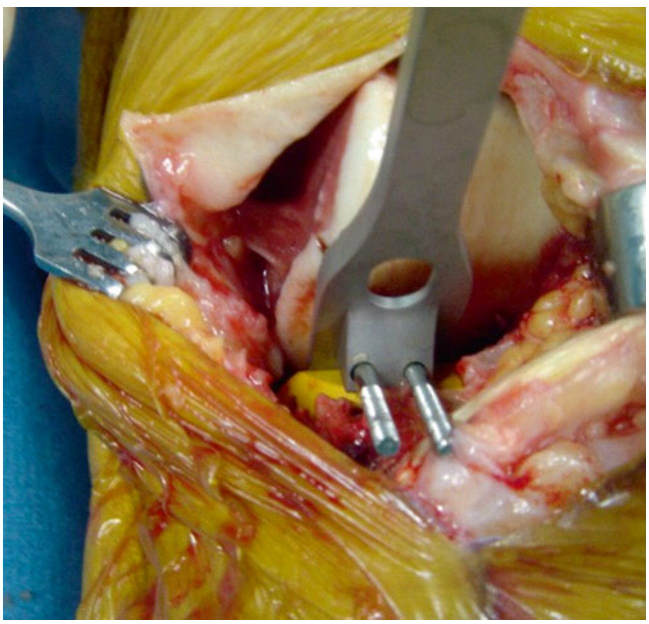


Fig. 23.6 Placement of the crocodile after performing the tibial cut (the tibial trial implant has been in placed)

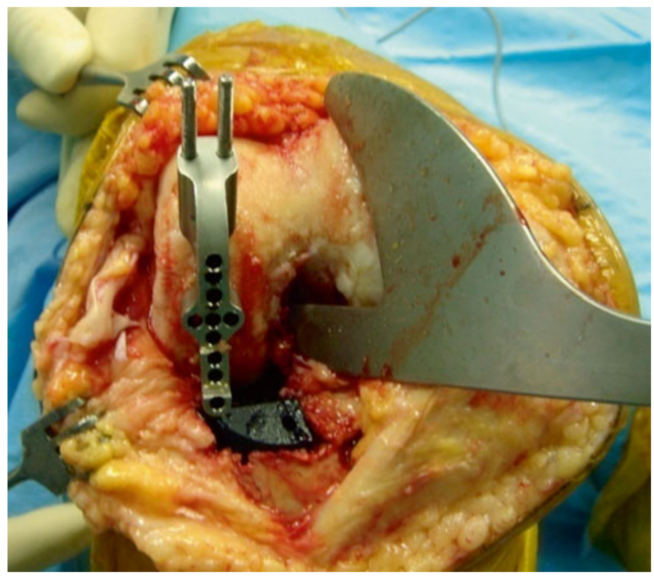


Fig. 23.7 Setting up of the femoral drill guide

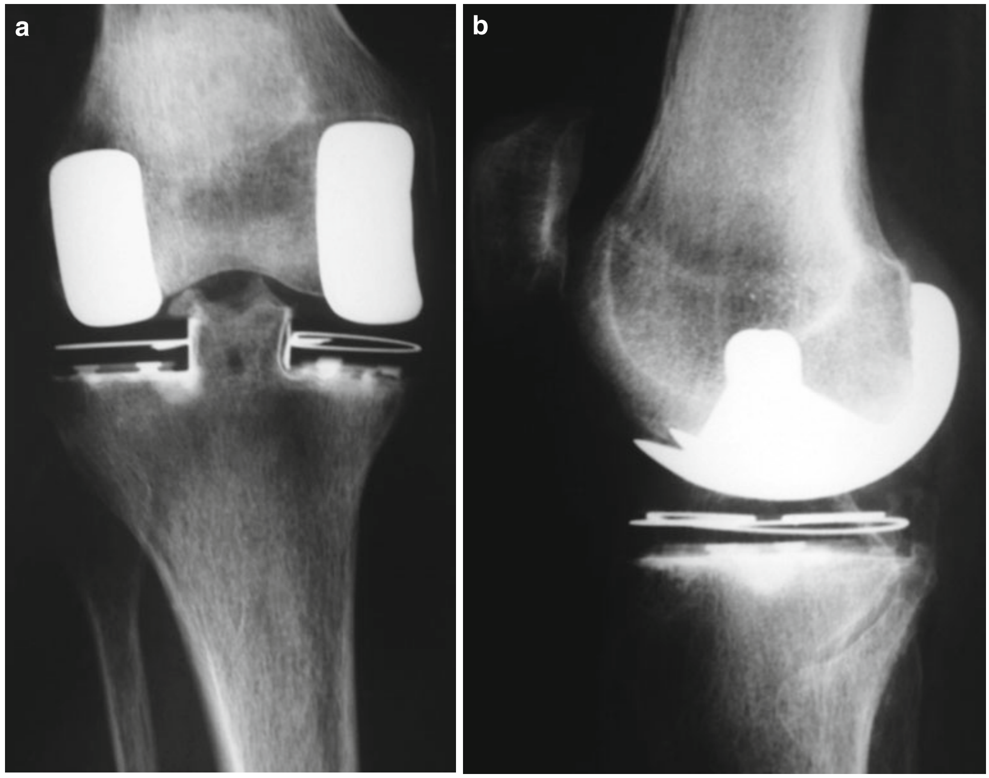


Fig. 23.8 (**a**, **b**) Postoperative X-rays

Fig. 23.9 Skin appearance (**a**) and hip to ankle view postoperatively (**b**)

Trials and Implant Fixation

The femoral trial component is introduced first followed by the tibial trial component. We check the primary stability of the implants and look for the existence of a discrete medial laxity when applying forced valgus. The lack of mild medial articular laxity when applying valgus suggests that overcorrection has occurred. In this situation, we should not do any ligament release but, after checking that the femoral component was well seated on the subchondral bone, make minimal cuts on the tibial plateau to increase the laxity. Both final components are then cemented into position.

Lateral Unicompartmental Arthroplasty After a Medial Unicompartmental Arthroplasty

The technique for the performance of a lateral UKA is the same as for a medial UKA, except for some small details. The setup is similar to that of the medial UKA. With the skin incision, we again respect a distance of at least 8 cm from the incision medially that is already present. It starts in the upper zone of the lateral edge of the patella, descending along the lateral border of the patella to the lateral edge of the patellar tendon and terminating on the upper limit of the tibial tuberosity (medial to the Gerdy's tubercle). The arthrotomy is performed from the lower edge of the vastus lateralis tendon (it is possible to extend it up to 1 cm by staying in the vastus lateralis) to the tibia. The anterolateral capsule is released without detaching the iliotibial tract from Gerdy's tubercle. As with a medial UKA, the preferred option is to extend the previous incision proximally and distally sufficiently to perform a lateral arthrotomy.

One important detail when preparing the femur is that, contrary to what is commonly done, we should not try to tilt the femoral component to cover the lateral condyle, but rather we seek to place the component perpendicular to the tibial cut as suggested by the instrument set, applying it if necessary on the superior and anterior parts of the lateral condyle osteophyte (technical principle of Philippe Cartier). The positioning of the femoral implant should be lateralized as much as possible to avoid conflict with the tibial spines during flexion. The rest of the intervention is essentially the same as described above.

Postoperative Care

These are the same as after a primary UKA:

Full weight bearing first day postoperatively.

Range of motion will be upgraded gradually, but it will be limited up to 95° for 45 days.

Prophylactic anticoagulation is prescribed for 15 days.

24 Total Knee Replacement in Medial Arthritis: Surgical Technique

G. Demey and Robert A. Magnussen

Preoperative Planning

A detailed history and orthopedic physical and radiological evaluation are required for preoperative planning. The aim is to establish which surgical approach is most suitable, to choose the appropriate prosthetic implant, and importantly to anticipate any possible intraoperative technical difficulties that may be encountered.

For the radiological evaluation, cf. Chapter 13 "Surgical indications in osteoarthritis of the knee" (Figs. 24.1 and 24.2).

Valgus stress radiographs show whether the varus deformity is reducible (Fig. 24.3). Incomplete reduction is secondary to contracture of the capsular and ligamentous structures on the medial side of the knee. In this situation, a surgical release will be necessary. The need for soft tissue release is also dependent on the asymmetry of the bony cuts (Fig. 24.4). This can be anticipated and appreciated when drawing the resection lines perpendicular to the anatomical axis. Although we commonly perform varus stress radiographs as well, lateral ligamentous laxity is more difficult to interpret. A pseudo lateral thrust is often observed in these patients. This pseudo thrust is not due to true lateral ligamentous laxity, but rather due to the closing down of the worn medial compartment (Fig. 24.5).

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
Suite 3100, 2050 Kenny Road,
Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_24, © Springer-Verlag London 2014

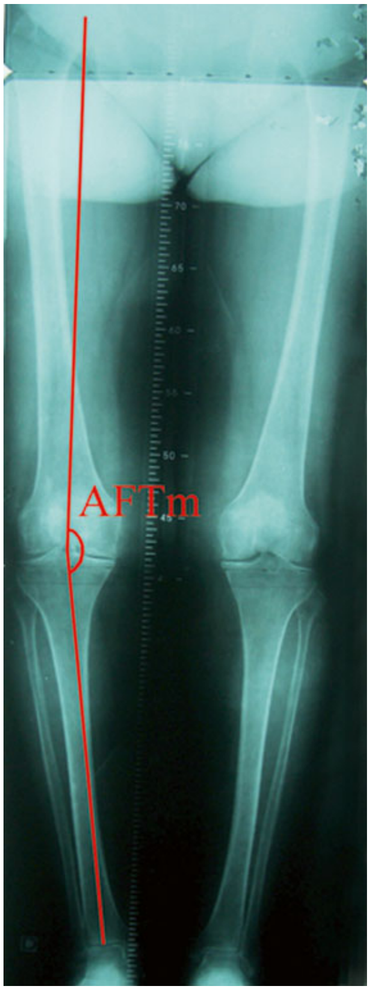


Fig. 24.1 Measurement of mechanical femorotibial angle

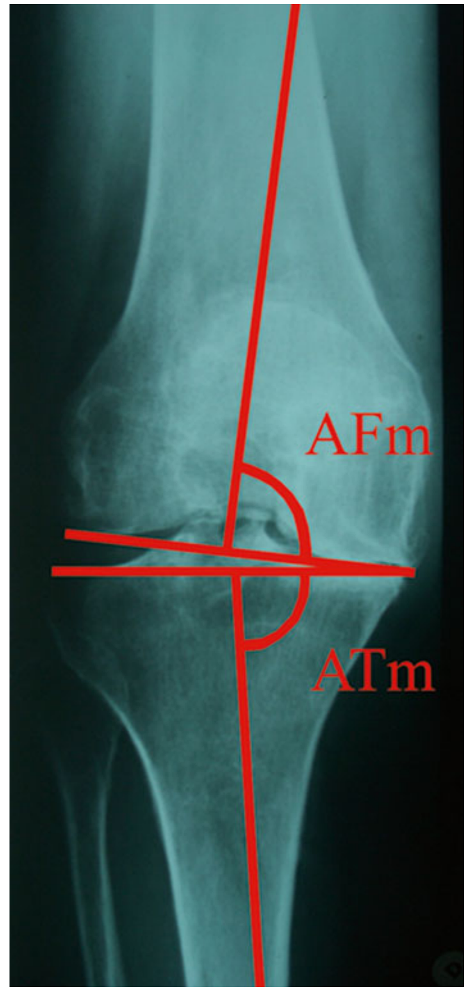


Fig. 24.2 Measurement of mechanical femoral and tibial angles

Fig. 24.3 Valgus stress x-ray (*arrow* designates direction of force)

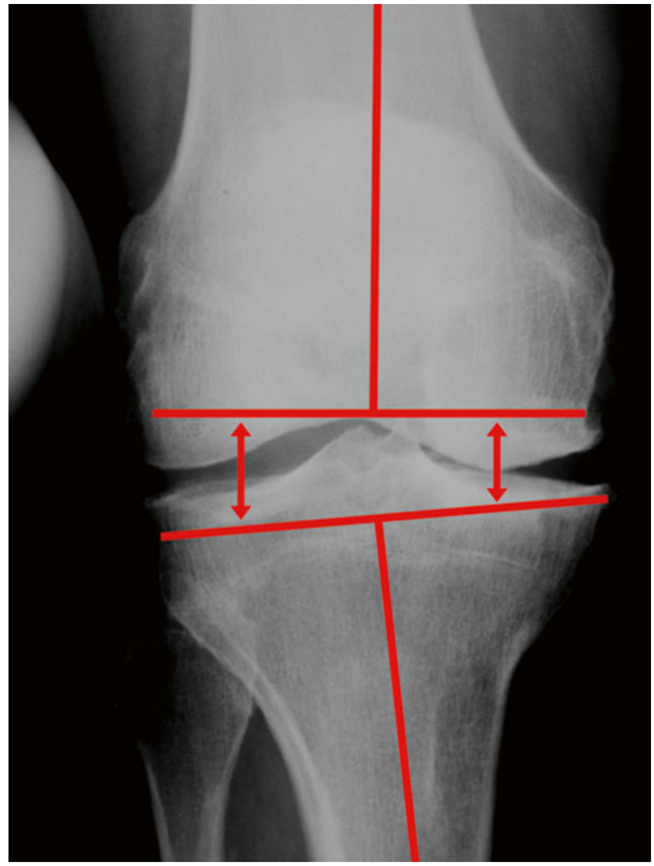


Fig. 24.4 Asymmetry of the bony cuts

Fig. 24.5 Varus stress x-ray (*arrow* designates direction of force)

Surgical Technique

Surgical Approach

A paramedian skin incision is made starting 5–6 cm proximal to the patella and ending on the medial border of the tibial tuberosity. After incising the skin and subcutaneous fat, it is important to dissect onto the superficial retinaculum. Undermining is performed between the superficial and deep retinacula. Laterally, the undermining should stop 5 mm past the patella. Proximally, the quadriceps tendon and distally the medial border of the patellar tendon are identified. At this stage we suture blue OR towels into the wound to isolate the skin edges from the rest of the operating field. Arthrotomy is performed with a 23 blade and starts on the medial side of the quadriceps tendon, leaving a small cuff of tendinous tissue attached to the muscle, to facilitate closure. The arthrotomy is continued distally on the medial side of the patellar tendon toward the medial side of the tibial tuberosity. The anterior part of the medial meniscus is incised while the scalpel blade stays in contact with the anterior border of the tibial plateau. Subsequently, the medial capsule is released from the anteromedial part of the tibial plateau. This release is triangular (Fig. 24.6). The deep fibers of the medial collateral ligament are released using a periosteal elevator on the proximal border of the tibial plateau at the joint line. Subsequently, a total medial meniscectomy is performed. The knee is now placed in full extension, and the extensor apparatus together with the patella are dislocated laterally and everted using a Volkmann retractor. The knee is then placed in flexion with the patella everted. Care must be taken not to rupture the patellar tendon or to avulse its insertion at the tibial tuberosity. Proximally, the synovium is removed to visualize the anterior cortex of the femur. We resect all of Hoffa fat pad and the anterior horn of the lateral meniscus, the intermeniscal ligament, and the footprint of the ACL. The femoral notch is debrided and all osteophytes are removed.

The tibia is now dislocated anteriorly using a Hohmann retractor in the condylar notch. The posterior border of the tibia should be exposed. A second Hohmann retractor is placed on the lateral side of the tibial plateau to complete the exposure.

Specific care should again be taken to prevent avulsion of the extensor mechanism during flexion of the knee between 30 and 100° with an everted patella and during the anterior dislocation of the tibia. Anterior dislocation of the tibia can be difficult in the presence of a patella infera or in arthritis secondary to chronic anterior cruciate ligament (ACL) instability. In this situation, the insertion of the patellar tendon, on the tibial tuberosity, can be secured using a pin. This pin is inserted and directed toward the lateral border of the tibia and should be placed so it does not hinder the next steps of the intervention (Fig. 24.7).

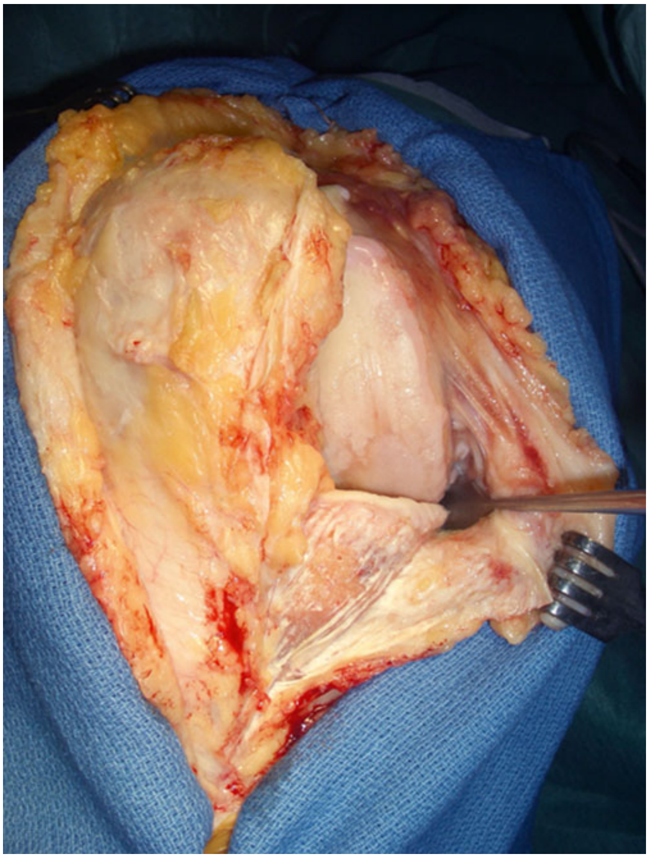


Fig. 24.6 The release of medial capsule is triangular

Fig. 24.7 In case of difficult exposure, the distal insertion of the patellar tendon can be easily secured using a pin

Tibial Cut

The tibial intramedullary (IM) aiming device is inserted at the footprint of the ACL. The entry point is opened up using a curved osteotome (Fig. 24.8). This ensures correct alignment in the sagittal plane; the tibial cut is best performed strictly perpendicular to the long axis of the tibia (we utilize a tibial implant with a 4° slope built into the polyethylene (PE)). However, as the intramedullary guide alone does not always ensure correct coronal alignment, an additional extramedullary (EM) aiming device is utilized to ensure appropriate varus-valgus alignment of the proximal tibial cut. This guide is aimed for the first intermetatarsal space. The thickness of the tibial cut is set to 9 mm referenced from the lateral tibial plateau. This is the nonaffected side in medial arthritic knees. The tibial cutting guide is subsequently fixed with four guide pins (Fig. 24.9). The IM aiming device is removed and the proximal tibial cut is performed using an oscillating saw. The tibial plateau is resected and, if necessary, a recut can be performed at the level of the pins. This maneuver is useful since the saw blade has the tendency to upslope on the more sclerotic parts of the tibial plateau. The saw blade should be controlled by both hands and should stay in contact with the guide pins at all times. After the tibial cut, the tibial plateau can be lifted off using a grabber that can be levered on the guide pins. These guide pins protect the remaining tibia from any damage (Fig. 24.10). A recut is sometimes necessary in the more inaccessible areas such as the edge and the posterior aspect of the lateral tibial plateau (Fig. 24.11). Care should be taken not to damage the popliteus tendon or the patellar tendon. An incomplete exposure of the lateral tibial border and the zone around Gerdy's tubercle can induce varus positioning of the tibial component or a medialization. After the tibial cut, the tibial plateau is sized using different trial sizers.

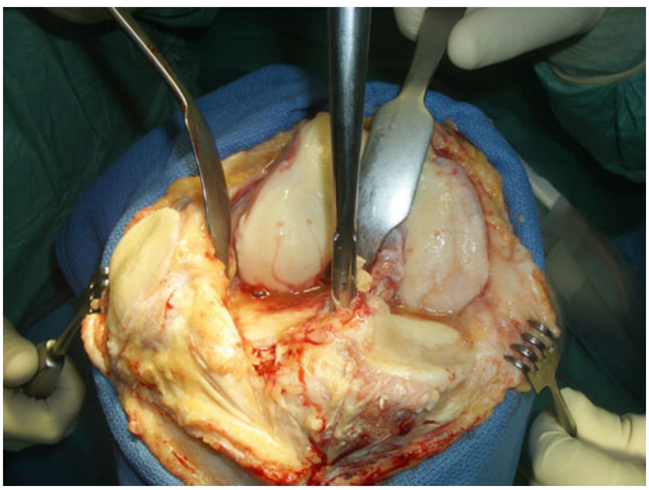


Fig. 24.8 The entry point is opened up using a curved osteotome

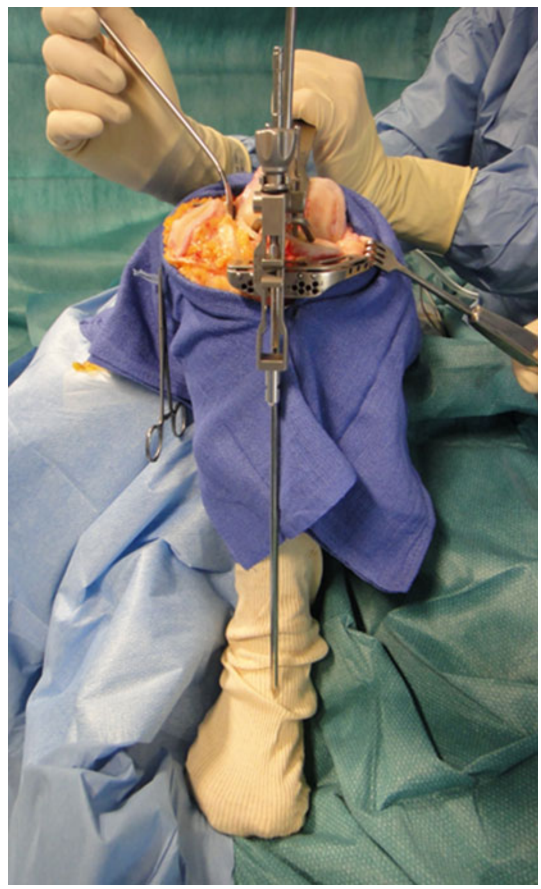


Fig. 24.9 Additional extramedullary aiming device

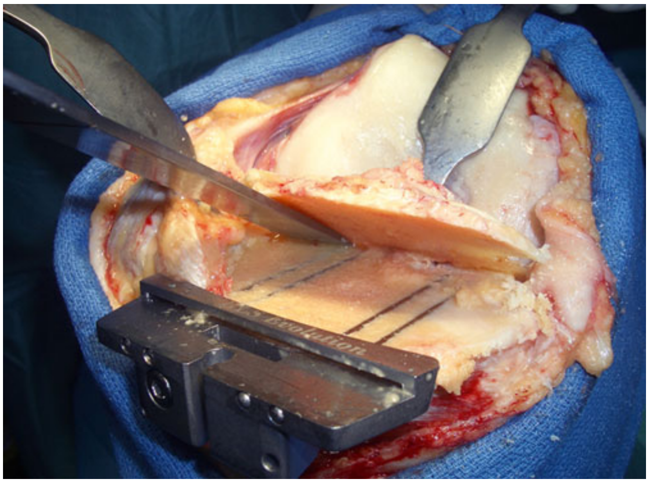


Fig. 24.10 The tibial plateau is lifted off

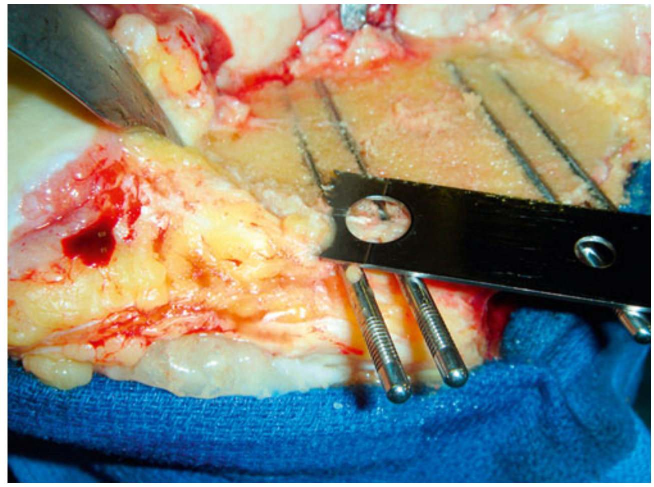


Fig. 24.11 Tibial recut on pins

Technical Points

All bone cuts are performed using an oscillating saw. The surgeon is protected from splatter of blood and bone fragments by covering the joint with a transparent plastic board (Fig. 24.12).

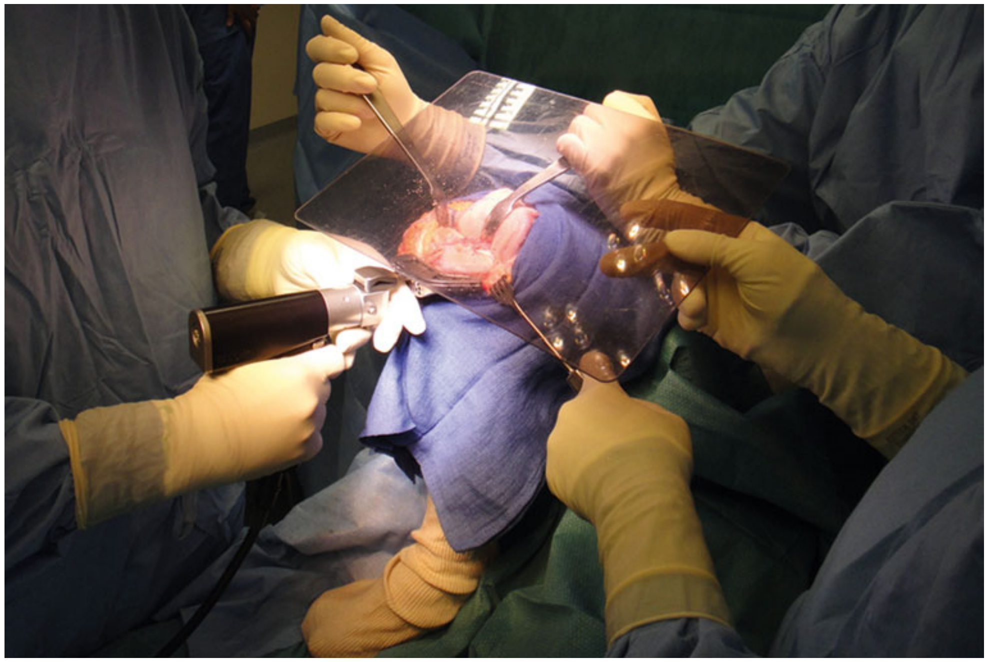


Fig. 24.12 Transparent plastic board

Particular Difficulties

The popliteus tendon is at risk on two occasions. The first is during the tibial cut and the second is during the posterior lateral femoral condyle cut (Fig. 24.13).

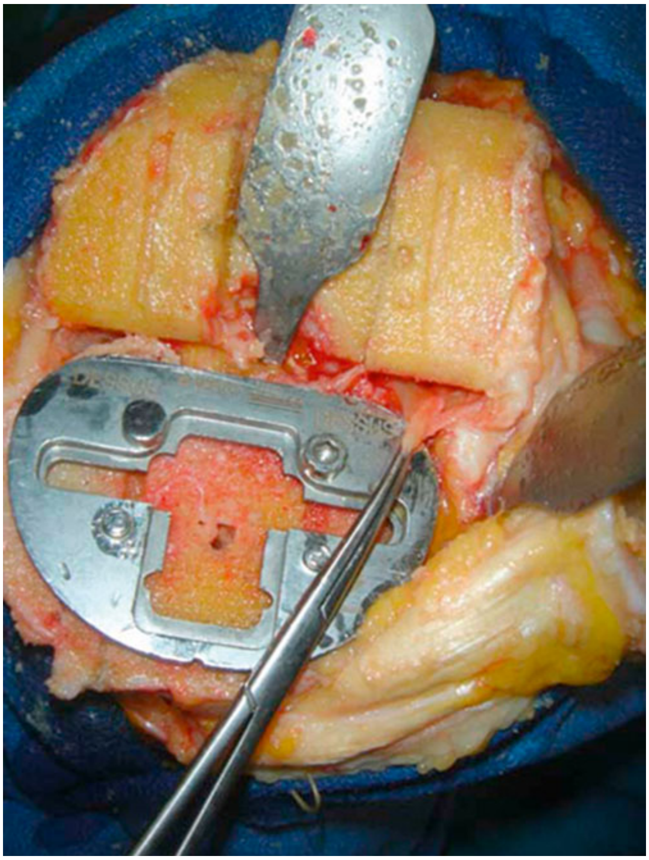


Fig. 24.13 Accidental popliteus tendon transection

Posterior Femoral Condyle cut

The knee is now flexed to 90°. The entry point for the IM aiming device is situated approximately 1 cm above the insertion of the posterior cruciate ligament (PCL) and somewhat to the medial side. This entry point is opened up using a curved osteotome. Special guides are available which enables us to optimize the position of this entry point taking into consideration the size of the femoral component (Fig. 24.14). An entry point which is too anterior on the femur results in malpositioning of the femoral component in flexion, while an entry point which is too posterior results in recurvatum of the component and anterior notching. It is of critical importance to achieve the correct sagittal alignment of the femoral cutting guide.

The aiming device references on the posterior condyles. The anterior cortex can be palpated using the stylus, and the approximate size of the femoral component can be determined (Fig. 24.15). This size can now be transferred to the entry point guide. A small drill now opens up the entry hole (Fig. 24.16), which is subsequently reamed (Fig. 24.17). In order to decrease the risk of fat embolus, the reaming is done in two steps, while the intramedullary bone marrow is aspirated in between these two steps.

Preoperative calculation of the HKS angle between the mechanical and anatomical femoral axis is not reproducible. Except in the case of specific anatomical variations, we always set the distal femoral cut to 7° of the valgus in the medial arthritic knee (see section "Rotation of the Femoral Component" for further information). The femoral cutting guide is applied to the distal femoral condyles and stays in contact with the posterior femoral condyles. This step is critical to the outcome of the procedure as it determines the size in the AP plane and the final rotation of the femoral component. The correct size of the femoral component is made using a stylus on the anterior cortex (Figs. 24.18 and 24.19). The posterior cut is performed and subsequently the posterior cutting guide is removed.

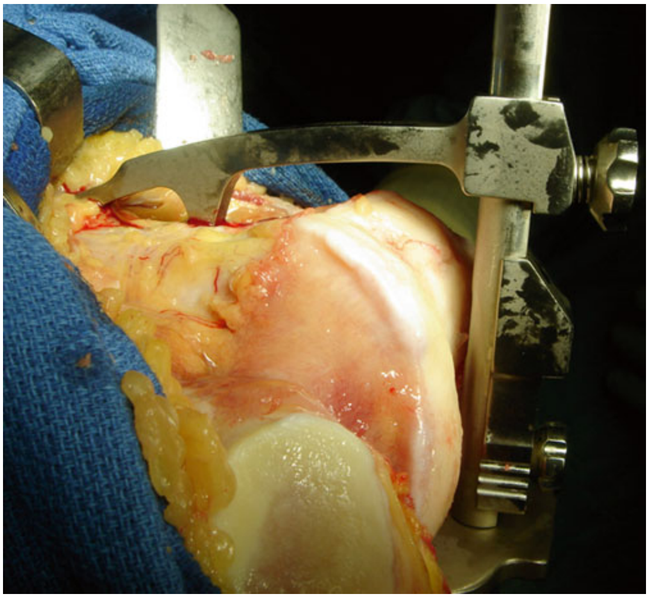


Fig. 24.14 Special guide to optimize the position of the entry point

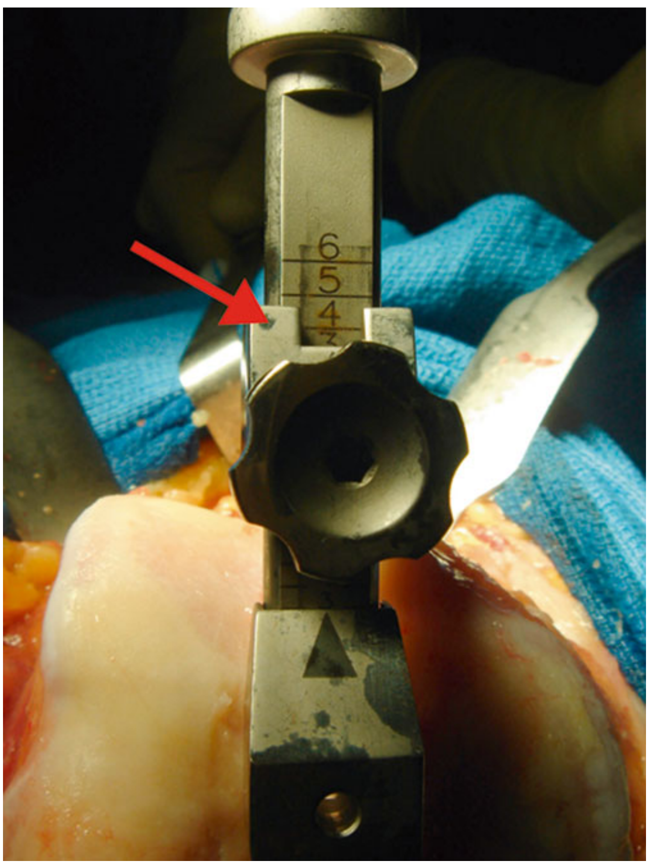


Fig. 24.15 Approximate size of the femoral component (here, size 3)

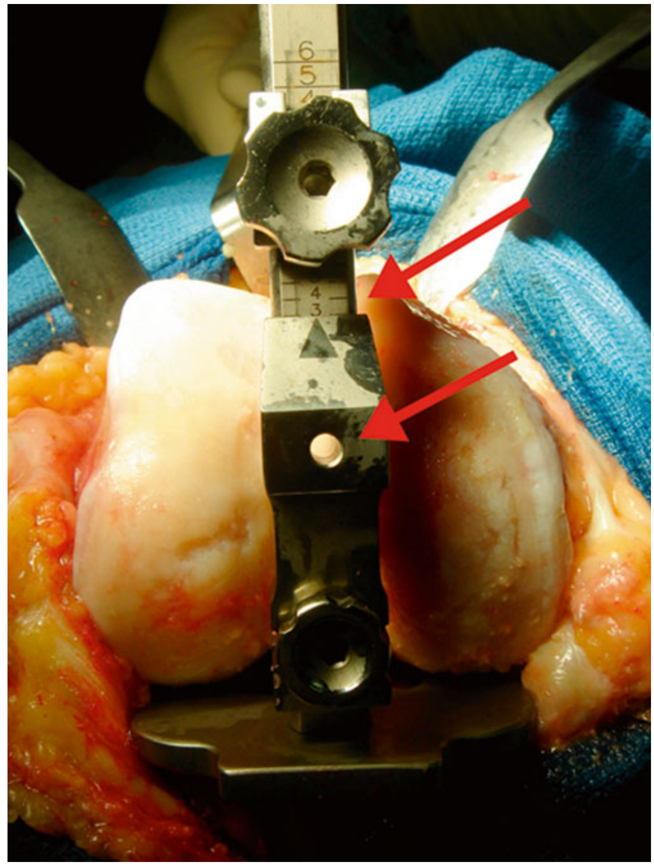


Fig. 24.16 Entry point (*lower arrow*) and size of the femoral component (*upper arrow*)

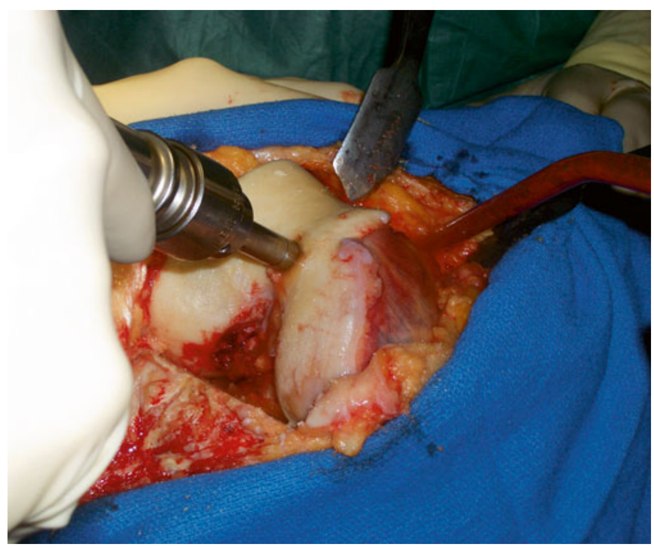


Fig. 24.17 Intramedullary reaming

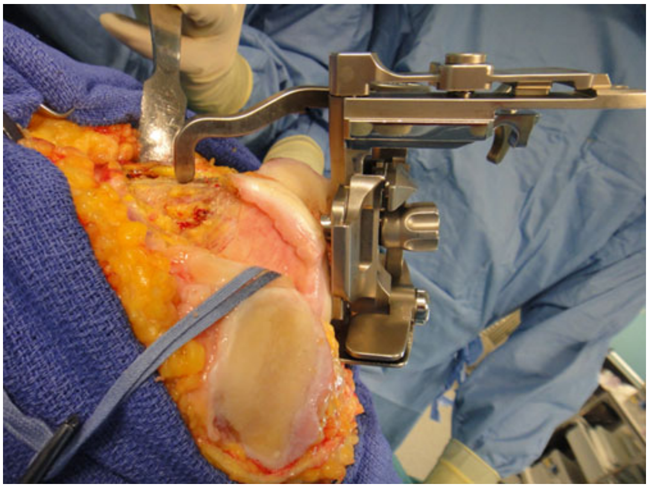


Fig. 24.18 Posterior cutting guide (lateral view)

Ligament Balancing in Flexion

The tibial cut and posterior femoral condyle cut create a flexion gap, which can be measured using a spacer. The thickness of the spacer represents the thickness of the femoral and tibial component as well as the PE. The PCL should now be completely resected using an 11 blade (Fig. 24.20). The femoral notch should be carefully debrided. In order to avoid the risk of neurovascular injury, the blade should stay in contact with the bone at all times. In case of contracture of the soft tissues on the concave side of the knee or in case of a malaligned tibial cut, the flexion space will be more trapezoidal. In these cases, a tibial recut or ligamentous release (depending on the etiology of the trapezoidal shape) is necessary in order to obtain a rectangular flexion space. A balanced flexion gap is necessary to achieve correct stability in the sagittal plane and allow an adequate range of motion without stiffness.

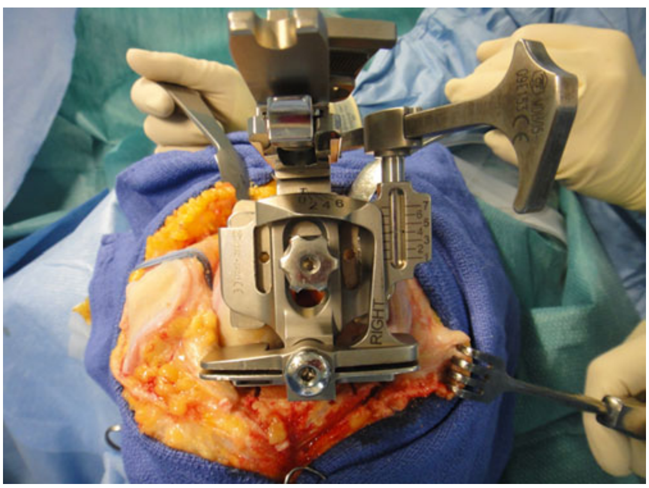


Fig. 24.19 Posterior cutting guide (front view)

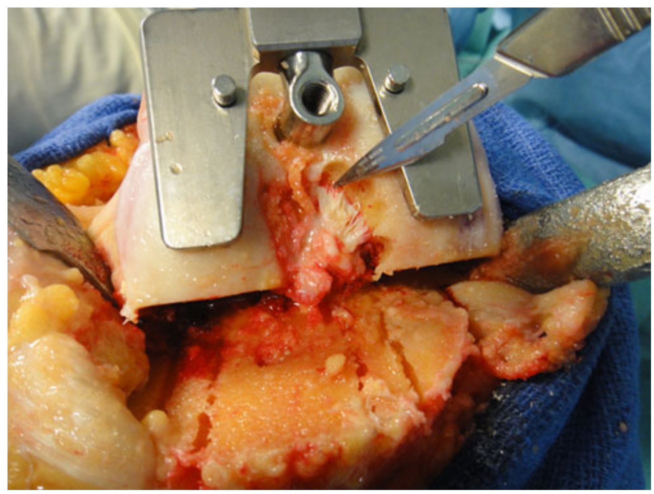


Fig. 24.20 PCL resection

Extension Gap Balancing and Distal Femoral Cut

Our aim is to reproduce this same rectangular flexion gap in extension. The original extension gap can be changed due to the previous flexion gap balancing, often resulting in a larger extension gap. At this stage, multiple options are available. We can fill up the extension gap by putting in a thicker PE, but this raises the joint line, inducing lowering of the patella. Another option—which we prefer—is to lower the distal femoral cut thereby reducing the extension gap. If the extension space is very large, one may have addressed both options.

If it is necessary to lower the distal femoral cut (usually 10–20 % of our cases), we use a femoral distractor. The purpose of this device is to obtain a satisfactory balanced extension gap. The distractor is mounted on the femoral IM cutting guide, which is in contact with the distal femoral condyles. The distractor itself is in contact with the tibial cut. The knee is now positioned in full extension and the extension space is evaluated. Ligamentous balancing in extension is performed. In case of balanced but extensive laxity, the ligaments are tensioned using the distractor device, and the distal femoral cut is lowered (Fig. 24.21). Overtightening of the extension gap results in a progressive flexion deformity, while under-tensioning results in ligamentous laxity. Once an optimal extension gap is obtained, the distal femoral cutting guide is fixed to the femur using pin fixation (Fig. 24.22). The IM femoral device is removed. The distal femoral cut is now performed. The tibial plateau is protected by a large osteotome or using a posterior shield (Fig. 24.23).

A preoperative fixed flexion deformity is another common problem and is easily addressed by cutting an extra 2 mm from the distal femoral condyles. This can be achieved by using an 11 mm distal femoral cutting guide instead of the usual 9 mm guide.

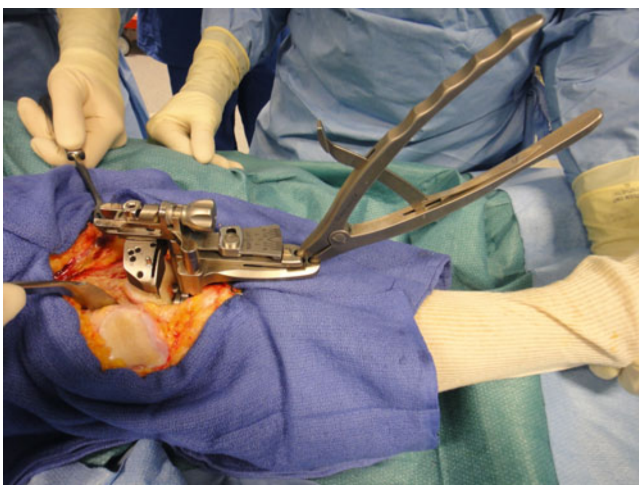


Fig. 24.21 Distractor device

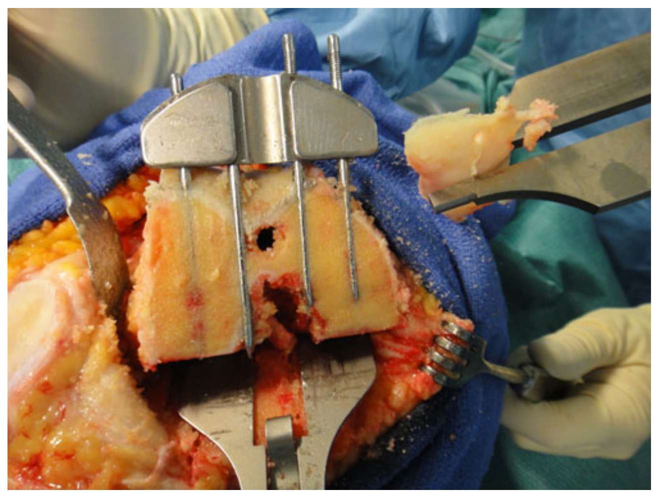


Fig. 24.23 Distal femoral cutting guide and protection of the tibial plateau

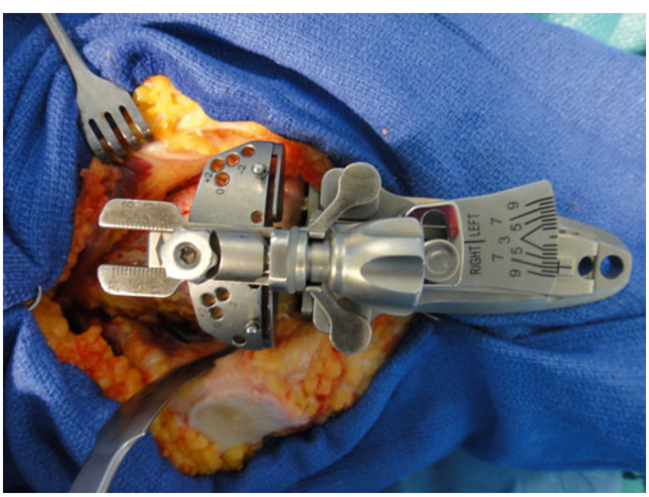


Fig. 24.22 Fixation of the distal femoral cutting guide

Anterior Femoral cut and Chamfer Cuts

The three-in-one cutting guide is positioned on the previously cut posterior and distal condyles. The size of the femoral component can be rechecked using a stylus on the anterior femoral cortex. Care is taken to avoid notching. If the femoral component is positioned in external rotation, the lateral anterior cortex should be checked since it is a high risk for femoral notching. We always do the anterior cut starting from the medial side and progressively move up to the lateral anterior cortex. Subsequently, the chamfer cuts are made.

Patellar Cut

The patella is the critical link to the extensor mechanism. One must substitute the articular surface without augmenting the total patellar thickness. Overcutting the patella can weaken it, increasing the risk of a fracture. The knee is placed in the extended position. The patella is everted to the lateral side. The proximal and distal soft tissues should be resected in order to expose the tendon structures. The thickness of the patella is measured. The patellar cutting clamp is designed using an anterior reference guide (Fig. 24.24). The aim is to obtain a symmetrical cut, parallel to the anterior cortex of the patella, with a residual thickness of approximately 15 mm. This should always be thicker than 12 mm to avoid fractures and sometimes goes up to 16 or 17 mm in larger patellae. The sum of the patellar component and the resected patella should never be thicker than the original patella.

After the patellar cut, symmetry should be checked manually. For sterility reasons, surgical gloves are changed and direct contact with the patella is avoided by using a compress while palpating the patella cut. The three patellar component fixation holes are reamed. These fixation holes should be positioned in order to avoid a horizontal alignment because of the risk of patellar fractures. Two fixation holes are reamed medially and one laterally (Fig. 24.25).

The patellar component is placed somewhat inferiorly and medially.

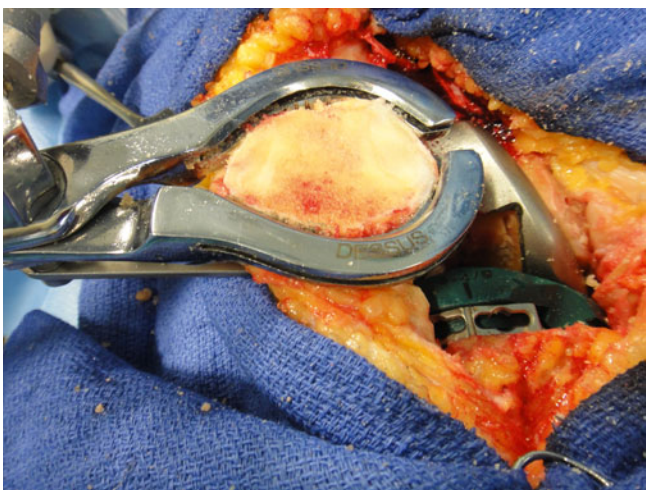


Fig. 24.24 Patellar cutting clamp

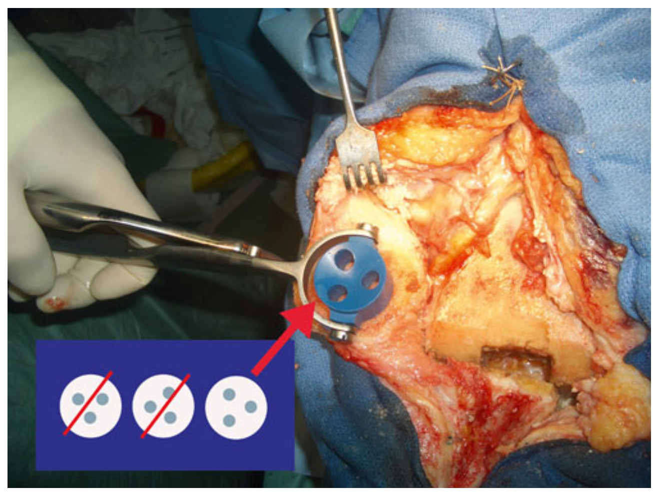


Fig. 24.25 Appropriate positioning of the patellar fixation holes (*arrow*)

Placement of the Trial Components

First, the tibial trial component is placed. The tibia is dislocated anteriorly, and specific attention should be paid to the lateral femoral condyle. Frequently impingement between the lateral condyle and the tibial component can result in the malpositioning of the tibial component in internal rotation.

Multiple references are taken into consideration (Fig. 24.26a):

- The posterior border of the tibial component should be parallel to the posterior border of the tibial plateau.
- The medial border of the tibial tuberosity should be aligned to the middle of the tibial base plate.
- The correct rotation of the tibial component is determined by the femoral tibial alignment.

The correct size of the tibial component is that size that maximally covers the tibial plateau without overhang. The femoral trial component is positioned in hyperflexion but is impacted in the 90° position. Care is taken such that the femoral trial component is in contact with the medial and lateral condyles. One must pay attention not to impact the femoral trial component in a flexed position. The trial patellar component is also positioned. If the patella is larger than the patellar trial component, the lateral bony overhang is resected freehand using the oscillating saw (Fig. 24.26b). Care is taken not to perform a lateral release since this can influence the blood supply to the patella. The ligamentous balance is assessed in the flexed and extended positions.

Multiple ROM cycles are done to assess the patellofemoral tracking. PF tracking is considered to be the thermometer of the TKR procedure (Bousquet). If every step of the surgical procedure has been performed correctly, the patellofemoral (PF) tracking should be perfect. Lateral retinacular release is seldom necessary; however, if needed it should be done at the end of the procedure with the tourniquet deflated.

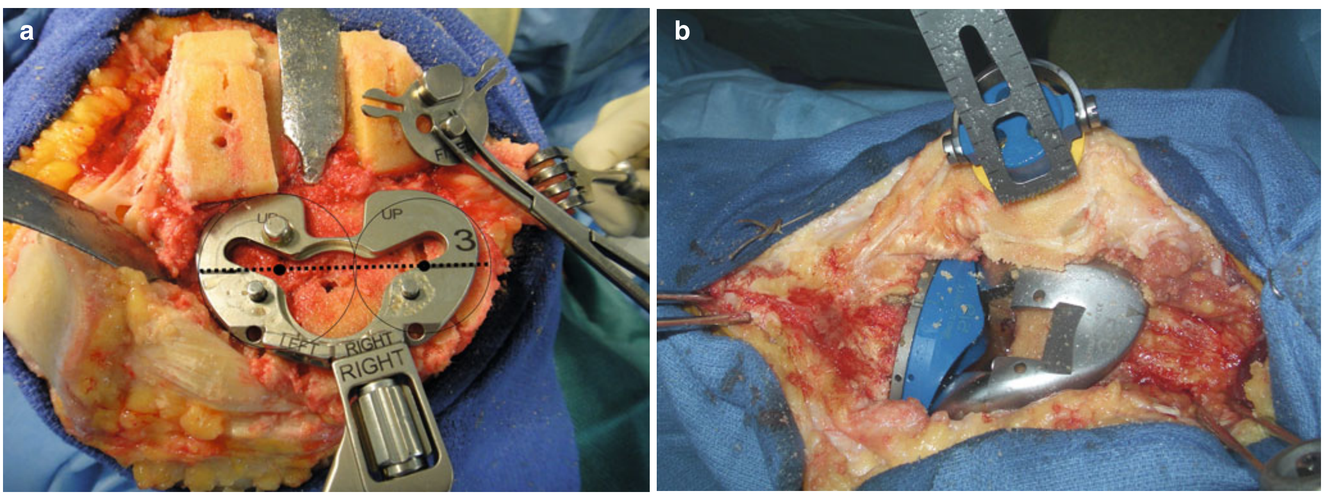


Fig. 24.26 (**a**) Current method for placement of the tibial trial component: it is aligned with the two centers of the medial and lateral plateau. (**b**) Lateral patella facetectomy

Final Tibial Keel Preparation and Cementation of the Final Components

Keel preparation is done while the cement mix is started (Fig. 24.27). The tibial component is cemented first. Impaction is done with a specific plastic impactor to avoid scratches on the tibial surface. Excessive cement is removed. Subsequently, the polyethylene is positioned, and the knee is then moved to a hyperflexed position to seat the femoral component. Again this component is impacted in the 90° position. The knee is subsequently positioned in the fully extended position to compress the cement. Subsequently the patellar component is cemented in compression using a specific clamp. The lower limb is held in this extended position by elevating the heel in neutral rotation until the cement has completely hardened.

Wound Closure

The tourniquet is released after the cement hardens and hemostasis is achieved. The knee is closed at 90° of flexion with multiple interrupted resorbable stitches. One intra-articular drain is left in situ.

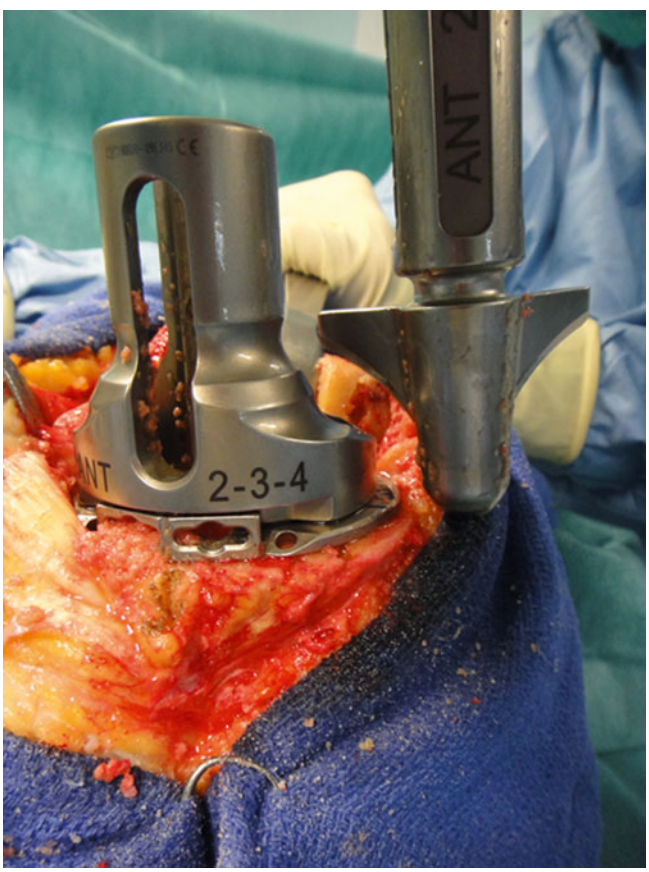


Fig. 24.27 Keel preparation

Specific Technical Points

Rotation of the Femoral Component

A posterior femoral cut parallel to the posterior condyles does not induce any rotation of the femoral component. For us, rotation of the femoral component is only necessary if the distal femoral cut is asymmetrical. When the femoral cutting guide is only in contact with the distal medial condyle, the distal cut will result in cutting less from the lateral condyle. This asymmetrical cut should be transferred to the flexion gap by externally rotating the femoral cutting guide so that less of the lateral posterior condyle is cut (Fig. 24.28). The exact rotation needed is calculated by measuring the distance between the lateral distal femoral condyle and the femoral guide (Fig. 24.29). This measurement is done using the thickness of multiple osteotome blades (thickness 2 mm). Subsequently, the exact same number of osteotome blades is applied to the lateral posterior condyle, and thus, the femoral cutting guide is rotated externally (Figs. 24.30 and 24.31a). The center of rotation in this case is the medial condyle.

A more recent device (Kneetec®) allows us to rotate the cutting guide by placing the center of rotation into the intramedullary axis (Fig. 24.31b).

Of course, in a varus-aligned knee (mFA <90°), an asymmetrical distal femoral cut is not translated into internal rotation.

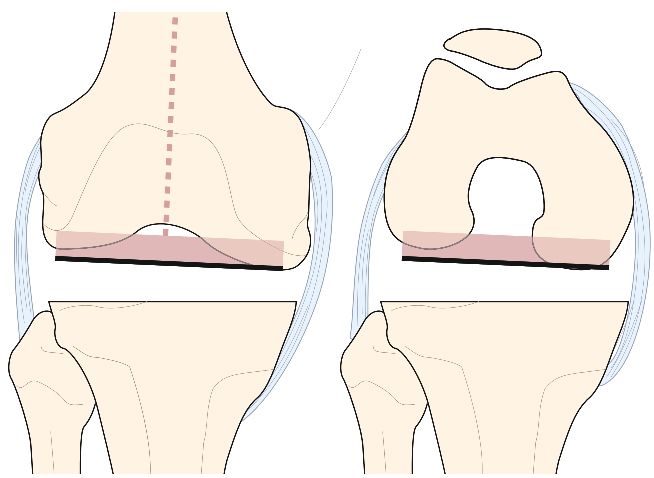


Fig. 24.28 Rotation of the femoral component

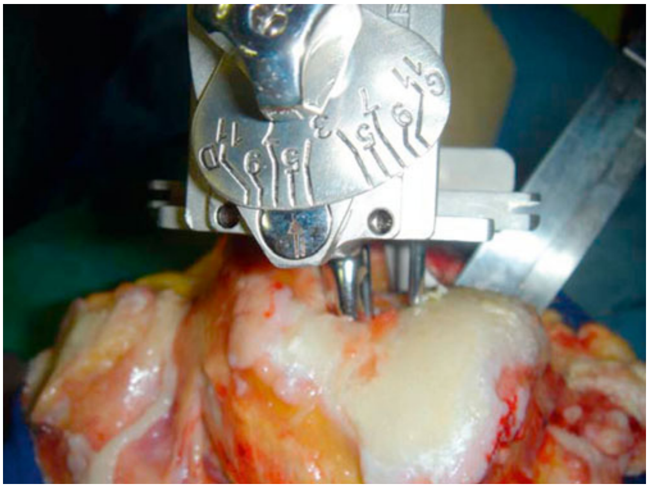


Fig. 24.29 Distance between the lateral distal femoral condyle and the femoral guide

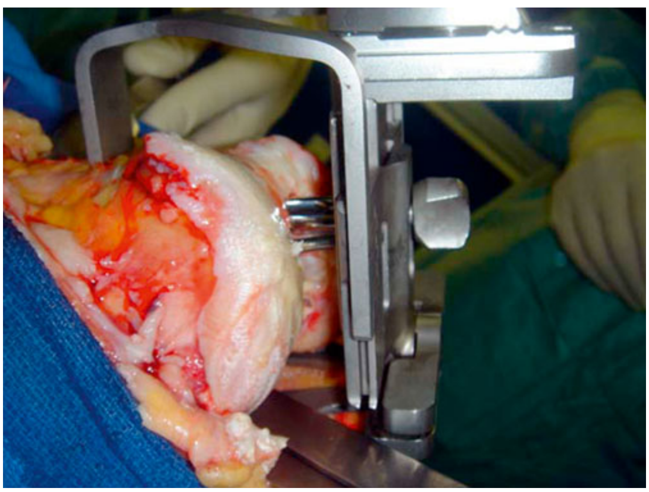


Fig. 24.30 The asymmetrical cut is transferred to the flexion gap using osteotome blades applied under the lateral posterior condyle

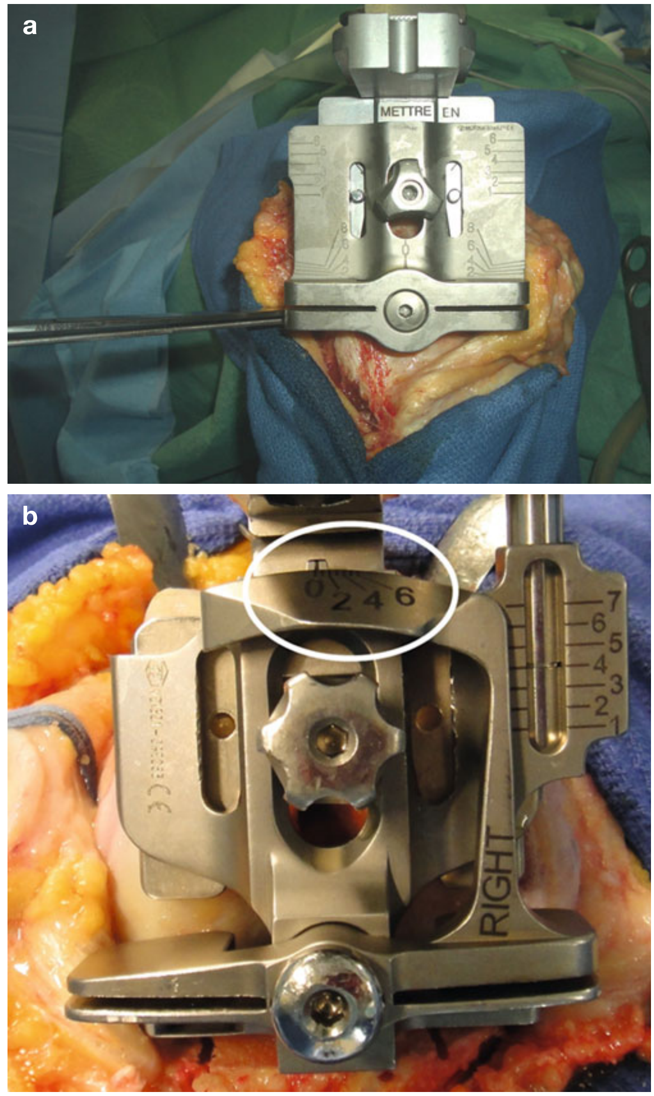


Fig. 24.31 (**a**) Osteotome blades applied under the lateral posterior condyle (*front view*). (**b**) A more recent device allows us to rotate the cutting guide by placing the center of rotation into the intramedullary axis

Release of the MCL

According to the initial recommendations of Insall in the 1980s, soft tissue releases should precede the bony cuts. At present, however, we feel it is more logical to perform any releases after the bony cuts. In the case of a constitutional tibial varus with a proximal metaphyseal varus deformity, a tibial cut perpendicular to the longitudinal axis will result in laxity on the lateral side (Fig. 24.32). This lateral laxity can increase when the anterolateral soft tissues are severed with a thick bony cut on the lateral tibial plateau (see section "Anterolateral Capsular Structures" below). In these cases, a medial release of the soft tissue structures is required. Usually, the medial approach releases the capsule and the deep MCL sufficiently for adequate balancing. However, if this is not sufficient, as with a significant constitutional varus deformity, several surgical techniques can be used to achieve an adequate medial soft tissue release:

Pie Crust of the MCL

Insall proposed to release the superficial MCL on the distal tibial side. This is to be considered an extensive release frequently ending up in an "all or nothing" situation: an excessive release of the MCL with excessive laxity on the medial side. We use the pie crust technique to release the MCL. To achieve this we use an 11 blade to make multiple perforations in the superficial MCL inside out. Subsequent testing in flexion allows us to progressively test and release the MCL and thus to obtain ligamentous balance in flexion and extension (Figs. 24.33 and 24.34). It is our experience that this procedure can be performed in cases with up to 6° of constitutional (extra-articular) deformity. The pie crust technique can lengthen the MCL by 6–8 mm in both flexion and extension. We do not agree with Whiteside that a selective release of the posterior and anterior fibers of the MCL to increase the extension and flexion gap, respectively, is routinely possible. In cases of more extensive deformities, the pie crust procedure can result in complete sectioning of the MCL.

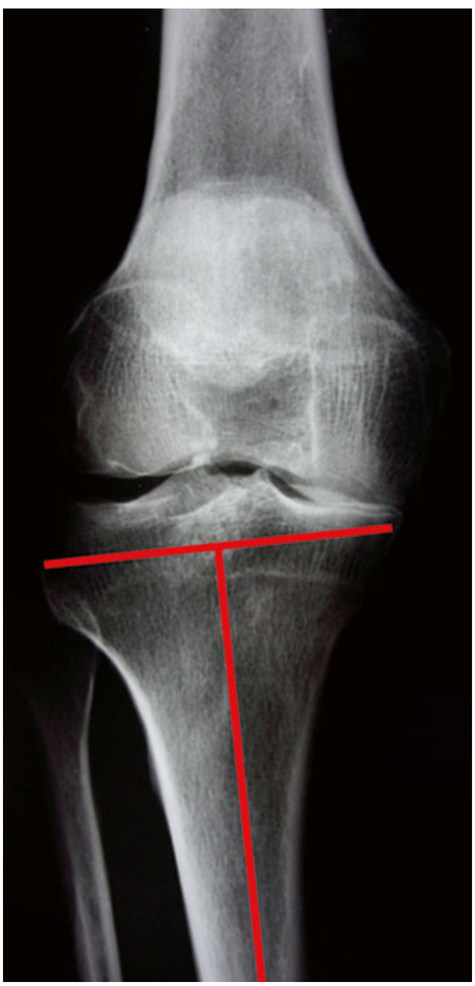


Fig. 24.32 An asymmetrical cut will result in laxity on the lateral side

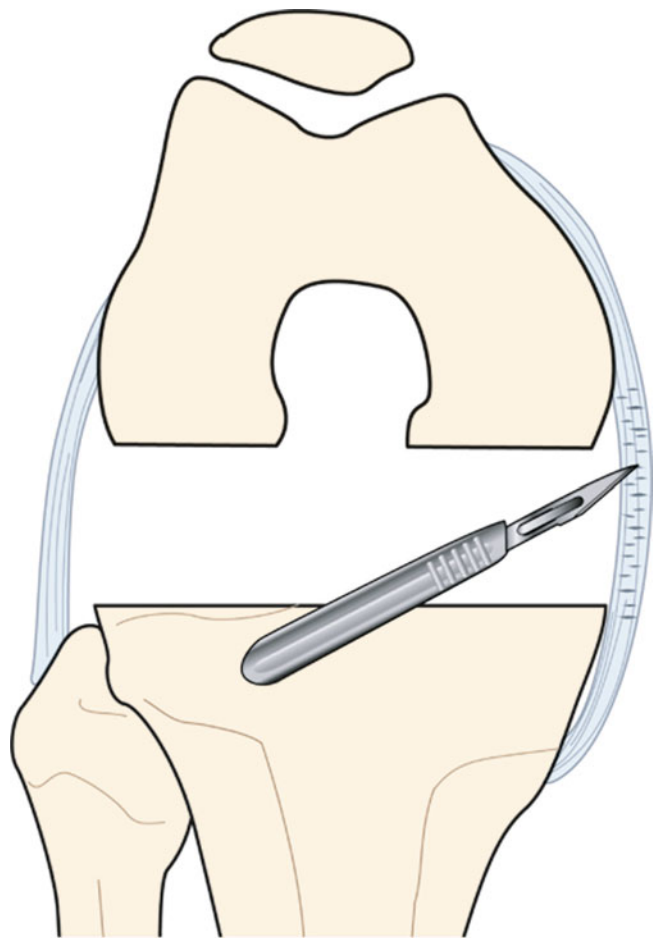


Fig. 24.33 Pie crust of the medial collateral ligament

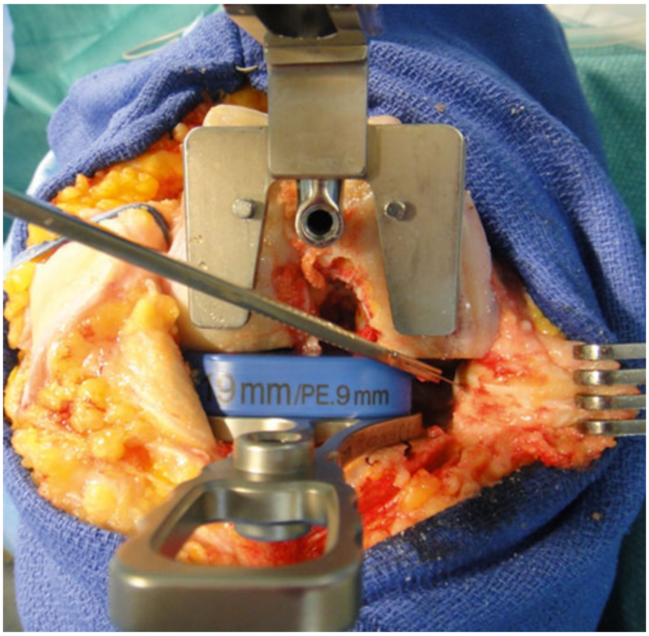


Fig. 24.34 Pie crust of the medial collateral ligament (perioperative view)

Distal Release of the MCL

In case of a varus deformity between 6 and 8°, a distal MCL release is performed on the tibial side. The release is performed close to the bone using a periosteal elevator, leaving the pes anserinus tendons in continuity (Figs. 24.35 and 24.36).

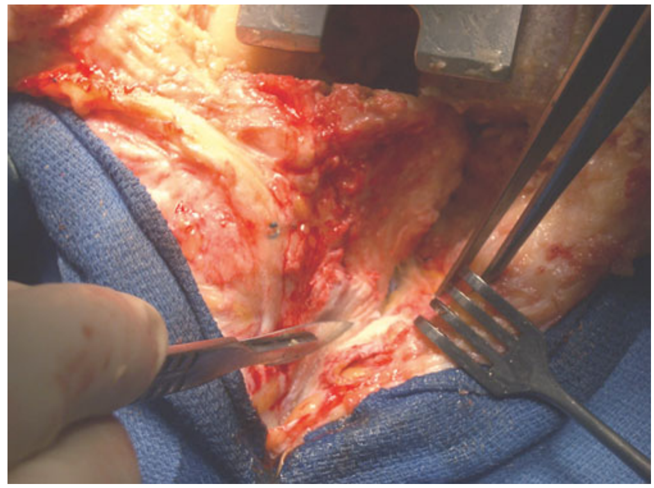


Fig. 24.35 Distal release of the MCL

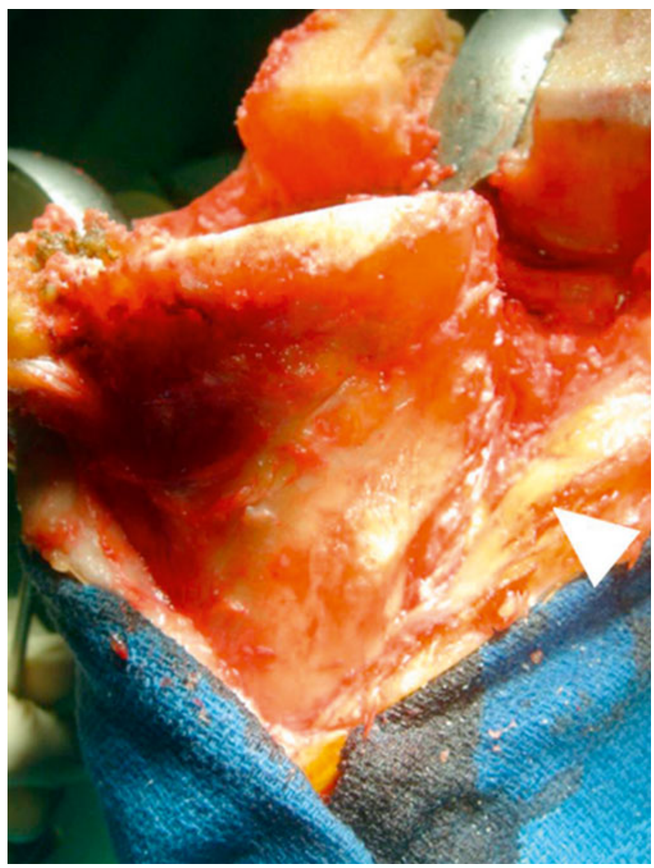


Fig. 24.36 The distal release is performed posteriorly until the posteromedial part of the capsule

Fixed Flexion Deformity (FFD) Correction

When large posterior osteophytes are present, one should remove them. These osteophytes are best observed on the lateral plain radiographs. These osteophytes tent the posterior capsule and result in a FFD. Frequently, contracture of the semimembranosus muscle and tendon is responsible for the FFD (Fig. 24.37). This tendon can be released on the posterior side of the proximal tibia (Fig. 24.38). In our hands, a preoperative FFD is better addressed with a thicker distal femoral cut of 11 mm instead of the normal 9 mm thus enlarging the extension gap. The final implantation of a 9 mm polyethylene spacer resolves the FFD. A posterior capsular release on the other hand is of little value to resolve FFD.

Lateral Patellar Release

Instability of the patella is very rarely observed in varus TKA. If detected during trialing, the surgeon should look for femoral component malrotation. Most commonly, the femoral component has been positioned in excessive internal rotation. If necessary, a lateral patellar release should be performed at the end of the intervention when the definitive components are in place and the tourniquet is deflated. A lateral release is performed from within the joint using a 23 blade and the knee in full extension. Sectioning of the lateral structures starts at the superior border of the patella and is extended distally. Care is taken to achieve hemostasis (Fig. 24.39).

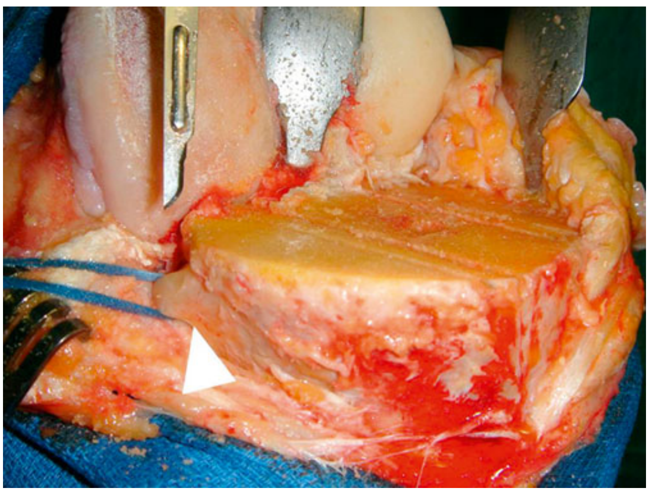


Fig. 24.37 Insertion of the semimembranosus tendon (*arrow*)

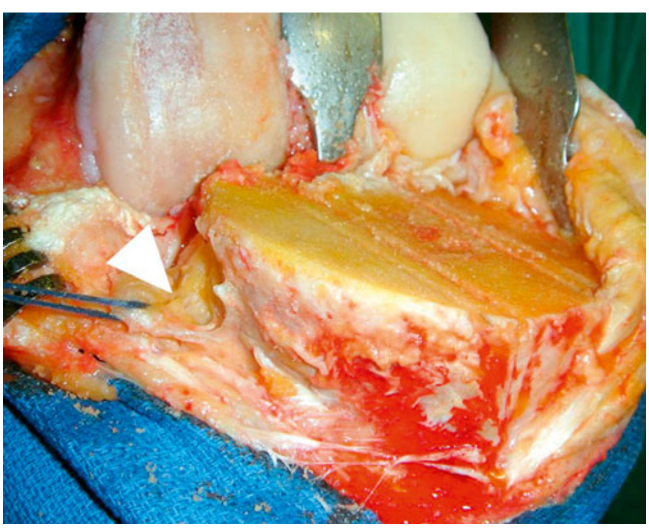


Fig. 24.38 Section of the semimembranosus tendon (*arrow*)

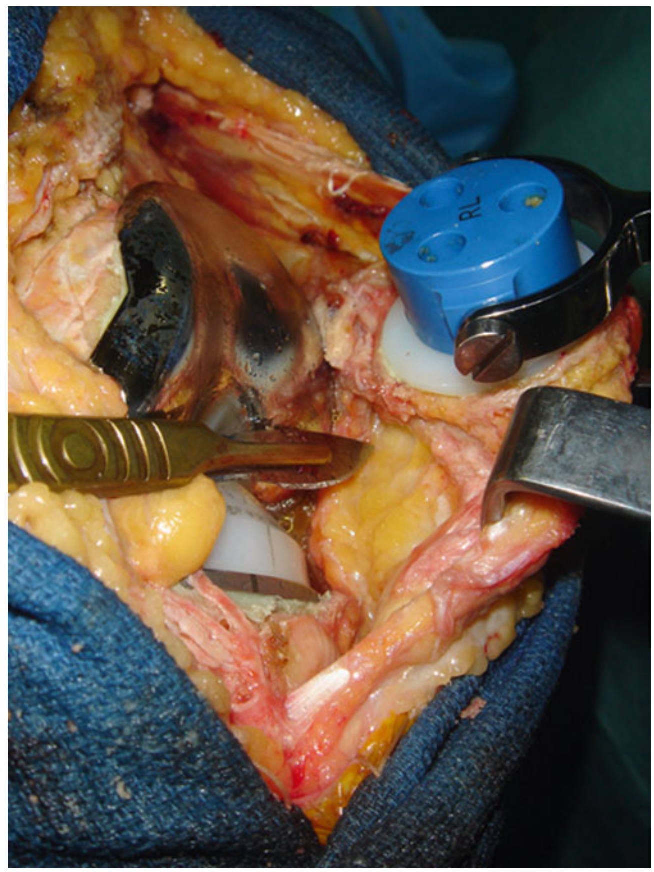


Fig. 24.39 Lateral patellar release performed from within the joint

Anterolateral Capsular Structures

The anteromedial approach in a varus knee preserves the lateral capsular structures. However, in case of a thick tibial cut, the anterolateral structures can be severed. Thus, the resection laxity is further increased laterally. To better understand this phenomenon, we use the example of an ACL tear complicated with a Segond fracture (Fig. 24.40). This type of fracture results from the avulsion during the torsion trauma of the anterolateral capsular structures from the tibial plateau (Fig. 24.41). A thick bony cut on the lateral tibial plateau can have the same effect, as can the anterior dislocation of the tibia during surgical exposure. These structures are readily identifiable during surgery (Fig. 24.42a, b). If the tibial cut is higher than its insertion, the structures remain intact and functional. They can be identified as a ropelike structure tensioned between the anteriorly dislocated tibial plateau and the femoral capsule. In a thick or asymmetrical tibial cut, its insertion is resected (Fig. 24.43).

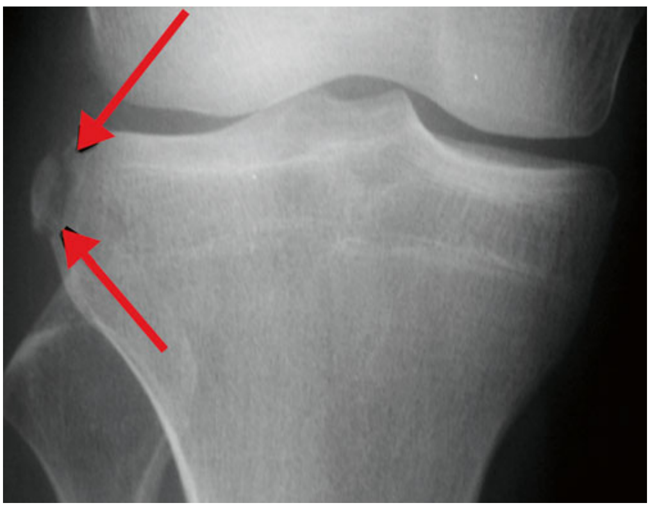


Fig. 24.40 Segond fracture (*arrows*)

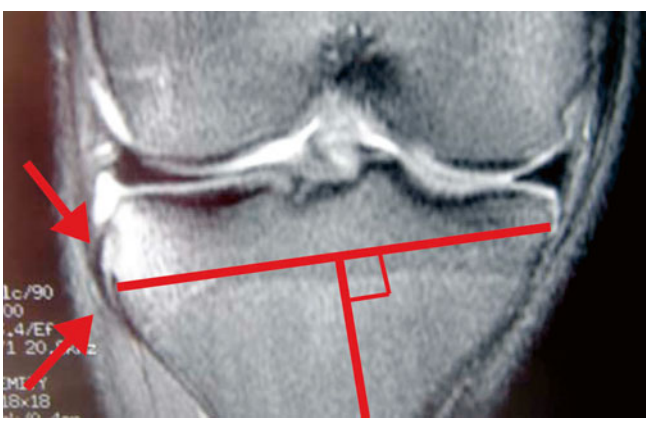


Fig. 24.41 MRI showing anterolateral capsular structures (*arrows*)

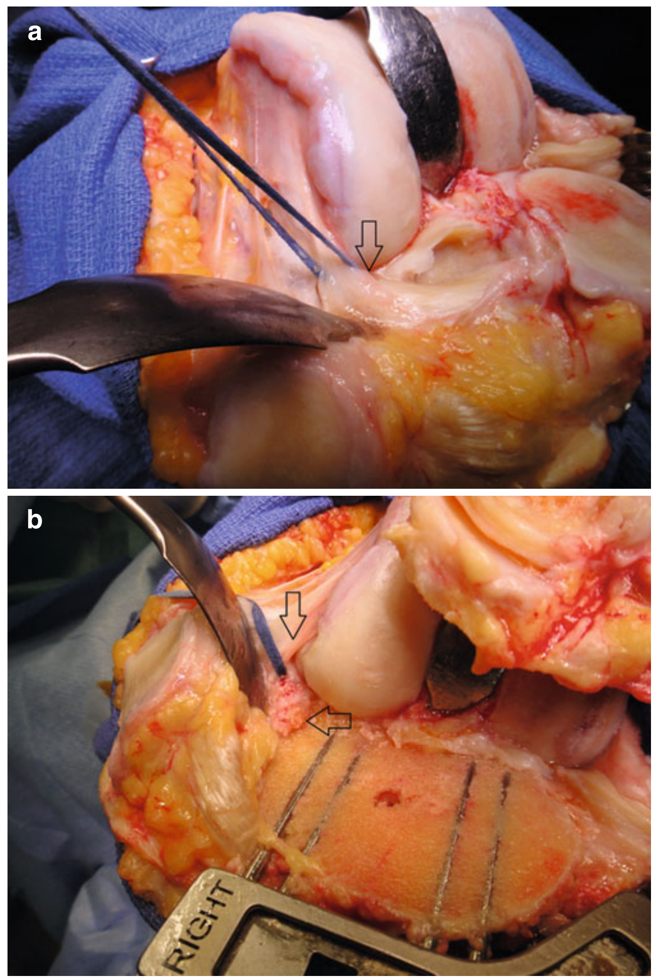


Fig. 24.42 (**a–b**) Anterolateral capsular structures (perioperative view)

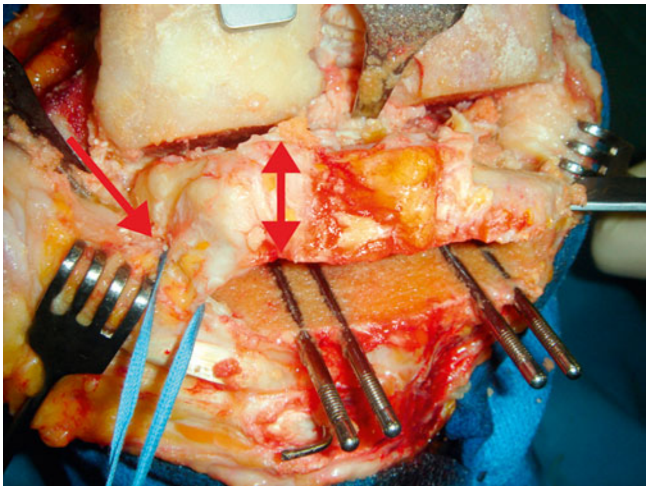


Fig. 24.43 Asymmetrical and thick tibial cut. The anterolateral capsular structures are resected (*arrow*)

Difficulties During the Patellar Preparation

The patella is infrequently significantly worn in medial OA. However, if this is the case, the patellar cut can be very difficult. In case of chondrocalcinosis, the wear of the patella can be extreme with a sawlike pattern on the Merchant view (Fig. 24.44). In this situation, we propose to preserve the lateral osteophyte during the positioning of the cutting guide. This will help to stabilize the guide and to obtain a flat and symmetrical cut of the patella (Figs. 24.45 and 24.46). In cases of severe patellar wear, one can consider avoiding patellar resurfacing altogether.

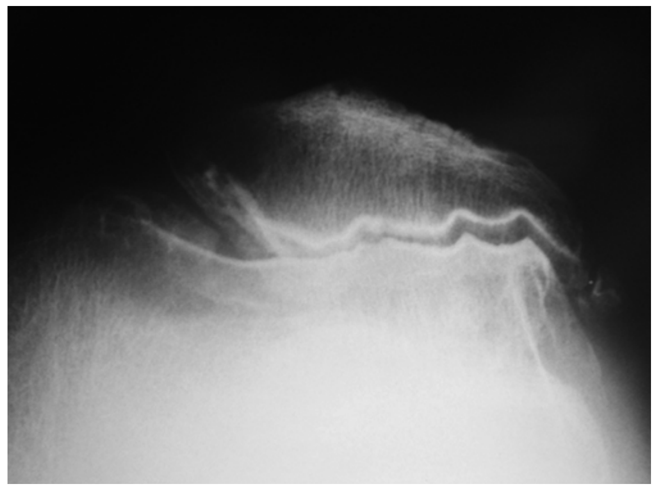
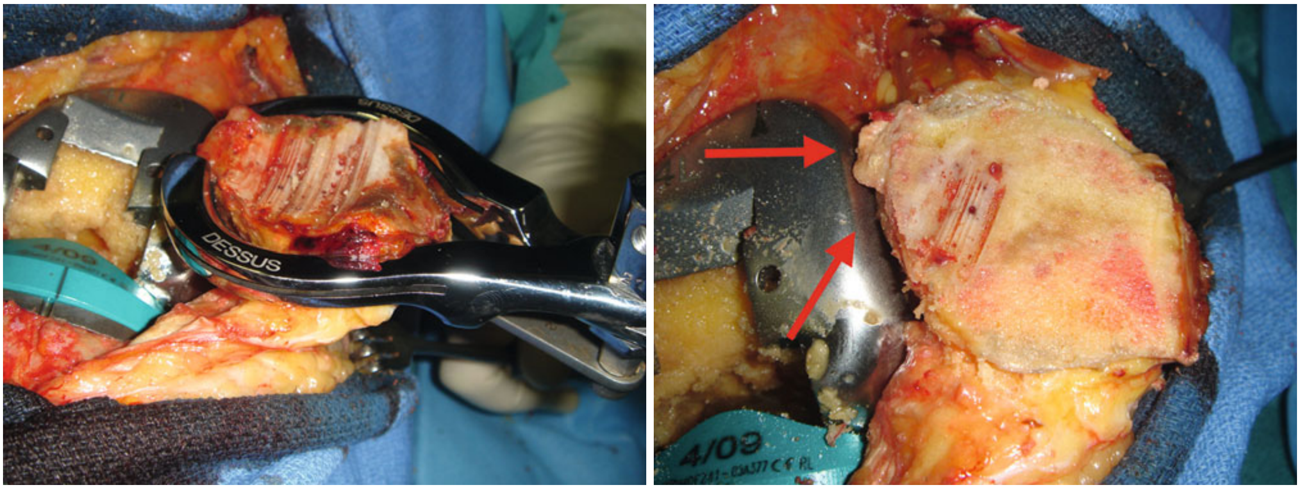


Fig. 24.44 Typical appearance of chondrocalcinosis



Figs. 24.45 and 24.46 Extreme wear of the patella. We propose to preserve the lateral osteophytes (*arrows*) during the positioning of the cutting guide

Postoperative Care

Compressive bandages are applied immediately after the intervention. A highly compressive Velpeau bandage is additionally applied to the knee, but is removed in recovery, 1 h after the intervention. The lower limb is immobilized with a brace in extension. Low molecular weight heparin is used as thromboprophylaxis and is started on the evening of surgery.

The foot is regularly checked for adequate perfusion. Both calves are frequently palpated to check for DVT. In doubt a duplex ultrasound is performed.

Close attention is paid to the respiratory function of the patient. Sudden desaturation may be a sign of pulmonary embolism. A spiral CT scan or VQ scan can rule out this pathology.

Rehabilitation

Rehab is started 1 day after surgery. A CPM is applied as well as progressive active training. The aim is to regain passive and active flexion and extension. Flexion is limited to 95° for the first 6 weeks. This protects the sutures, limits pain, and avoids hematoma formation. Generally, patients leave the hospital on day 7 and are transferred to a rehab center. A patient visit is scheduled 2 months after surgery.

Future Perspectives in TKA Surgery

Recently, computer-assisted surgery (CAS) and navigation system have been developed to assist the surgeon during TKA.

The sequence of priorities for TKA surgery are:

1. Mechanical tibial angle (mTA) at 90° in the frontal and sagittal plane
2. Ligamentous balance in extension
3. Ligamentous balance in flexion
4. Reproduction of the joint line height
5. Mechanical femoral angle (mFA) close to 180° (some variation is accepted in the mDFA according to the initial deformity)

However, the *sequence of priorities* is not the sequence of the different steps during the surgical procedure. This discrepancy is largely due to the currently used surgical instrumentation. Therefore, the surgeon has to think one or two steps ahead during the procedure and foresee the influence of the current step on the next steps:

- Tibial cut first at 90°
- Posterior femoral condyle cut
- Flexion gap balancing
- Extension gap balancing
- Matching extension gap to flexion gap (distraction possible)
- Distal femoral cut

CAS enables the surgeon to anticipate the effect of one step on the following step(s) and to perform this virtually. However, in current TKA surgery, the main problem remains the so-called resection laxity. It is currently impossible to anticipate or precisely predict this type of laxity by virtual surgery using any current CAS or navigation system available on the market due to:

1. The amount of resection laxity is highly correlated to the size of the knee.
2. During the tibial cut, ligaments and capsular structures could be partially or completely released. Thus, a bony cut could result in a larger flexion or extension gap than originally planned using CAS or navigation.

In our experience, the "tibial space" can and should only be evaluated and quantified once the tibial cut is made and the ligament balancing in flexion and extension is performed. However, ligament balancing in flexion and extension is classically performed after the femoral cuts. By means of CAS or navigation, one is able to perform this balancing prior to the femoral cuts, which is in accordance with the *sequence of priorities* stated earlier:

1. Tibial cut.
2. Virtual positioning of the distal femoral cut.
3. Ligamentous balancing in extension creating the virtual rectangle in extension.
4. Virtual positioning of the posterior femoral condyle cut. The rotation of the femoral component can be determined using several systems:
   - Equally tensioning the collateral ligaments in flexion (CORES system) and then performing a posterior condyle cut parallel to the tibial cut.
   - The asymmetry of the distal femoral cut in extension is reproduced in flexion (this implies an anatomical correlation between the distal femur and the posterior condyle): our choice.
   - The Whiteside line.
   - The epicondylar axis.
5. The height of the joint line is obtained automatically.
6. The femoral cuts are now made according to the virtual planning.

Nevertheless, some considerations can be made on:

1. An anterior or posterior referencing system for the femoral component. Anterior referencing will affect the size of the flexion gap, while posterior referencing could result in either overstuffing of the anterior compartment or notching.
2. The center of femoral external rotation. An intercondylar center will result generally in a decreased posterior offset with more bone resection from the medial posterior condyle and less from the lateral. If centered on the medial condyle, the anatomical offset is maintained, but even less bone is resected from the lateral condyle.

In conclusion, CAS and navigation systems offer us the possibility to achieve the proposed "sequence of priorities." These new evaluation tools will affect the way we perform a TKA and will give rise to novel arthroplasty concepts.

25 Total Knee Replacement in Lateral Arthritis Specifics and Surgical Techniques

P. Archbold, J. Pernin, and G. Demey

Surgical Approach

A lateral paramedian skin incision is made. Proximally the quadriceps tendon is identified and distally the lateral border of the patellar tendon exposed. The arthrotomy is made with a longitudinal incision of the quadriceps tendon on its lateral side leaving a small cuff of tendinous tissue attached to the vastus lateralis muscle allowing later closure. The patella is dislocated and the arthrotomy is continued distally, lateral to the patellar tendon onto the anterolateral tibial plateau. When dissecting at the level of the patellar tendon, we prefer to bring a portion of the fat pad laterally with the retinaculum. This maneuver results in additional soft tissue for use during closures and can be quite useful in cases in which a significant valgus deformity is corrected with the TKA. The lateral capsule is released close to the bone on the anterolateral border of tibial plateau. The capsule remains in continuity with the tendinous origin of the tibialis anterior muscle. The insertion of the ITB is released subperiosteally from Gerdy's tubercle with the scalpel. Because of the continuity of the ITB proximally with the tibialis anterior muscle distally, we prefer this digastric dissection (Fig. 25.1).

The lateral exposure is completed with the resection of the anterior corner of the lateral meniscus. The Trillat periosteal elevator is used to release the capsular structures from the lateral tibial plateau at the level of the joint line. In specific cases, this lateral release is continued posteriorly to Gerdy's tubercle reaching the posterior border of the lateral tibial plateau (Fig. 25.2). The popliteal tendon can thus be visualized completely (Fig. 25.3).

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis road, Belfast BT95JH, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

J. Pernin, MD
Clinique Saint-Léonard,
18 Rue de Bellinière, Trélazé 49800, France
e-mail: jerome.pernin@yahoo.fr

G. Demey, MD
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_25, © Springer-Verlag London 2014

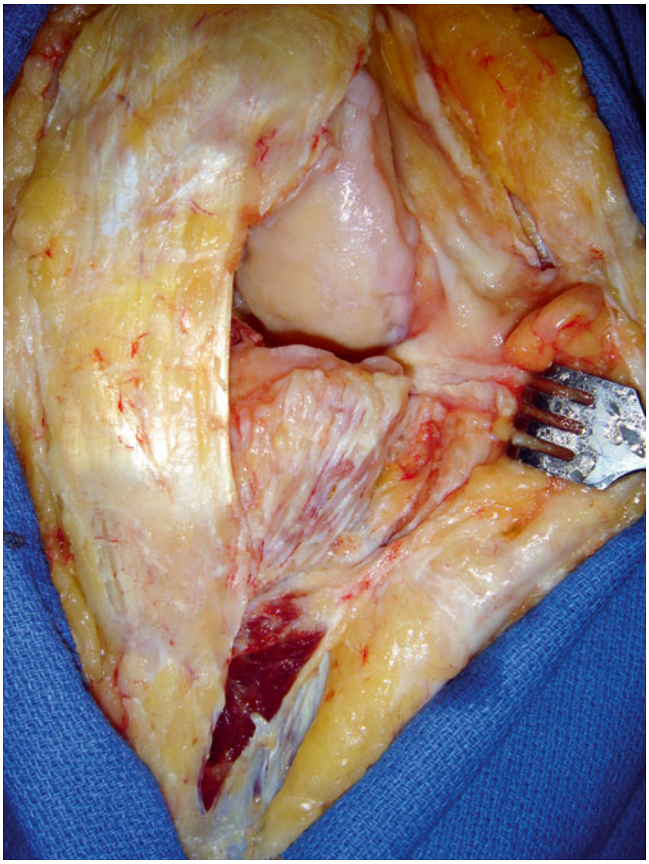


Fig. 25.1 Digastric dissection of the iliotibial band

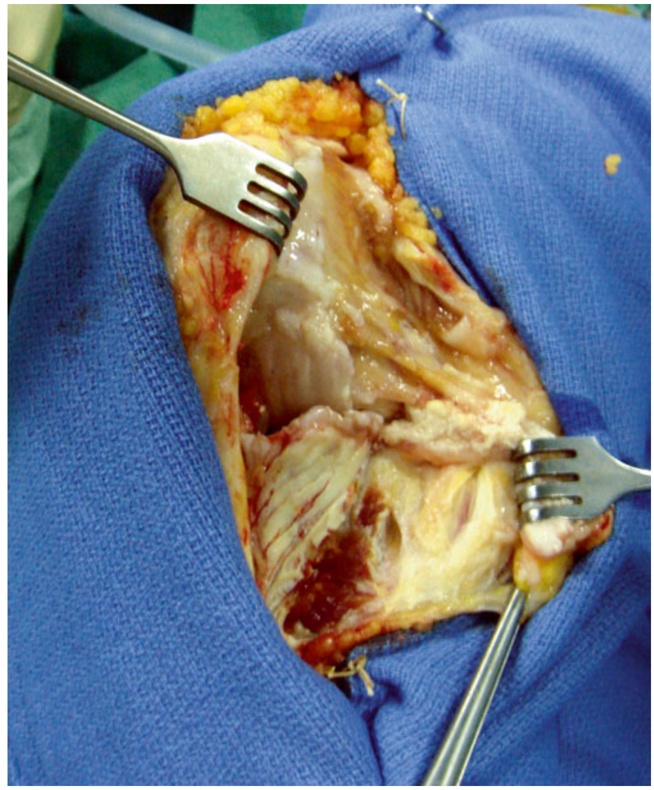


Fig. 25.2 Release of the capsular structures from the lateral tibial plateau

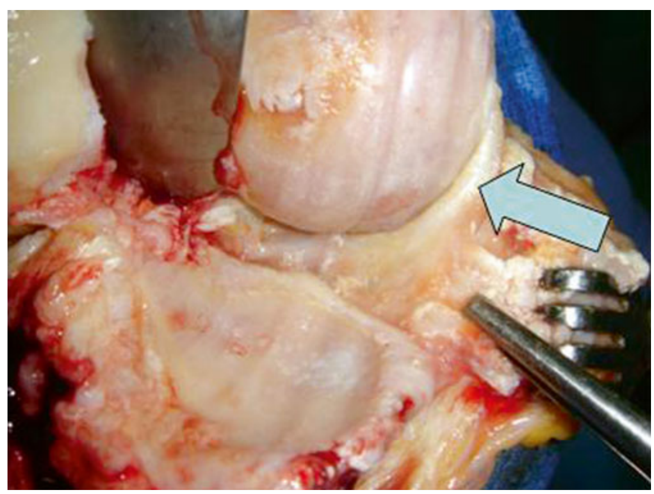


Fig. 25.3 Popliteus tendon (*arrow*)

Anterior Tibial Tuberosity Osteotomy

Dislocation of the patella is more difficult in the lateral approach than in the medial approach. When there is excessive tension on the patellar tendon and insufficient exposure of the tibial plateau, an osteotomy of the tibial tuberosity can be performed. Since this technique differs from the technique used when performing an osteotomy of the ATT for episodic patella instability, the specifics are detailed in the following paragraphs.

The osteotomy must be of a certain thickness and length in order to be in the cancellous bone and to create an area of contact sufficiently large to achieve union of the osteotomy.

However, the osteotomy must not be too thick due to the risk of fracture of the tibial epiphysis. The transition of the osteotomy into the anterior cortex distally has to be progressive and smooth. The osteotomy should not be performed distally with a transverse bone cut because this could weaken the anterior cortex of the tibia and result in a fracture (Fig. 25.4). At the end of the intervention, the osteotomy is fixed with two bicortical 4.5 mm screws. No washer is used. Another option is to use three 3.5 mm screws. The holes in the anterior cortex should be made prior to the osteotomy. It is very important that each screw is 2 mm longer than the distance to the posterior cortex, as this achieves optimal fixation. We do not use the technique using metal wires (Whiteside) or resorbable wires (Vielpeau).

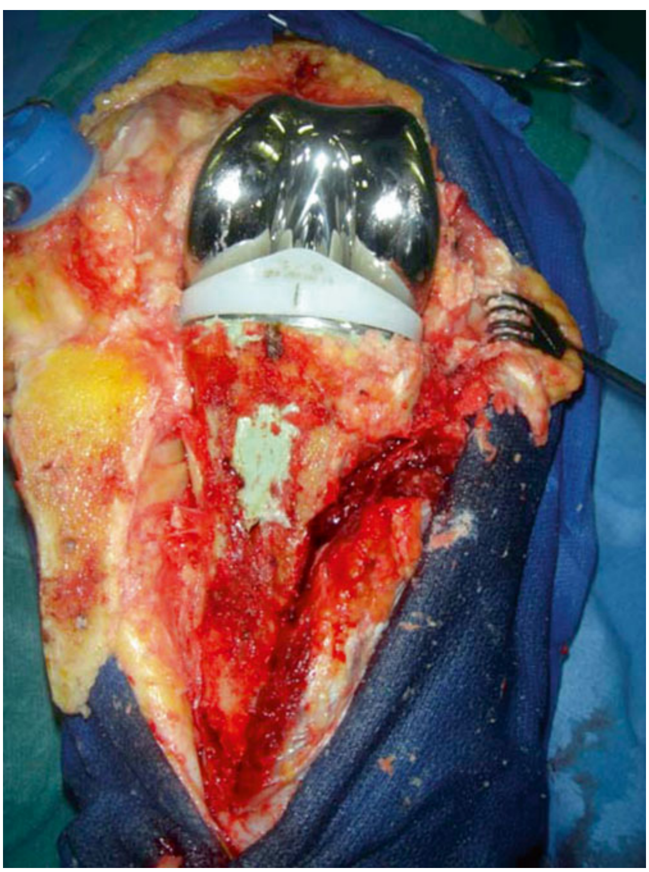


Fig. 25.4 Tibial tubercle osteotomy. It must be thick and long enough

Bone Cuts

Tibial Cut

As in the varus knee, the reference for the tibial cut is the contralateral plateau. In a varus knee, the cut is made 9 mm inferior to the lateral tibial plateau, which is convex. For a valgus knee, the reference is the medial plateau, which is concave. A cut 9 mm inferior to the medial convexity would be excessive and would lower the joint line. We therefore always cut 6 mm inferior to the medial plateau. It is seldom necessary to perform recuts.

Femoral Cuts

The HKS angle is always set at 5°. The proximal deformity of the femur, which is different in each patient, is NOT routinely considered in this technique. We consider our technique simple and more reproducible than the measurement of an individual HKS angle. In others words, we do not correct (in the majority of cases) the proximal extra-articular deformity intra-articularly. Transferring the individual HKS to the distal cut could result in an asymmetrical distal femoral cut and difficulties in balancing the collateral ligaments. The theory about the rotation of the femoral component is completely applicable in the case of a total knee arthroplasty in a valgus knee (cfr. chapter medial arthritis). Frequently in these cases, hypoplasia of the lateral condyle is observed. This hypoplasia can be seen very easily once the intramedullary femoral guide is positioned in 5° of valgus. Frequently, the distal cutting guide is not in contact with the lateral femoral condyle because of both wear to and also because of hypoplasia of the lateral condyle. It is in this situation that the asymmetrical distal cut is transferred to the posterior femoral cut, thereby externally rotating the femoral component.

Lateral Releases

Osteotomy of the Lateral Condyle According to Burdin

The knee is flexed at 90°. The synovial tissue covering the lateral condyle is incised and the popliteal tendon and lateral collateral ligament are identified. The osteotomy is performed with a fine oscillating saw blade. The osteotomy is approximately 1.5 cm in thickness (or in others words approximately one third of the width of the lateral condyle). In the sagittal plane, the cut is parallel to the long axis of the femur. In the coronal plane, the cut is anterior to the insertion of the LCL and popliteus tendon. The osteotomy can be completed carefully with the use of an osteotome (Figs. 25.5 and 25.6). The posterolateral structures must be released with a knife to move the bone block distally and posteriorly.

Ligament balancing in flexion and extension is performed using a spacer. If the flexion gap is tight laterally, the osteotomy will slide posteriorly (with the knee in flexion). It would slide distally (with a knee in extension) (Figs. 25.7 and 25.8), if the knee is tight in extension. With the use of the electric cautery, one can now mark the optimal position of the osteotomy for later fixation using a cortical screw diameter 4.5 with a washer.

The osteotomy at the level of the condyle has the advantage that it allows a controlled release of the lateral ligamentous structures. The osteotomy can be moved either distally or posteriorly independent from each other to address tightness in extension or in flexion. Currently, we prefer the osteotomy above the soft tissue release of the lateral collateral ligament and the popliteal tendon (Fig. 25.9). Indeed, release of the lateral structures associated with the use of a total knee arthroplasty design where the anterior cruciate ligament is not substituted could result in “retroligamentary” anterolateral laxity. This deformity is even more significant and exaggerated in cases of residual varus. However, the soft tissue releases are unable to precisely control the lengthening and the resultant lateral laxity.

Insall replaced the soft tissue release of the lateral collateral ligament and the popliteal tendon by a piecrust of the posterolateral soft tissues structures (with risk for the SPE) through a medial arthrotomy.

The postoperative instructions are slightly modified in the case of a condylar osteotomy. Toe touch weight bearing is allowed with the use of a splint during 45 days. Range of motion exercises follows the conventional rehab protocol (Figs. 25.10 and 25.11).

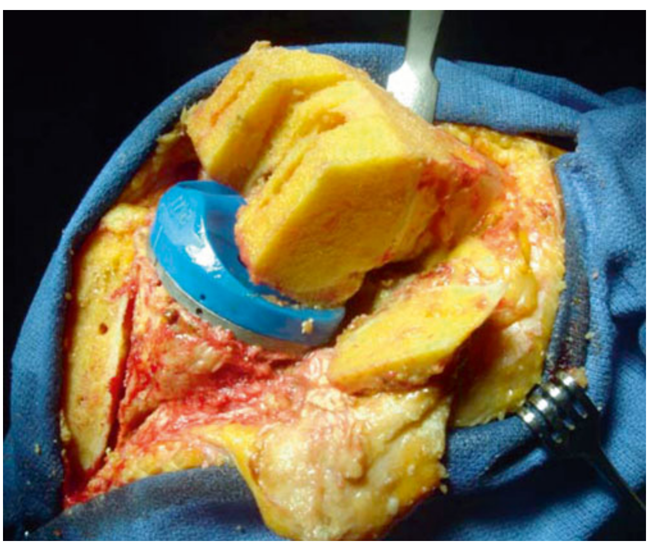


Fig. 25.5 Osteotomy of the lateral condyle (lateral view)

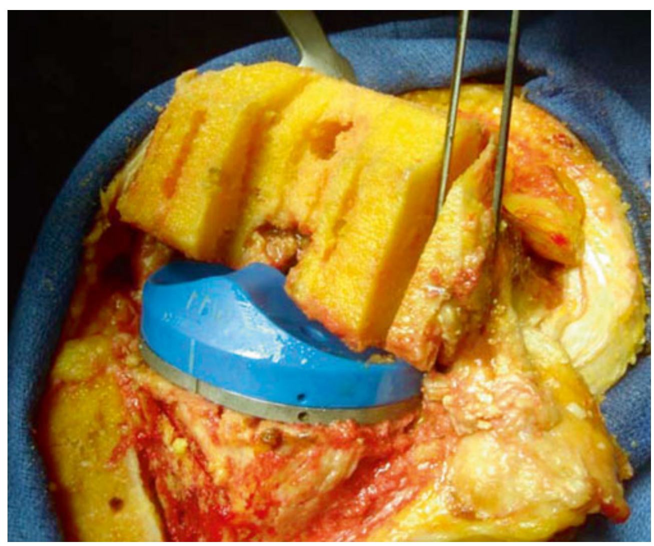


Fig. 25.6 The osteotomy is approximately 1.5 cm in thickness. Proximal insertions of the lateral collateral ligament and popliteus tendon are intact

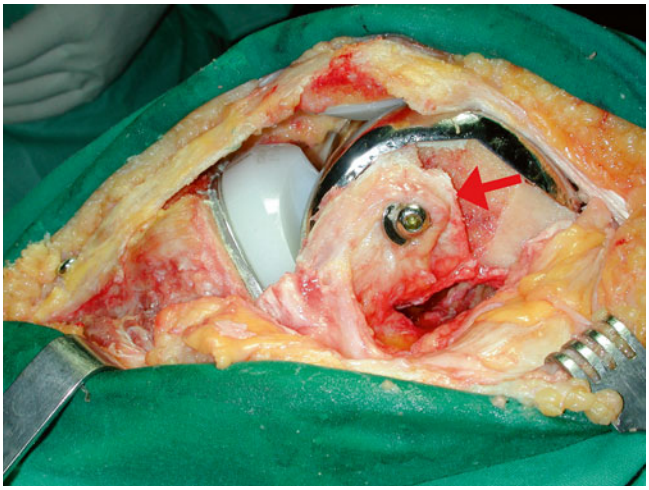


Fig. 25.7 Posterior transfer of the osteotomy

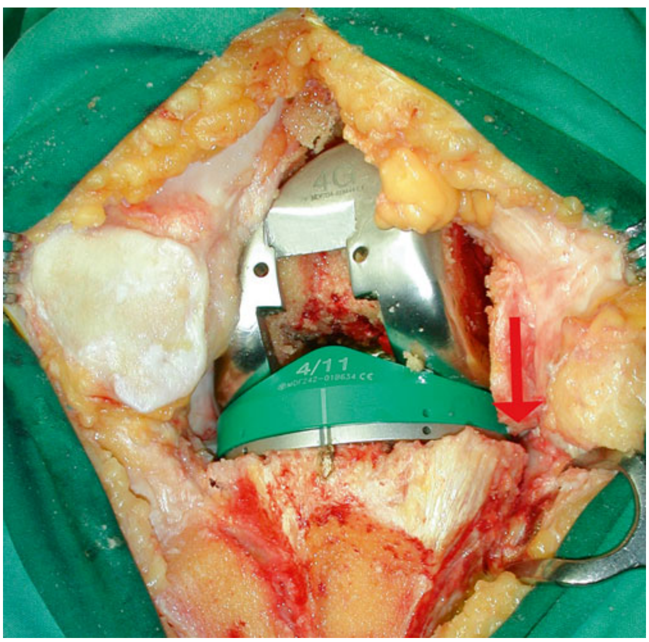


Fig. 25.8 Distal transfer of the osteotomy

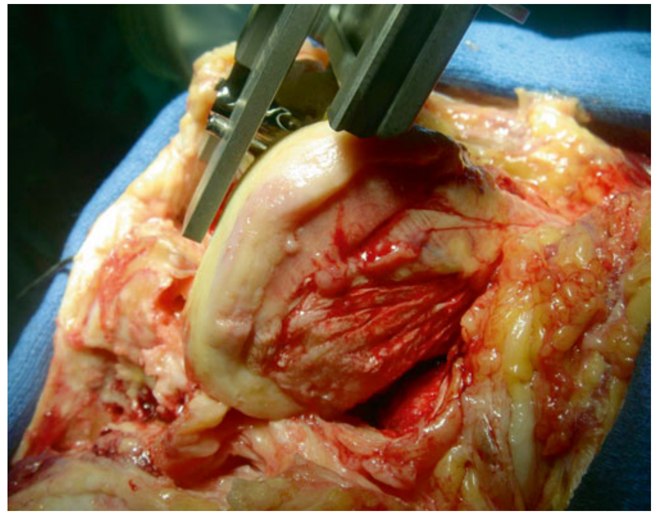


Fig. 25.9 Subperiosteal release of the lateral structures (LCL and popliteus tendon)

Fig. 25.10 Postoperative X-ray (AP view)

Fig. 25.11 Postoperative X-ray (lateral view)

Piecrust of the ITB

The piecrust technique encompasses multiple incisions in a staggered fashion in the body of the ITB tendon. We rarely perform this technique unless an important retraction remained in extension at the end of the intervention (Fig. 25.12).

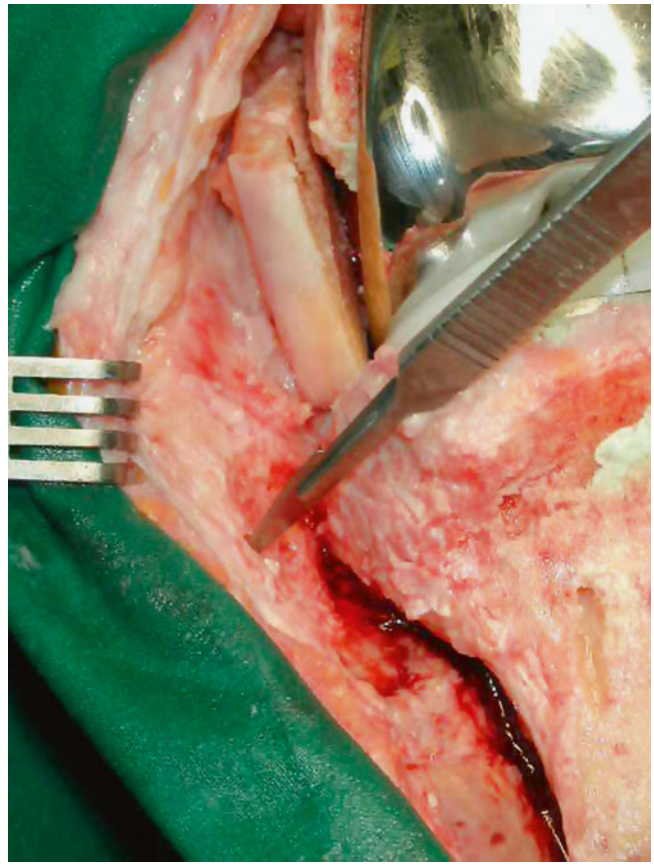


Fig. 25.12 Piecrust of the ITB: multiple incisions in a staggered fashion

Surgical Sequence

A valgus deformity of the knee is a dynamic phenomenon, which is not yet well understood. In contrast to the varus knee, the preoperative radiographic evaluation (full leg and stress X-rays) does not allow one to foresee certain difficulties that can be encountered during the surgical procedure. Frequently, one can predict if an additional soft tissue release is necessary once the tibial cut is performed. If, after releasing the capsule at the level of the joint line on the lateral tibial plateau, the flexion or extension gap remains trapezoidal, we routinely perform an osteotomy of the lateral femoral condyle.

At the end of the procedure, contracture of the IT band can be the cause of a soft tissue imbalance in extension. In this very rare situation, we perform a complementary piecrust of the IT band. Although release of the biceps tendon or osteotomy of the fibular head is discussed in the literature, we have never needed this technique to obtain correct alignment and ligamentous balance. If significant laxity is present in the elderly patient, one can use a more constrained prosthetic design. The use of the type of prosthesis, however, has to remain limited because of the potential complications associated with the use of more constraining implant. In our department, this decision has to be made prior to the intervention since we do not have this type of prosthesis permanently available in our hospital.

Computer-Assisted Total Knee Arthroplasty

26

S. Lustig, R. Badet, and Maad F. AlSaati

Introduction

The theoretical aspects of computer-assisted total knee arthroplasty (TKA) were discussed at the end of the previous chapter, and we will consider in this chapter the practical applications of computer-assisted TKA. We have described conventional TKA in prior chapters and will discuss here a similar technique with computer assistance.

The use of "navigation" surgery using the computer has developed over the past 10 years since the first computer-assisted TKA in a human was performed under the direction of D. Saragaglia. The goal of this technique is to have more accurate and reproducible surgery (while at any time having the option of switching to a traditional guide system if needed). We use a PLEOS navigation system (Fig. 26.1), which allows us to use one of three surgical strategies:

- Performing cuts independently
- Performing cuts dependently
- Simulating the distal and posterior femoral cuts (after the tibial cut is made)

Fig. 26.1 PLEOS navigation system

S. Lustig, MD, PhD (✉)
Albert Trillat Center, Croix Rousse Hospital,
103 grande rue de la Croix Rousse, Lyon 69004, France
e-mail: sebastien.lustig@gmail.com

R. Badet, MD
Clinique Saint-Vincent-de-Paul,
70 avenue du Médipôle, Bourgoin-Jallieu 38300, France
e-mail: badetr@roger-badet.fr

M.F. AlSaati, MD
Saati Medical Center,
88591, Riyadh 11672, Saudi Arabia
e-mail: maad.saati@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_26, © Springer-Verlag London 2014

Setup

Patient positioning and setup are the same as for a conventional knee arthroplasty

Surgical Approach

There is no difference from the standard TKA approach. We perform an anteromedial approach in cases involving a varus knee and anterolateral approach in cases involving a valgus knee.

The cruciate ligaments are resected and the tibia dislocated forward with a Hohmann retractor. This maneuver is required for acquisition of all necessary landmarks.

Introduction of the Sensors

One sensor is affixed to the tibia and one to the femur for detection by the camera. Both are placed percutaneously and in positions that will not interfere with access to the knee during the procedure.

The tibial sensor is positioned 10 cm below the skin incision so as not to interfere with the tibial cutting guide. The two threaded pins are introduced to the medial cortex of the tibia using a drill with spacing corresponding to the width of the sensor, which is then attached to the two pins. Two percutaneous femoral pins are similarly placed 10 cm above the skin incision to avoid impingement on the femoral cutting guide.

One then checks the positioning of the computer and the receiving antenna. The tibiofemoral sensors must be clearly visible to the cameras in both full extension and maximum flexion of the knee.

Acquisitions

Femur

We start by identifying the center of the femoral head by putting the knee in extension and performing a slow, repeated circumduction movement with the entire lower limb. It is important to ensure that the pelvis is immobilized at this stage (Fig. 26.2).

The remaining points are acquired using a wand with an attached optical sensor. We identify first three points corresponding to the anterior cortex of the femur. It is important to identify the most anterior part of the cortex to avoid notching the femur during the anterior femoral cut (Fig. 26.3). Three points marking Whiteside's line are then marked with the use of the wand (Fig. 26.4).

The knee center is identified as a point about 5 mm anterior to the femoral insertion of PCL (Fig. 26.5).

The most distal part of the medial and lateral condyles is marked by scratching on the corresponding areas (Fig. 26.6a, b). They give us the reference level (height) for the cuts.

The posterior condyles are identified using special instruments that have two appendages that rest at the back of the condyles and in the bearing zone distally which are applied against the femur. The pointer is inserted in this instrument and the computer to indicate the flexion contracture or recurvatum positioning of the tool. It is positioned at 0 ° (or 3° depending on the surgeon's choice) to confirm the palpated zone on the posterior condyles.

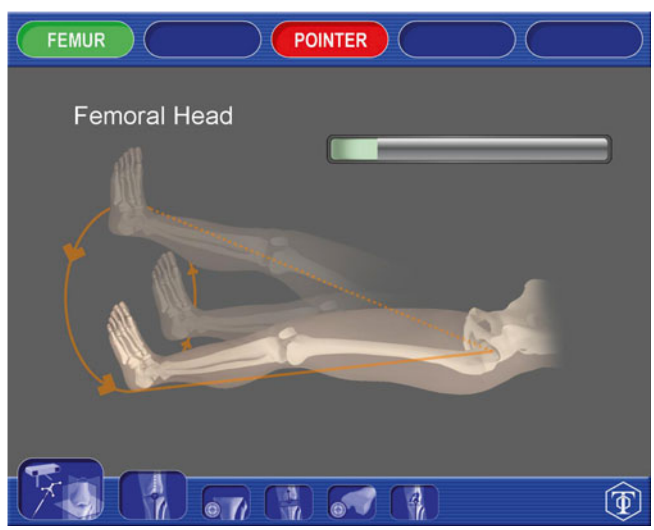


Fig. 26.2 Acquisition of the center of the hip. We must make small rotary movements clockwise

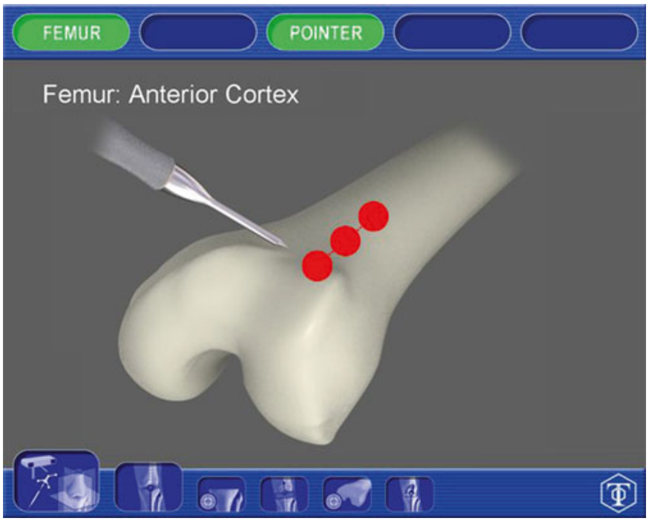


Fig. 26.3 Acquisition of the anterior femoral points

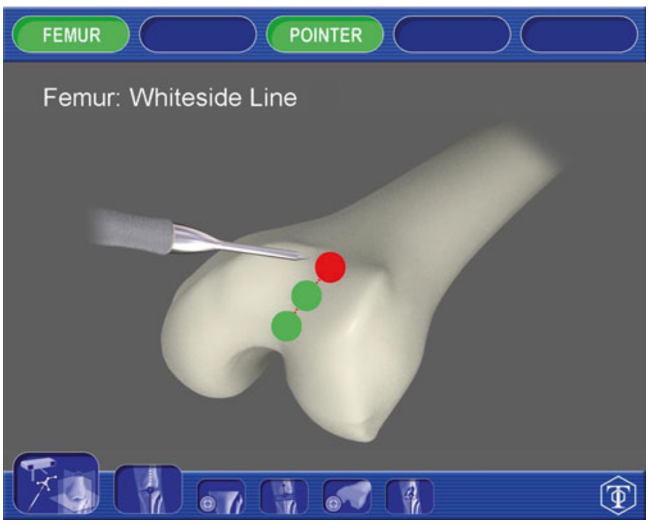


Fig. 26.4 Acquisition of the bottom line of trochlea (Whiteside's line)

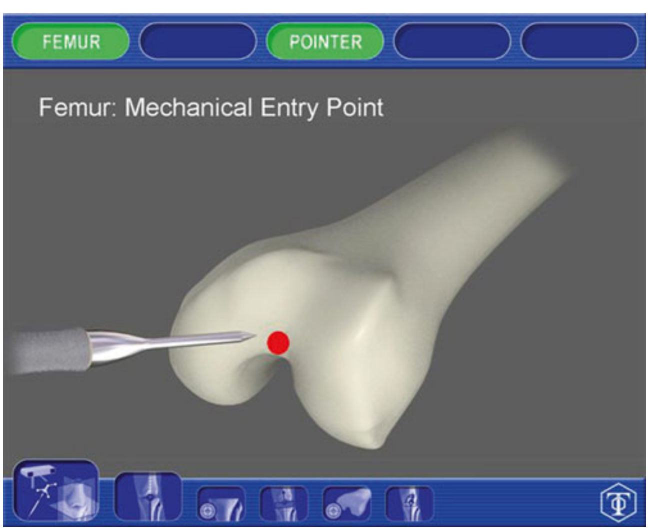


Fig. 26.5 Acquisition of the femoral center, 5 mm above the femoral insertion of the PCL

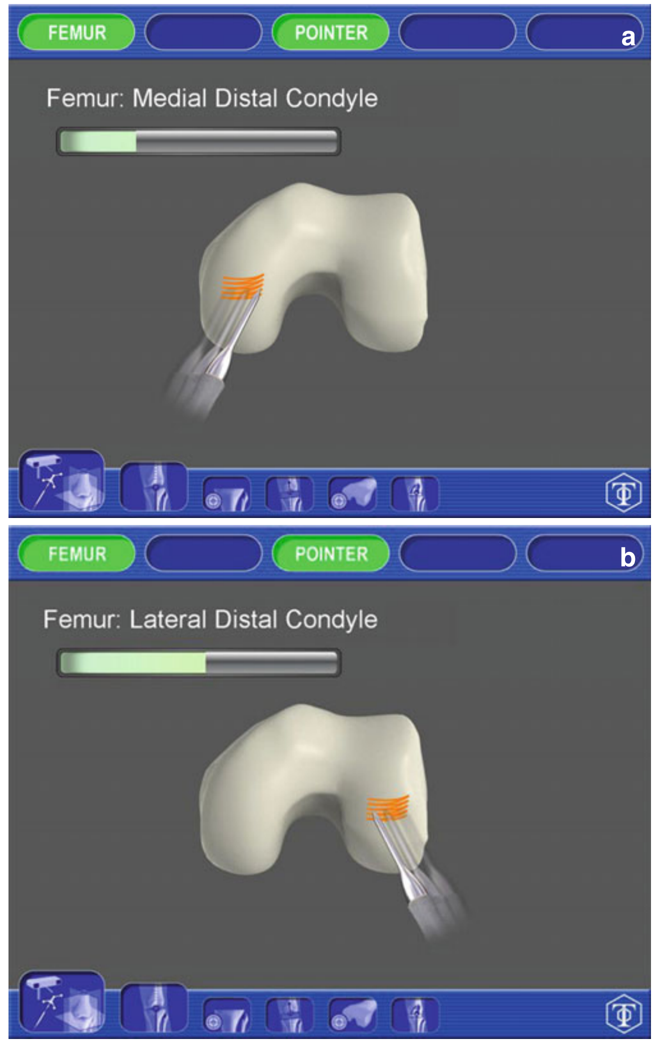


Fig. 26.6 Acquisition of the distal part of the femoral condyles (**a** medial, **b** lateral)

Tibia

We first identify the ACL insertion site between the tibial spines (Fig. 26.7).

Then we locate:

- The deepest area of the medial tibial plateau and most prominent point on the lateral plateau, by scratching on the corresponding areas. They give us the reference for cutting levels (Fig. 26.8a, b).
- The area of insertion of the PCL at the back of the posterior tibial spine and the medial third of the ATT in front of the tibia (Fig. 26.9). The straight line joining insertion of the PCL and ATT gives the orientation of the tibial plateau.
- The medial and lateral malleoli of the ankle using the probe tip (Fig. 26.10).

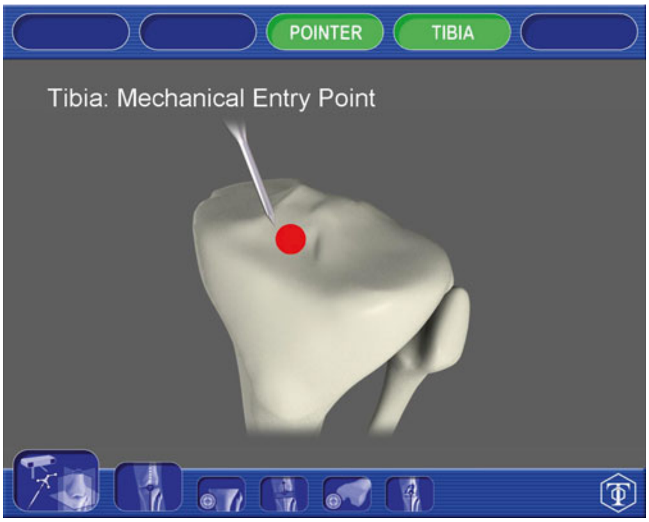


Fig. 26.7 Acquisition of the insertion zone of the ACL to the tibia

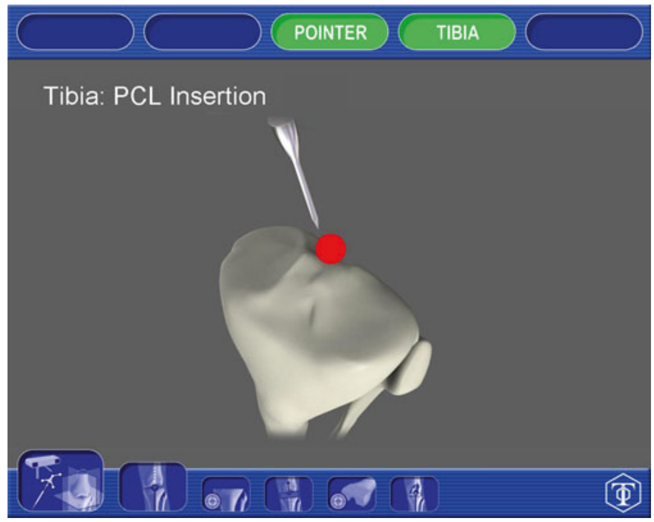


Fig. 26.9 Acquisition of the insertion zone of the PCL to the tibia

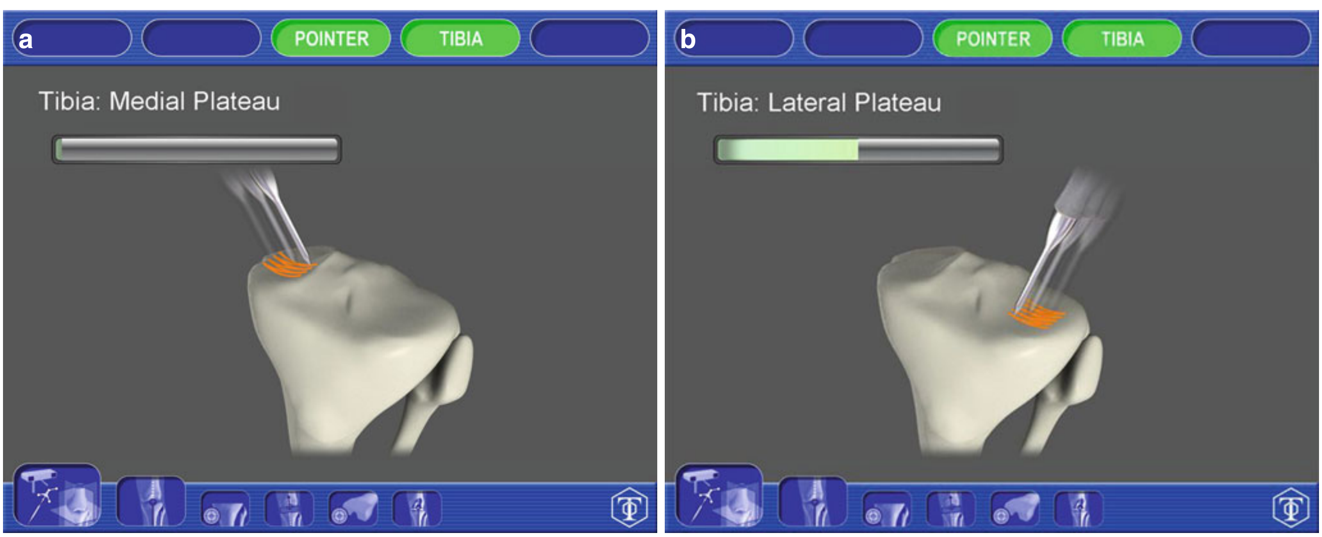


Fig. 26.8 Acquisition of the tibial plateau (**a** medial, **b** lateral)

Fig. 26.10 Acquisition of the medial and lateral malleoli

Axis and Ligaments

The overall axis of the lower limb is measured by the navigation system, at an angle close to full extension (Fig. 26.11).

We evaluate the varus and valgus laxity in extension. This measurement is performed by applying maximum stress in varus and valgus while the navigation system notes the maximum value in degrees.

The same measurements of laxity are carried out at 90° of flexion.

Finally, the maximum flexion is registered.

Fig. 26.11 Initial assessment with measurement of the deformity (HKA angle), the laxity in extension/flexion and range of motion

Tibial Cut

The knee is in 90° of flexion with the tibia dislocated anteriorly. A Hohmann retractor is positioned behind the tibia while another is applied to the lateral side of the lateral tibial plateau to maintain patellar eversion and provide visualization.

The tibial guide is fixed by a pin that is placed at the center of the tibial epiphysis, in the insertion of the ACL. We control the correct positioning of the guide with the target sign on the screen (Fig. 26.12). The center of the target is the correct positioning for varus/valgus and the slope is set by the surgeon (for us 0° in the coronal and sagittal planes). We then adjusted the height of the desired tibial cut (usually 9 mm with respect to the lateral tibial plateau in case of genu varum and 6 mm from the medial tibial plateau in case of genu valgum) (Fig. 26.13).

Once the parameters are validated, two pins are used to "save" the position of the tibial cutting guide that will then be removed. The pins enable the introduction of the "joker" for the tibial cut. The cut is carried out either through the tibial guide or on the pins (our choice). We check that the cut is made consistent with our prediction surgically by placing a sensor on the tibia after the cut has been performed (Fig. 26.14).

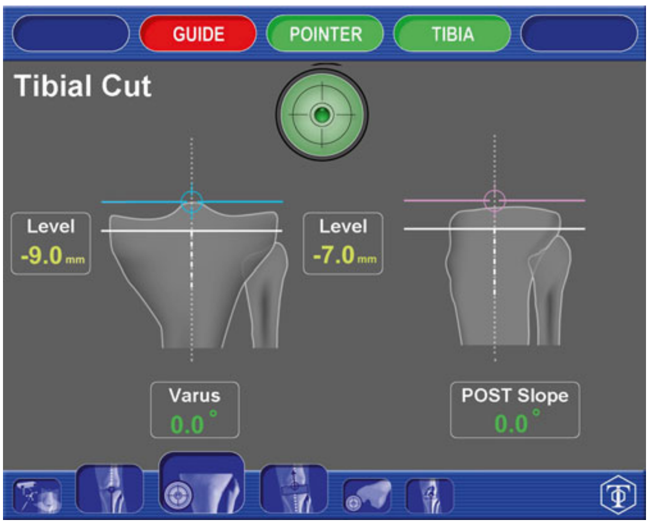


Fig. 26.12 Introduction of the ancillary tibia

Fig. 26.14 Verification of the tibial cut with the specific sensor positioned on the cut

Fig. 26.13 Setting up the tibial cutting guide with control of the varus/valgus, slope and height of cut

Balancing

The 9 mm tibial spacer is used to evaluate knee balance before making the femoral cuts.

We check the balance in flexion first (Fig. 26.15). The computer shows the medial and lateral spaces as well as the planned femoral cut. We need a minimum space of 19 mm (9 mm tibial space and 10 mm for the femoral cuts). We can perform if necessary a medial or lateral release to balance the space in flexion.

We then check the spaces in extension (Fig. 26.16). The computer shows the medial and lateral spaces as well as the planned femoral cut. We need a minimum space of 19 mm (9 mm tibial space and 10 mm for the femoral cuts).

The positioning is validated (varus/valgus and flexion contracture) and the size of the femoral implant needed to obtain the desired mechanical axis of the femur is selected.

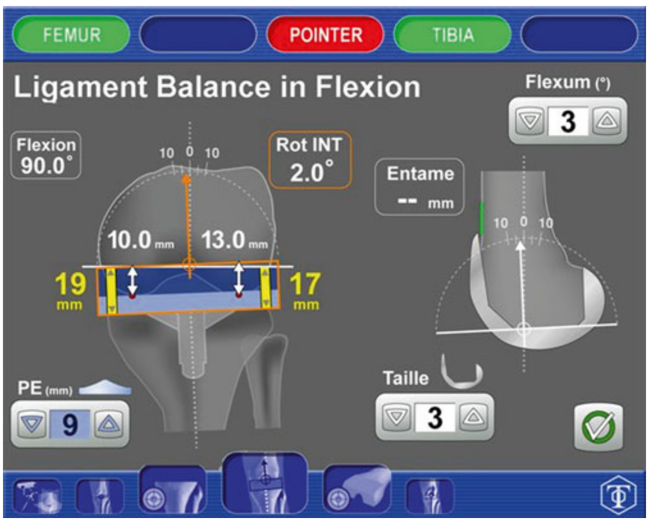


Fig. 26.15 Control spaces in flexion

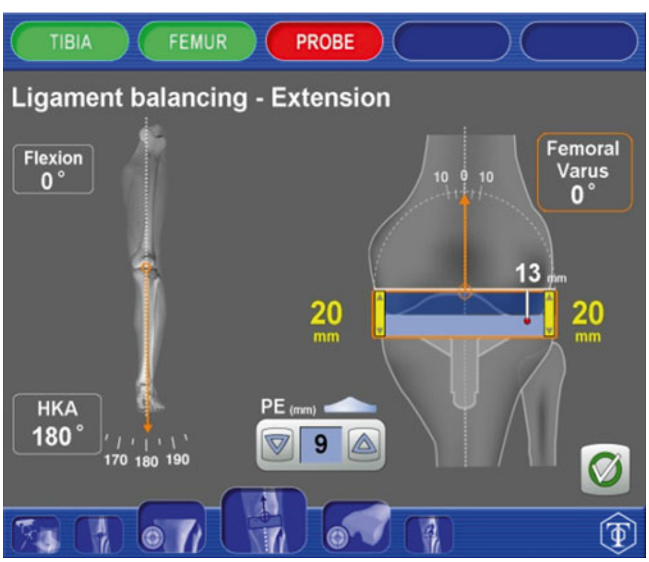


Fig. 26.16 Control spaces in extension

Femoral Cut

The femoral guide is fixed by pins that are applied just above the intercondylar notch, above the insertion of the PCL. We control the proper positioning of the guide with a target sign on the screen. The center of the target is the correct positioning as defined in the previous step (varus/valgus and flexion contracture at 0°).

Then we adjusted the desired height of the femoral cut (usually 10 mm from the distal femur) (Fig. 26.17).

We can verify with the navigator that the cut performed is consistent with the programming (e.g., 0° flexion contracture and femoral mechanical axis of 90° by setting a specific device on the distal femoral guide).

The joker is then positioned to implement the two positioning pins of the 4-in-1 femoral cutting guide. It is applied to the distal femoral cut, and two hind legs are positioned in contact with both posterior condyles. Adjusting the rotation and especially the anterior-posterior positioning; according to the validated values at the time of equilibration. We can thus control the rotation, sizing, offset, and balancing in flexion without the use of compact multifunction cutting guide. Once positioning is controlled, we impact the two positioning pins and then remove the navigation, so we can apply the two pins on the 4-in-1 cutting guide, where four remaining femoral cuts are performed. The distal femoral cut is then controlled using the specific sensor (Fig. 26.18).

Fig. 26.17 Setting up the femoral cutting guide with control of the varus/valgus and of the flexion and the cutting height

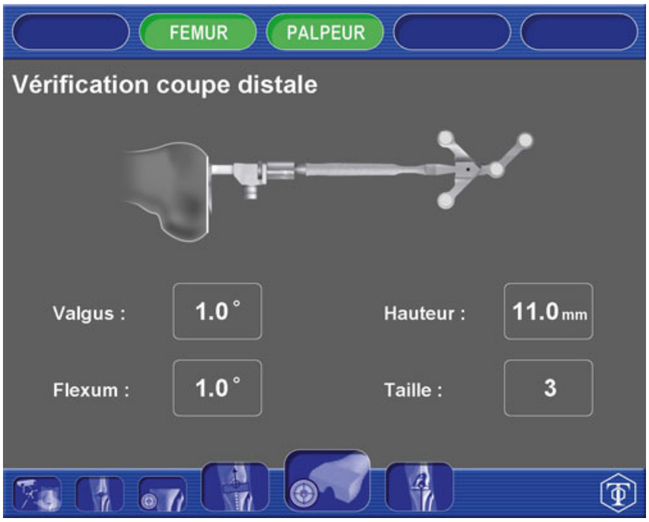


Fig. 26.18 Controlled femoral cut with the specific sensor positioned on the distal cut

Trials

The trial parts are placed and we check the overall axis of the lower limb and laxity in flexion and extension (the same parameters at the beginning of the operation).

The patellar cut is not navigated.

Applying the Final Implants

The final implants are cemented in place. We can control the final positioning by the verification of the tibiofemoral axis, and once the cement hardens, we can evaluate the varus/valgus laxity (Fig. 26.19).

Fig. 26.19 Final check of the HKA angle, laxity in extension/flexion and maximal flexion

Closure and Postoperative Care

All navigation pine is removed and closure and postoperative care proceed as for a non-navigated case.

Total Knee Prosthesis After Valgus Osteotomy of the Tibia

27

G. Demey and H. Hobbs

The need for a total knee arthroplasty (TKA) after a high tibial osteotomy (HTO) presents several difficulties. The osteotomy induces a bony deformity that can lead to unbalanced bone cuts if the resection is based on ligament balancing techniques. This potential difficulty should be considered before surgery, anticipated, and planned for with a thorough clinical and radiologic examination. Specifically, radiographs should include:

- AP and lateral single leg stance views
- Axial view of the patella at 30° of knee flexion
- Stress views (varus and valgus)
- Full leg views (weight bearing)

Analysis of the tibial shape includes assessment of the translation and angulation of the epiphysis. This is quantified by measuring the mechanical tibial angle (MTA) and the tibiofemoral mechanical angle (AFTM) in the frontal plane and the tibial slope in the sagittal plane (Fig. 27.1). The angle of the previous osteotomy is of lesser importance. The mechanical axis at the knee is critical. Preoperative planning of the procedure is important. Templating of the implant, position of the implant, anticipated mismatch of the bone and the implant, estimated cuts, induced spaces, and the joint level are all essential to make the right choice of prosthesis (type of prosthesis – constrained or not, custom prosthesis, keel offset, associated osteotomy) and intraoperative technique (ligament release, sliding osteotomy of the lateral condyle of Burdin, etc.).

In practice, there are two preoperative situations that need to be understood: undercorrection (AFTM ≤180°) or overcorrection (AFTM >182°).

G. Demey, MD
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

H. Hobbs, MD (✉)
Sports Science Institute,
Boundary Road Newlands, Cape Town, South Africa
e-mail: haydhobbs@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_27, © Springer-Verlag London 2014

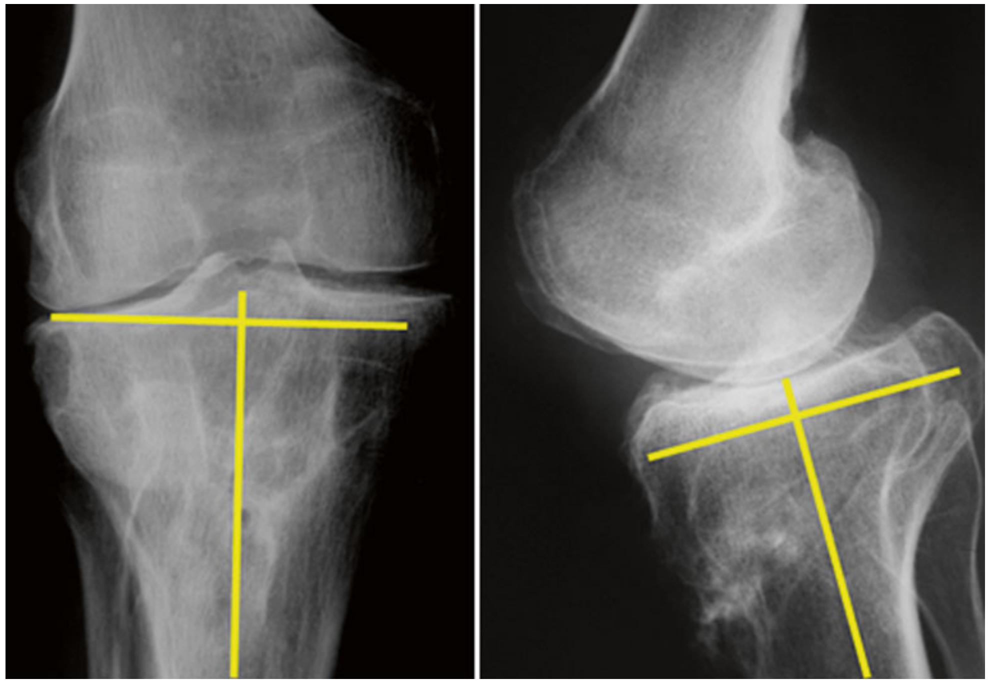


Fig. 27.1 Assessment of the translation and angulation of the epiphysis

Surgical Technique

Typical setup for a TKA is employed.

1. Incision
   The choice of surgical approach is essential because it facilitates the releases and ligament balancing.
   The previous vertical incision can be used and extended, if necessary, since it is close to the midline.
   A previous horizontal incision cannot be reused. The new incision is created vertically in the midline, crossing the previous scar at right angles (Fig. 27.2).
   The location of the incision does not influence the choice of whether a medial or lateral arthrotomy is used.
   - In cases of undercorrection (varus knee), a medial parapatellar arthrotomy is preferred.
   - In case of overcorrection (valgus knee), a lateral parapatellar arthrotomy is preferred (Fig. 27.3).

   In cases with multiple scars where there is a possibility of skin necrosis, the opinion of the plastic surgeons is sometimes needed.
2. Removal of equipment
   Previous hardware is not routinely removed. When hardware removal is required, we remove it during the TKA procedure when possible in order to avoid two interventions and hospitalizations.
   Nevertheless, a two-stage surgery is preferable when there is a question about infection. Microbiology advice is required if there is a positive history of infection.
   The previous scar from the osteotomy may be used independently to remove the hardware, but there is a risk of skin necrosis.
3. Exposure
   If there is a patella baja or significant knee stiffness (flexion ≤90°), there is a risk of avulsion of the patellar tendon whilst flexing the knee to dislocate the patella. Osteotomy of the tibial tuberosity is sometimes necessary. However, one must attempt to avoid this by initially performing an arthrolysis. When performed, the tubercle osteotomy has the advantage of allowing a proximal transfer of the tibial tubercle when the patella is low. It is necessary to osteotomize a piece of tibial tubercle long enough (≥6 cm) and deep enough (it must reach the cancellous metaphyseal bone) and perform the fixation with two screws in order to avoid a nonunion (Fig. 27.4).
   The exposure is completed by the release of the condylar gutters.
   A lateral retinacular release is not routinely performed. If necessary, this release is performed from within the joint to limit undermining in the prepatellar region.
   In some cases, putting a 2 mm pin as an artificial constraint in the patella tendon once the patella is dislocated (Deschamps) will strengthen its attachment and avoid avulsion during flexion and anterior dislocation of the tibia.
   The posterior femoral cut can be made at this time to facilitate the exposure and the dislocation of the tibia (Fig. 27.5).
4. Tibial cut
   The objective is to obtain a mechanical tibial angle of 90°, cutting perpendicular to the mechanical axis of the tibia in the frontal and sagittal planes. We use intra- and extramedullary guides as a double check to determine the correct cutting angle on the tibia (the extramedullary guide gives the varus-valgus alignment). Two difficulties are then encountered: restoration of the joint line and compromise between coverage and conflict between the tibial stem and the tibial cortex.
   This must be planned preoperatively when templating to ensure that there is no conflict between the tibial stem and tibial metaphysis. Similarly, one must draw the proposed cuts and evaluate their asymmetry.
   The cutting height is difficult to determine. Due to the tibial shape, it is difficult to use the plateau to determine the cutting level and space height. The lateral compartment has been "reduced" by the osteotomy and now also has unusual cartilage wear. The medial compartment also has osteoarthritis but with bone loss.
   - In the case of undercorrection, the tibial cut is perpendicular to the long axis of the tibia and 6 mm is taken from the lateral tibial plateau (this is for an insert of 9 mm). Multiple drill holes in the medial tibial plateau may be necessary, to help with cement fixation (Fig. 27.6).
   - In the case of overcorrection, the tibial cut is perpendicular to the long axis of the tibia and 6 mm is taken from the medial tibial plateau (always for an insert of 9 mm) (Fig. 27.7).

   The translation created by the epiphyseal osteotomy may require a compromise between good tibial coverage and conflict between the keel or stem and the tibial cortex. Sometimes an offset tibial keel or a custom-made prosthesis is necessary (Fig. 27.8). Preoperative planning is therefore important so that these implants may be ordered if required (Fig. 27.9a, b).
   We recommend using a long tibial stem (75 mm or 100 mm) in cases of opening wedge osteotomy especially when synthetic bone substitute was used.
   The concept of tibial slope in total knee arthroplasty is important because increased tibial slope can lead to anterior tibial translation and anterior subluxation of the tibia when weight bearing. It is for this reason that we want a postoperative tibial slope of 0°. The problems found with asymmetric bone cuts in the coronal plane can also be found in the sagittal plane. Tibial slope should be carefully evaluated before surgery. We measure the angle between the axis of the diaphysis and the medial tibial plateau, which is less variable than using the medial tibial plateau and the anterior tibial cortex (this is affected by rotation on the radiographic films).

Soft tissue balancing precedes the distal femoral cut. Resection of osteophytes and a lateral release will help to balance the ligaments. We perform our lateral release in the following order:

– Loosening of the IT band insertion on Gerdy's tubercle during the lateral parapatellar approach
– Pie crusting of the IT band (extended release)
– Osteotomy of the lateral condyle (of Burdin) if there is contracture in flexion and extension (see previous chapters for the surgical technique) (Fig. 27.10a–c)
– Rarely, a femoral release of the popliteus and LCL in extreme cases (Fig. 27.11)

Finally, in cases of severe overcorrection (malunion >100°), a corrective osteotomy is performed prior to the TKA, so that the definitive procedure can be performed under the best conditions. We try to avoid doing the corrective osteotomy and the TKA in a single surgery. We also usually do a sliding osteotomy of the lateral condyle in these cases.

The distal femoral cut is performed with a 5° valgus angle. The three components, femoral, tibial, and patella, are then cemented in place.

The closure is unremarkable.

5. Postoperative

Weight bearing and crutches from day 1. Flexion is limited to 95° for 60 days and then without limitation. An extension splint is used for walking until the quadriceps is able to lock the knee in extension. If a proximalization of the tibial tubercle is done, the extension splint is kept for 2 months and the patient is reviewed at day 60.

Fig. 27.2 Case of previous horizontal incision. The new incision crosses the previous scar at right angles

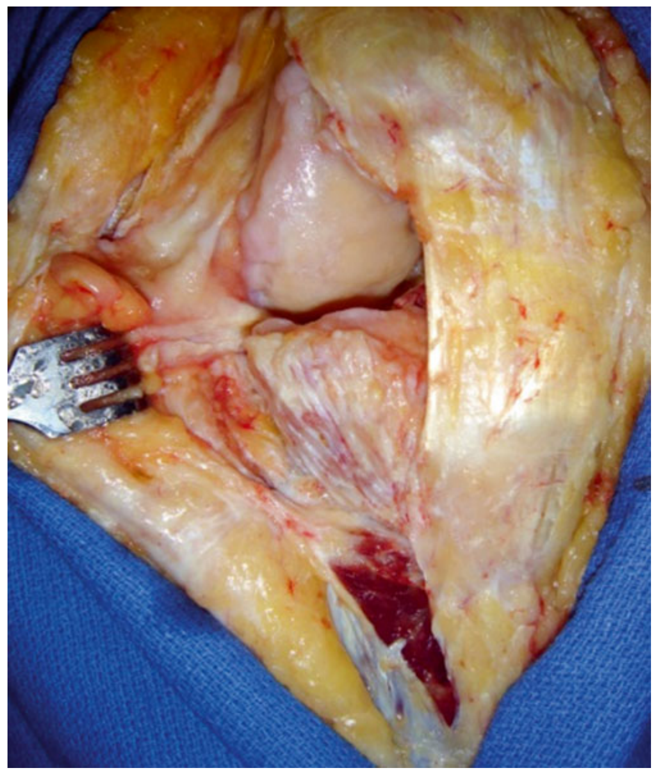


Fig. 27.3 Lateral parapatellar arthrotomy in case of overcorrection (valgus knee)

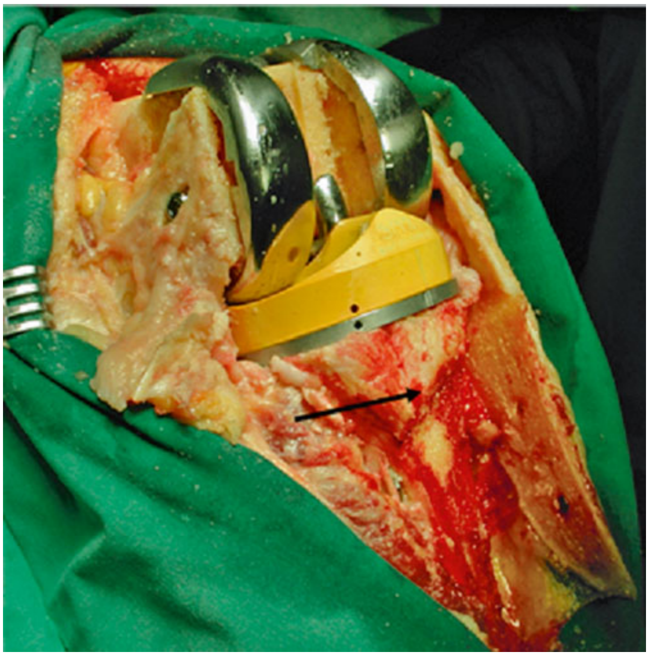


Fig. 27.4 Tibial tubercle osteotomy

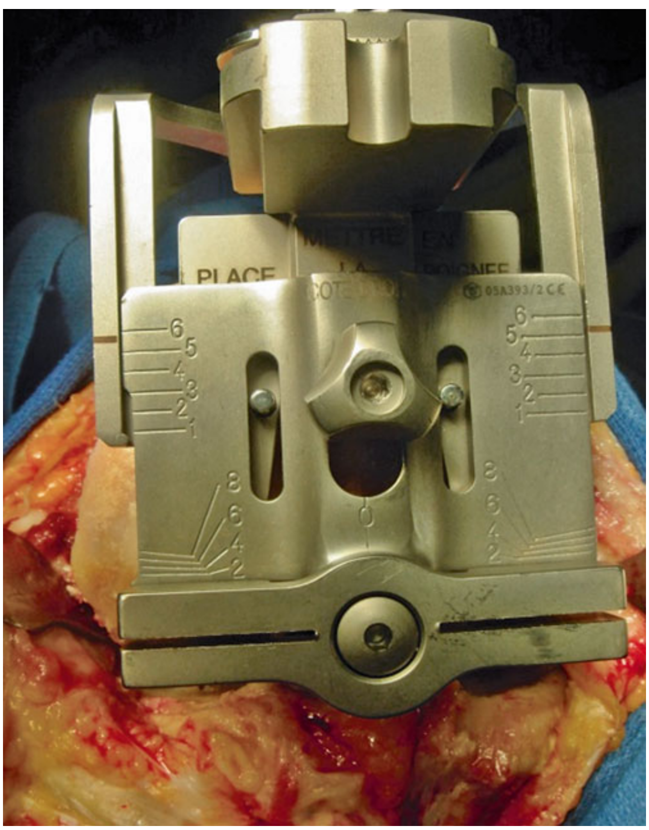


Fig. 27.5 The posterior femoral cut can be made first to facilitate the exposure of the tibia

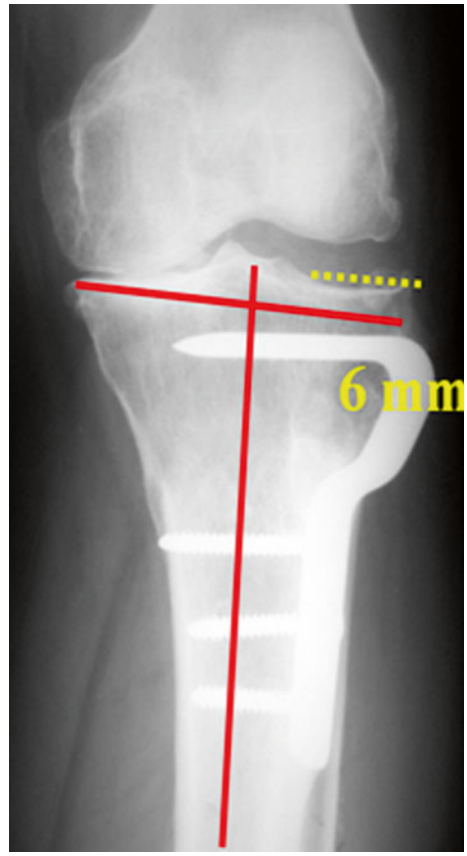


Fig. 27.6 Tibial cut of 6 mm from the lateral tibial plateau in case of undercorrection

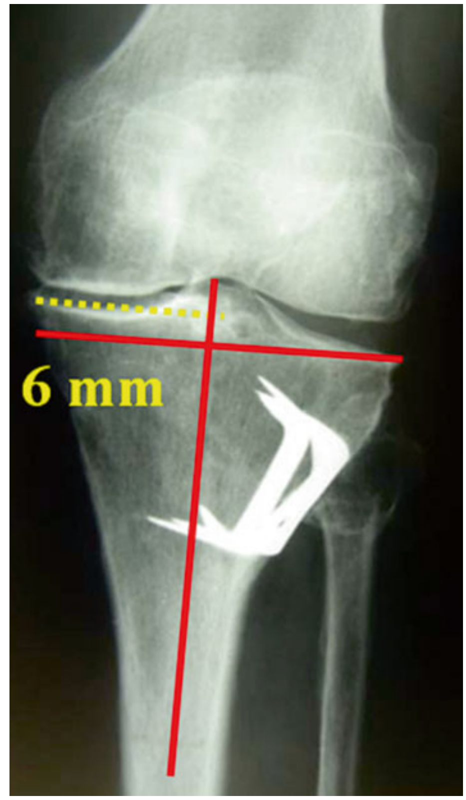


Fig. 27.7 Tibial cut of 6 mm from the medial tibial plateau in case of overcorrection

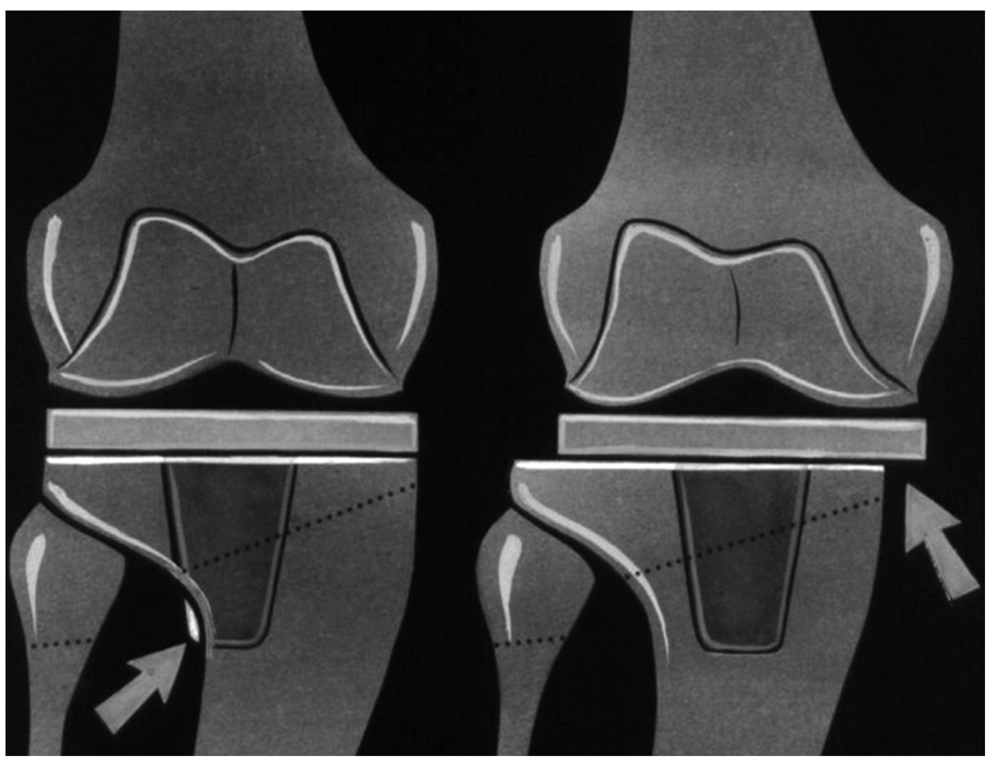


Fig. 27.8 Case of important tibial translation. A tibial component overhang or a conflict between the keel and the tibial cortex may occur. An offset tibial keel or a custom-made prosthesis should be discussed

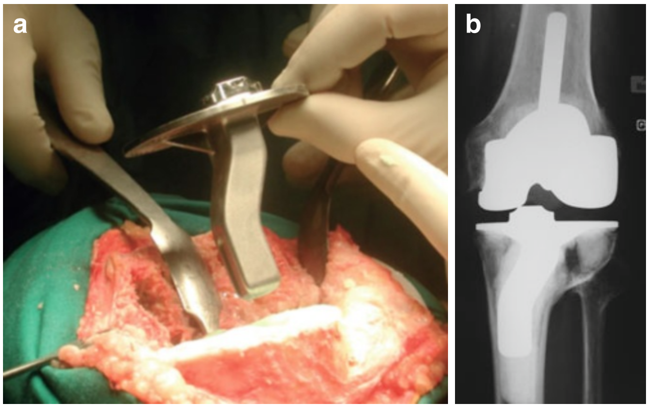


Fig. 27.9 Custom-made prosthesis with an offset tibial keel. (**a**) Preoperative view; (**b**) postoperative X-ray

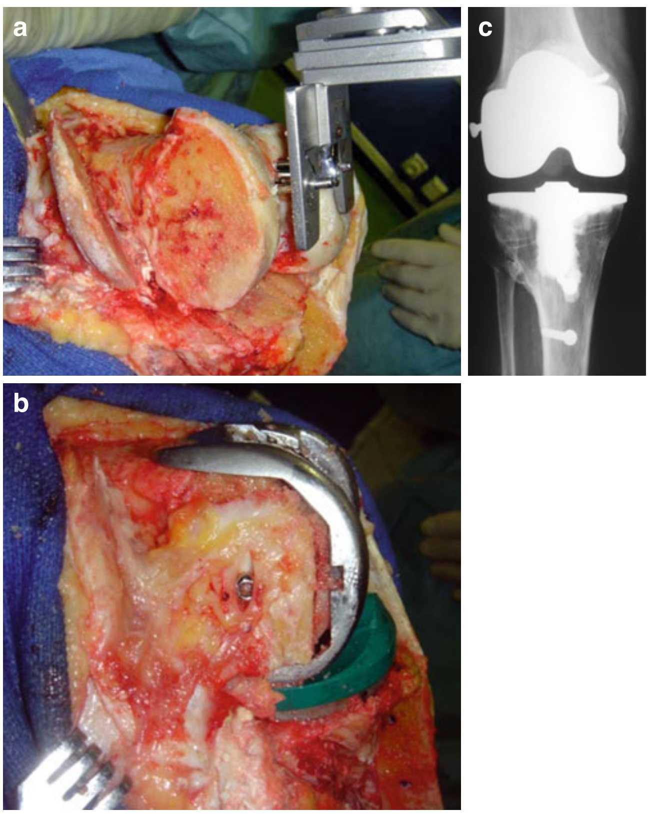


Fig. 27.10 (**a–c**) Osteotomy of the lateral condyle providing balancing in extension and in flexion

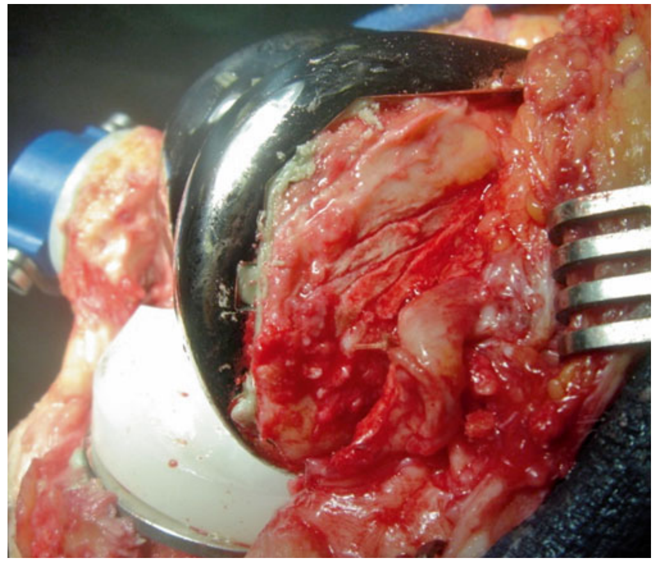


Fig. 27.11 Subperiosteal femoral release of the popliteus tendon and LCL

Revision Unicompartmental Knee Arthroplasty

28

G. Demey and Robert A. Magnussen

Plan

Introduction

Unicompartmental knee prosthesis (UKA) has excellent results for unicompartmental tibiofemoral osteoarthritis. However, poor results and failures may occur.

UKA revision to total knee arthroplasty (TKA) is common. Some surgeons think that this procedure is as easy as a primary TKA. We do not agree, even if it may be easier than a TKA revision.

Surgical history of the knee must be known to plan the revision surgery: the type of UKA (bone resection, versus resurfacing) and cause of failure (metallosis, loosening, wear, tibial plateau fracture, etc.).

UKA revision is not limited to revision to TKA. Sometimes, only one of the two components needs to be changed. Arthroscopy after UKA may be indicated in cases of chronic and unexplained pain, but this indication is very rare.

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_28, © Springer-Verlag London 2014

Revision of a UKA to a TKA

Surgical planning and techniques are described here, but details of surgical technique to implant TKA are not. We focus on specifics of a UKA revision.

Indications

The cause of failure must be known. Usual causes of UKA revision are:

- Aseptic loosening.
- Implant malpositioning.
- Polyethylene wear or fracture (Fig. 28.1).
- Osteoarthritis of one of the two other compartments (opposite tibiofemoral or rarely patellofemoral).
- Sepsis is rare (<0.5 %), but if present we prefer two-stage revision.
- Sometimes, causes of failure are multiple.

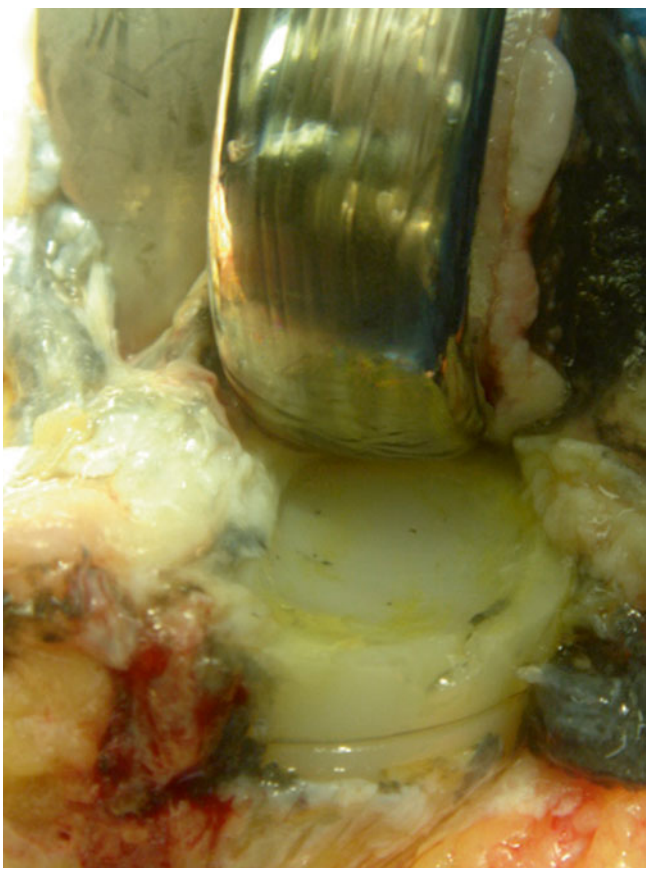


Fig. 28.1 Metallosis and polyethylene wear

Preoperative Planning

Clinical examination along with biological and radiological screening is essential to plan surgery. Infection must be ruled out with history, clinical exam, inflammatory markers, radiographs, and bone scintigraphy.

Standard radiographs needed are:

- AP single leg stance view (loosening, quality of contralateral tibiofemoral compartment)
- Lateral single leg stance view with 30° of knee flexion
- Schuss view with 45° of knee flexion (Fig. 28.2)
- Stress valgus/varus radiographs
- Standing long-axis view to measure both lower limbs' axes and angles, as in the planning of primary TKA
- Contralateral knee radiographs

  Computed tomography is very useful to diagnose failure of a UKA (osteolysis, prosthesis oversizing, loosening, etc.) and to plan surgery. Measure of biepicondylar posterior angle will let you know if the femoral component is well positioned and if the cutting guide can be used without removing the femoral component.

  Technetium (Tc-99m) scintigraphy and marked leukocyte scintigraphy (LeucoScan) may confirm if loosening is septic or aseptic.

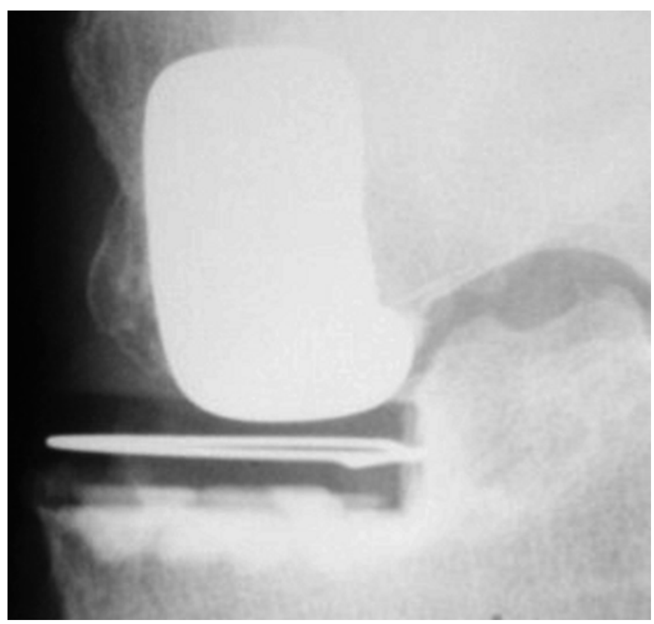


Fig. 28.2 Schuss view showing polyethylene wear

Technical Difficulties: Planning

Technical difficulties are mainly bone loss and ligament laxity.

- Bone loss is more frequent. It can be evaluated on preoperative radiographs (Fig. 28.3) and CT scans. But the true extent of bone loss can only be known during the surgery, after removal of the components.
- Frontal laxity is evaluated on valgus and varus stress radiographs. In case of lateral laxity with failure of a medial UKA, ligament balancing must be done and can be difficult. In our experience, the need for revision to a hinged TKA is rare. In addition, laxity on the concave side of the limb, which can be easily compensated by a TKA, is different from laxity on the convex side of the limb (due to ligamentous lengthening) which is more difficult to handle.
- We use posterior-stabilized UKA, so sagittal laxity is rarely a technical problem. In cases of undiagnosed anterior laxity, metallosis occurs when the polyethylene wears down to the metal backing. In this situation, precise evaluation of bone lesions is more difficult and a CT scan should be obtained.
- Implants: They can be left in place if they are perfectly placed in flexion and extension (preoperative radiographs are very important to evaluate it). Axis in flexion is evaluated on the side-view radiograph and on the scanner. Axis in extension is evaluated on the front radiograph and the long-axis one. However, the femoral component usually prevents adequate positioning of cutting guides, and it is better to remove it prior to making the bone cuts.

Fig. 28.3 Preoperative X-ray showing a bony defect of the medial plateau in case of a 9 mm cut (*dotted line*)

Surgical Technique

Medial UKA Revision

Surgical Approach

Skin incision for a medial UKA revision to a TKA is done extending the previous scar proximally and distally if needed. A medial parapatellar arthrotomy is done (Fig. 28.4). Tibial tubercle osteotomy is usually not necessary.

The cause of UKA failure is confirmed, and wear and fixation of implants are evaluated. Synovial and bone biopsies are done to look for wear debris or infection.

Tibial Cut

The tibia is easily anteriorly dislocated (Fig. 28.5). The tibial component and cement are carefully removed to prevent increasing bone loss. The femoral implant can often be left in place. An osteotome is used to prepare the introduction point of the intramedullary guide. The landmark is the ACL footprint.

The tibial cut is done the same way as in a primary TKA. The bony reference for the tibial cut is the native lateral compartment and the resected bone should be 9 mm thick on the lateral side (Fig. 28.6a, b). An oscillating saw is used. The goal is to prevent worsening bone defect by cutting too much and to reproduce tibiofemoral joint line.

This cut may be proximal to the medial compartment after removal of the tibial component. A medial compartment tibial cut of 4 mm, 8 mm, or 12 mm can be done parallel to the lateral compartment tibial cut (Fig. 28.7). This space will be filled with a metal augment (Fig. 28.8).

When the tibial cut is done, the trial tibial implant with augments is positioned (Fig. 28.8) and temporarily fixed. The posterior border of the tibia and the tibial tubercle are accessory landmarks. The tibial keel is prepared. When augments are necessary, the tibial keel must be lengthened (30 or 70 mm long keels are available). We do not hesitate to use long (75 mm) and thin keels (10–12 mm thick), so that implant positioning is easier (Fig. 28.9).

A tuliped tibial keel is another option (Fig. 28.10a). The tibial hemi-epiphysis is filled and the prosthesis lies on the medial cortical bone, similar to the femoral stem of a total hip prosthesis (Fig. 28.10b).

Femoral Cuts

The knee is positioned at 90° of flexion. The femoral guide for the posterior cut must be applied on the distal and posterior condyles, as described in the TKA chapter.

This can be done without removing the femoral component if it is well positioned, as determined before surgery with radiographs or a CT scan. Rotational malposition and over-/undersizing of implant must be absent. In case of malpositioning of the femoral component, it is removed and the posterior defect is filled with augments placed on the femoral cutting guide (Fig. 28.11a, b). Distal augments are not needed as the guide usually rests on the native condyle.

The femoral entry point is prepared with an osteotome above the medial side of the notch (just anterior to the PCL origin). The femoral medullary canal is prepared with a drill bit and is generally placed in 7° valgus. The stem of the femoral cutting guide is then inserted in the femoral medullary canal and the femoral cutting guide rests against the distal femoral condyle(s). The guide must also be applied on the posterior femoral condyles (or on the lateral condyle and the posteromedial augment if the femoral implant had to be removed).

The anteroposterior size of the implant is measured with the guide on the anterior femoral cortex. Rotation is determined by ensuring that the guide is flush against both condyles posteriorly. If the femoral component of the medial UKA was oversized, an excessive internal rotation of the femoral TKA component can occur. However, if the femoral component of the UKA has been removed, excessive external rotation must be prevented with the posterior augment. Thus, control of the femoral component rotation based on the posterior condyles is more unpredictable than in a primary TKA. When in doubt, the epicondylar axis and Whiteside's line can be used as landmarks.

After the cutting guide is appropriately positioned, it must be taken off to remove the femoral component and then replaced to do the distal and posterior femoral cuts (Fig. 28.12).

Distal Femoral Cuts

The femoral guide is pressed on the native condyle. The distal femoral cut and the chamfers are done as described before (Fig. 28.13a, b).

Filling Bone Defects

If bone loss is moderate (sparing most of the periphery), filling is done with autograft from the bone cuts or with cement (Fig. 28.14). A long keel must be used if the bony support is not strong enough. If bone loss is large or segmental, a metallic augment in association with a long keel should be used (see Chap. 29 on TKA revision). Augments can be posterior, distal, or both:

- Positioning of the trial implants: tibial, femoral, and 9 mm thick insert (Fig. 28.15a–c)
- Ligament balancing

In our experience, PCL resection and use of a posterior-stabilized TKA make the ligament balancing easier. However, increased lateral laxity associated with medial UKA failure can make ligament balancing difficult.

The first release is done during the surgical approach, by sectioning the deep MCL. As described before, medial release can be increased by "pie crusting" the MCL. If needed, a complete release of the distal superficial MCL can be performed. In cases of flexion contracture, release of the semimembranosus tibial insertion is done.

Final Implants

Any impingement between the tibial augment and the MCL must be prevented. Different size and thickness of augments must be available (Fig. 28.16).

The tibial plateau is cemented first. The tibial keel is also cemented. If the tibial keel is long (>75 mm), a polyethylene cement restrictor is inserted in the tibial medullary canal in order to prevent cement extrusion distal in the canal. Excess of cement is removed from around the implant.

The polyethylene is positioned and the knee is hyperflexed to insert the femoral component. It is impacted with the knee in 90° of flexion (Fig. 28.17). A polyethylene cement restrictor is also inserted in the femoral canal if a long femoral keel is used (>75 mm). The knee is extended to compress the cement and the patellar button is cemented (Fig. 28.18).

Lateral UKA Revision

The surgical technique is the same except for the surgical approach and the level of the tibial cut.

Surgical Approach

For lateral UKA revision to a TKA, the skin incision is created by extending the previous scar proximally and distally (Fig. 28.19). In case of multiples scars, the most lateral one is reused. We prefer a lateral approach over a medial one because soft tissue release is easier and some complications may be avoided including skin necrosis, patellar necrosis, and exposure difficultly. A tibial tubercle osteotomy is rarely necessary – only if exposure is difficult (Fig. 28.20).

Preparation of the Tibia

The reference for the bone cut is the native compartment. The cut should be 6 mm below the medial tibial plateau (native). As it is concave, the cut is less than in cases of medial UKA revision (Fig. 28.21). As with medial UKA revision, this cut may be above the lateral compartment after removal of the lateral tibial component. A minimal cut of the lateral compartment can be done parallel to the medial compartment cut. A 4 mm, 8 mm, or 12 mm difference between the lateral and medial tibial plateau will be compensated by the corresponding metallic augment (Figs. 28.22, 28.23, and 28.24). Minimal bone resection is preferred.

Preparation of the Femur

As the posterior femoral condyle is absent (after removal of the implant), one must avoid positioning the femoral cutting guide in internal rotation. The guide is placed on the distal medial femoral condyle and external rotation is assured by placing an augment of the posterior aspect of the lateral femoral condyle. Alternatively, external rotation can be achieved by placing one or more osteotomes between the posterior lateral condyle and the guide (Fig. 28.25). Posterior cuts are done first (Fig. 28.26) and then distal cuts and chamfers (Fig. 28.27).

Ligament Balancing with Trial Implants

Medial laxity associated with lateral UKA failure can lead to difficult ligament balancing. The first release is done during the anterolateral surgical approach where the lateral capsule is released and iliotibial band is released from Gerdy's tubercle (but left in continuity with tibialis anterior muscle fascia). Laxity in flexion and in extension is checked after positioning the trial implants. If medial laxity in extension persists, "pie crusting" of the IT band is done with an 11 blade. To do so, multiple transverse incisions are done.

Final Implants

Cemented implants are positioned and the knee is extended to compress the cement (Fig. 28.28).

Postoperative Care

Postoperative rehabilitation is the same as after primary TKA (see chapter TKA). In case of tibial tubercle osteotomy, flexion is limited at 95° for 45 days. Two knee braces are worn during the first 45 days: one in extension for walking and one at 20° of flexion for rest. A radiograph is done at day 45 to ensure adequate healing of the osteotomy before removing the braces and increasing knee flexion.

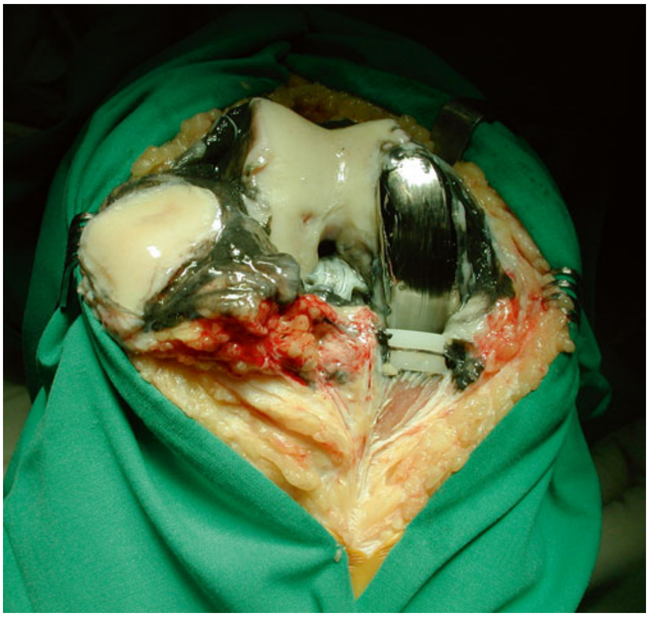


Fig. 28.4 Medial parapatellar approach

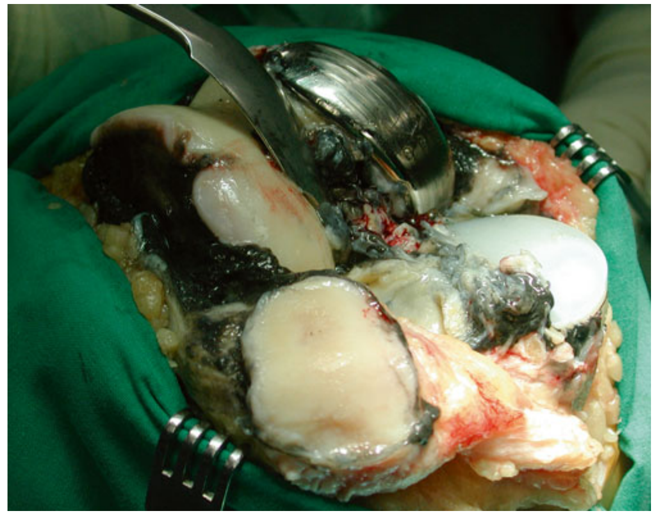


Fig. 28.5 Tibial exposure

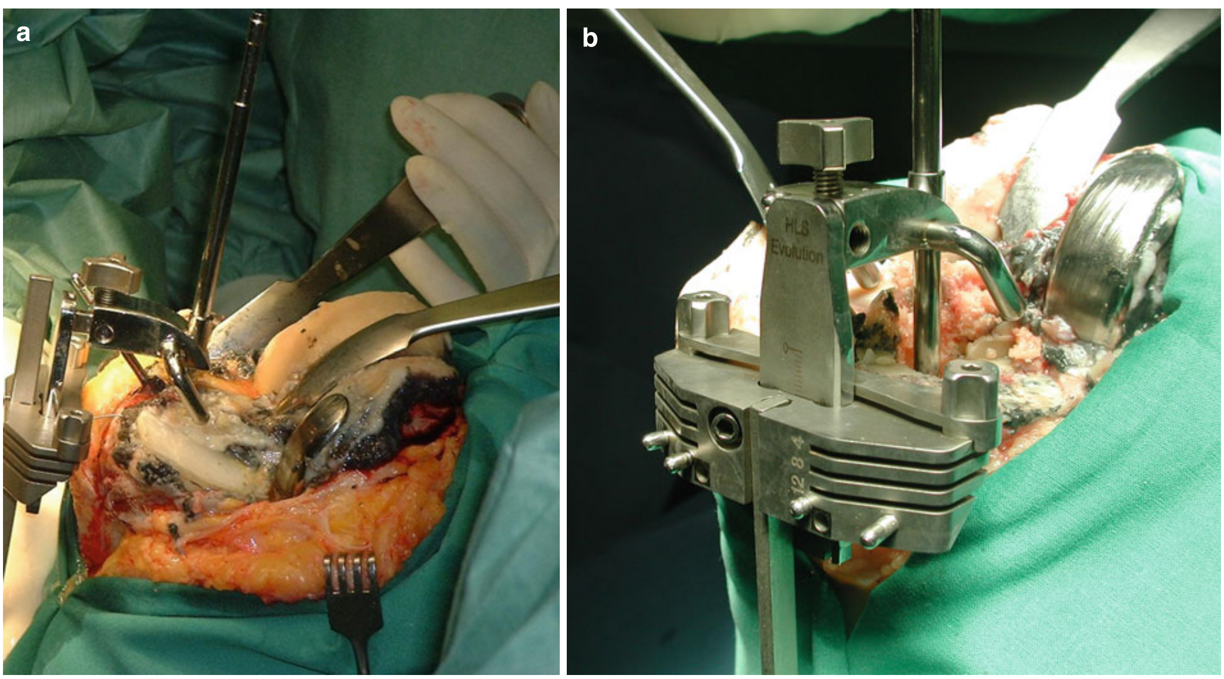


Fig. 28.6 Intramedullary guide introduction (**a**) and fixation of the tibial cutting guide (**b**)

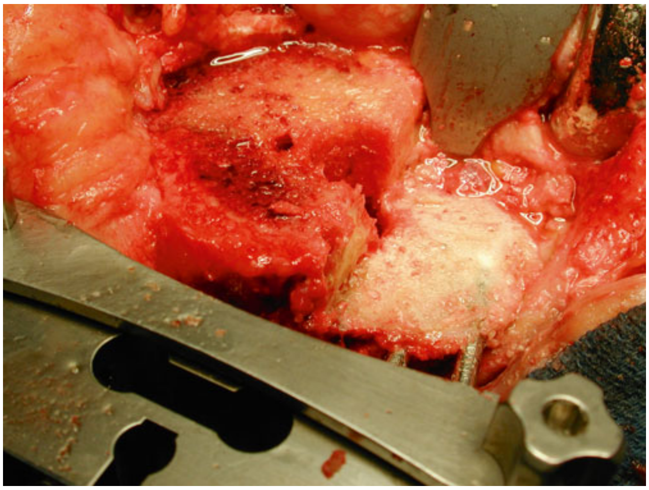


Fig. 28.7 Medial compartment tibial recut (4, 8, or 12 mm)

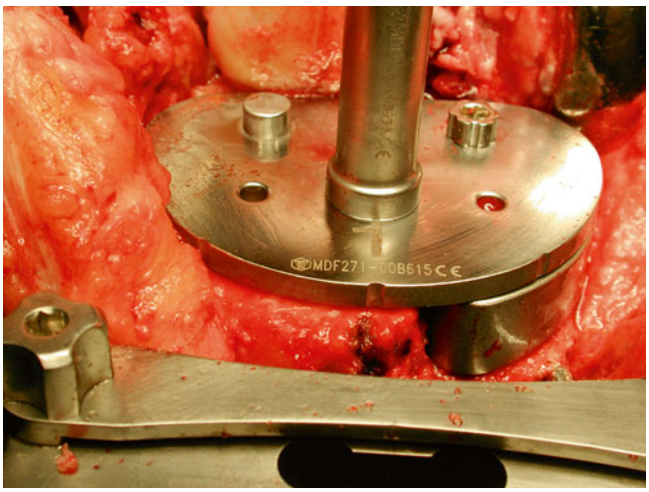


Fig. 28.8 Metal augment filling the medial space

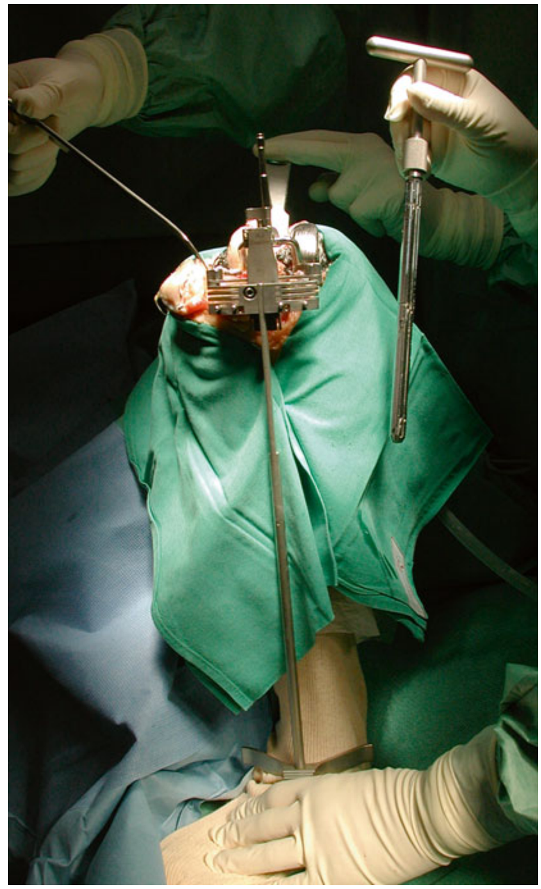


Fig. 28.9 A long tibial keel is used in case of metal augment

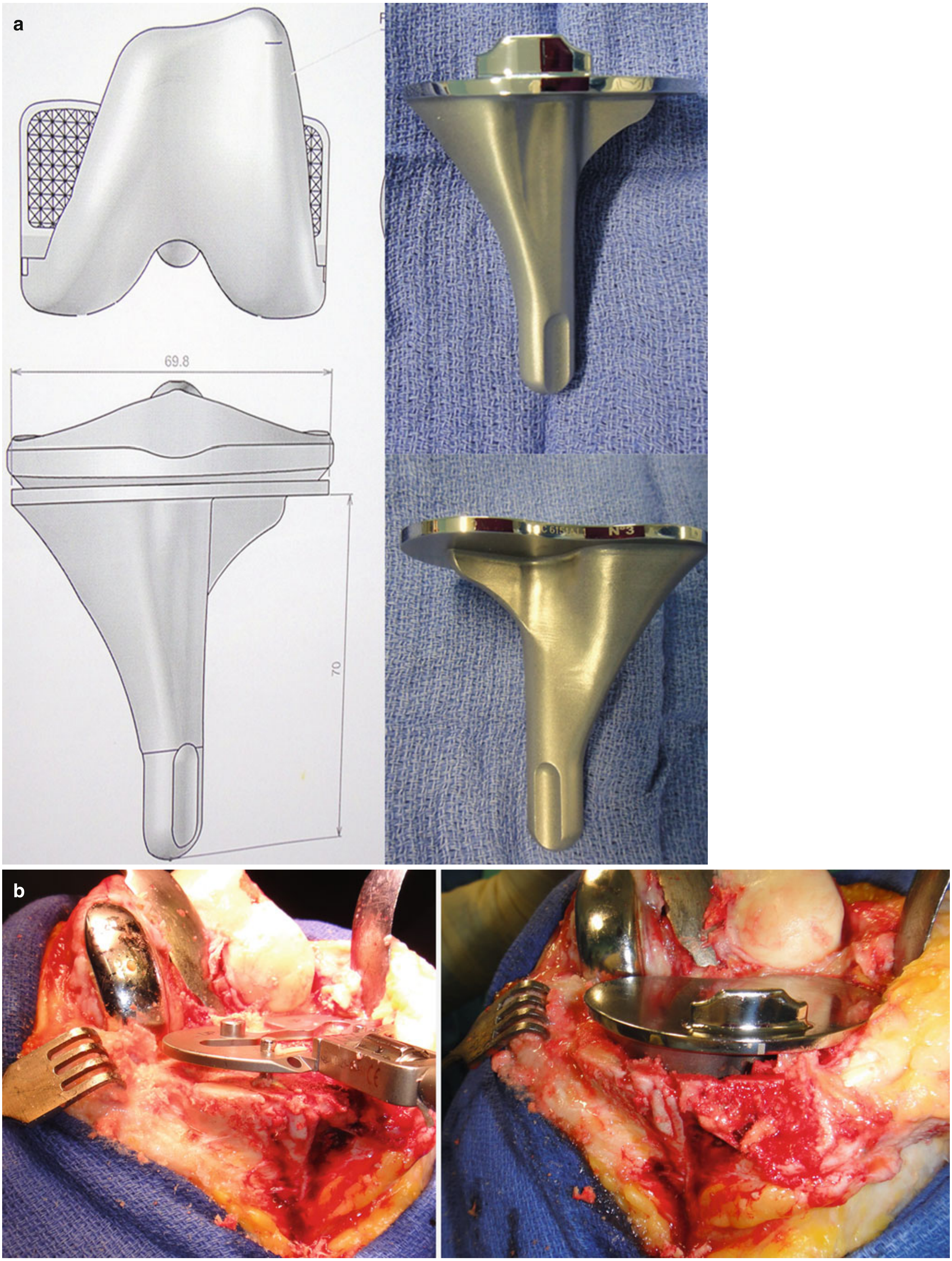


Fig. 28.10 (**a**, **b**) Tuliped tibial keel lies on medial cortical bone

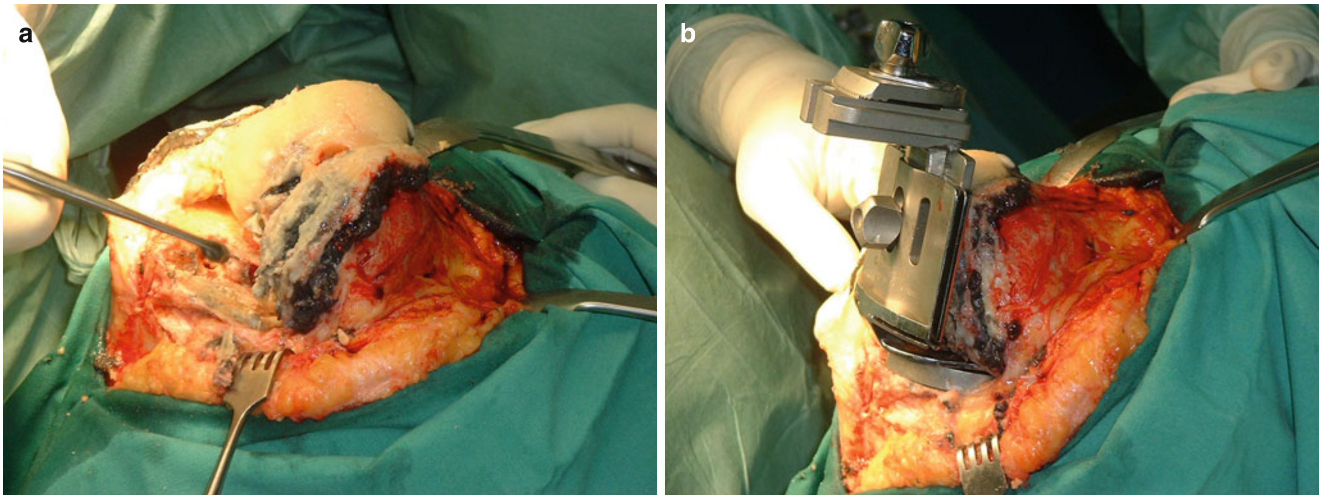


Fig. 28.11 The femoral component is removed (**a**) and the femoral cutting guide is positioned (**b**)

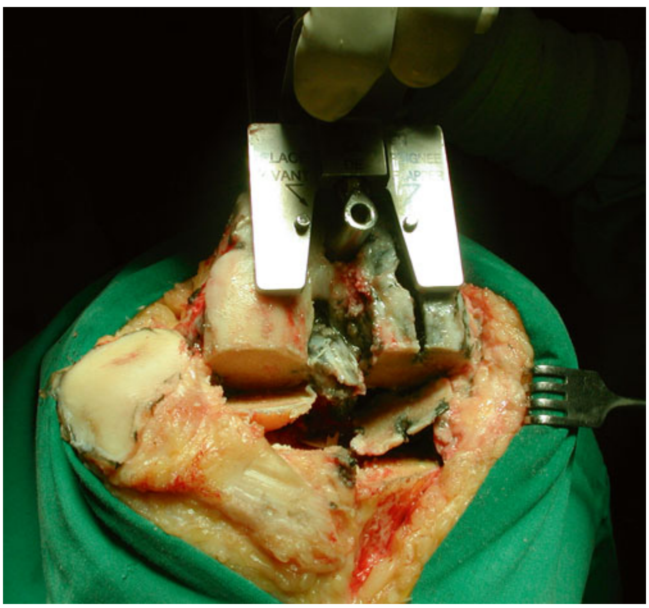


Fig. 28.12 Posterior femoral cut

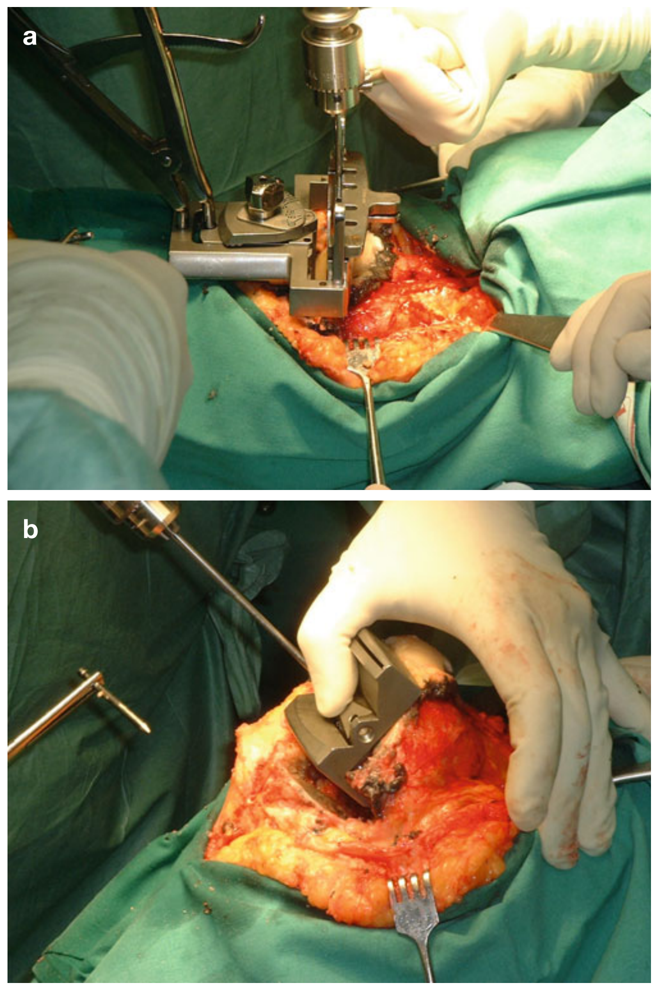


Fig. 28.13 Distal femoral cut (**a**) and then anterior and chamfers (**b**)

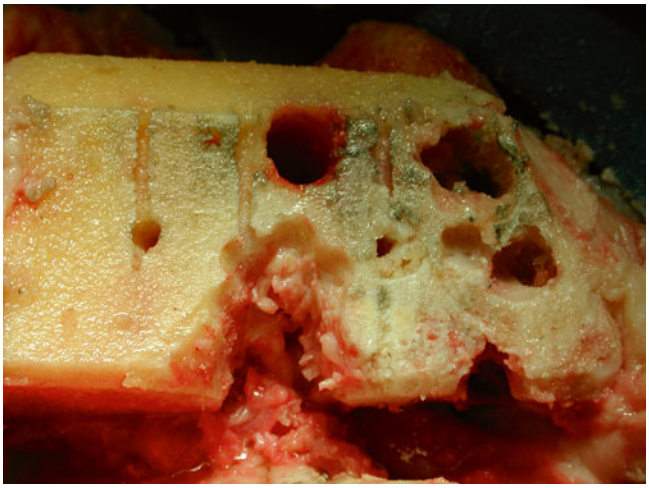


Fig. 28.14 Moderate bone loss

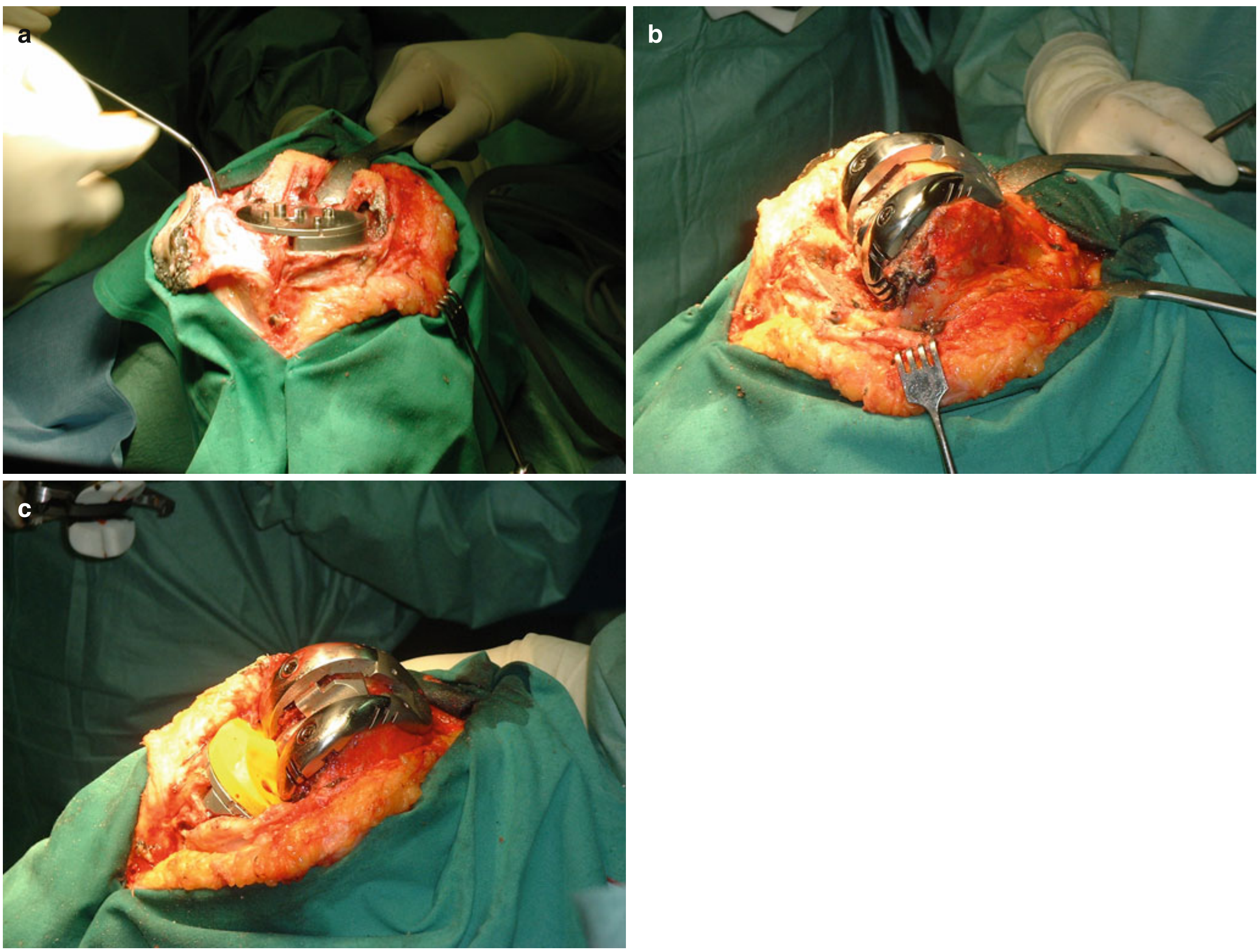


Fig. 28.15 Positioning of the trial implants (**a**) tibial, (**b**) femoral, and (**c**) insert

Fig. 28.16 Medial augments attached to the medial component

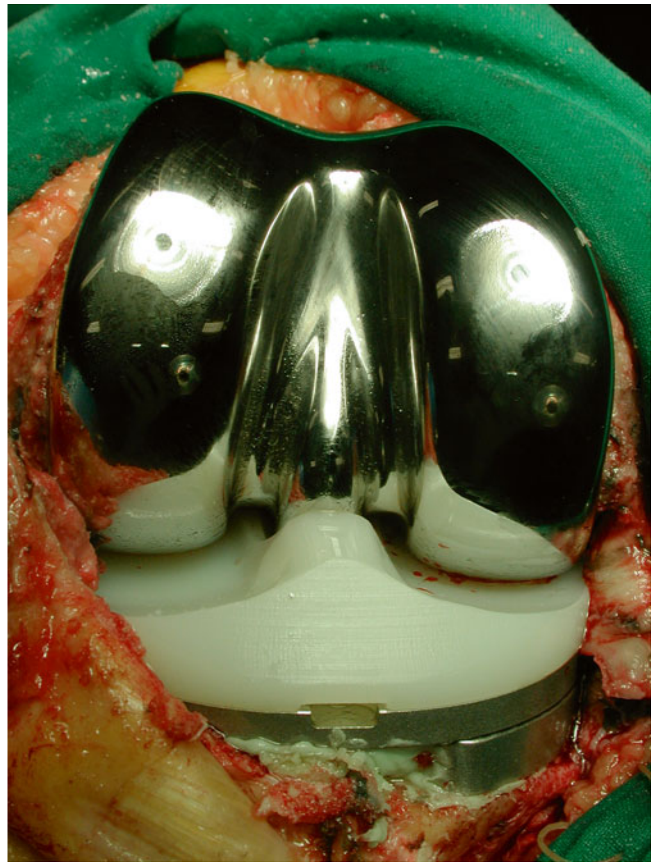


Fig. 28.17 Cemented components

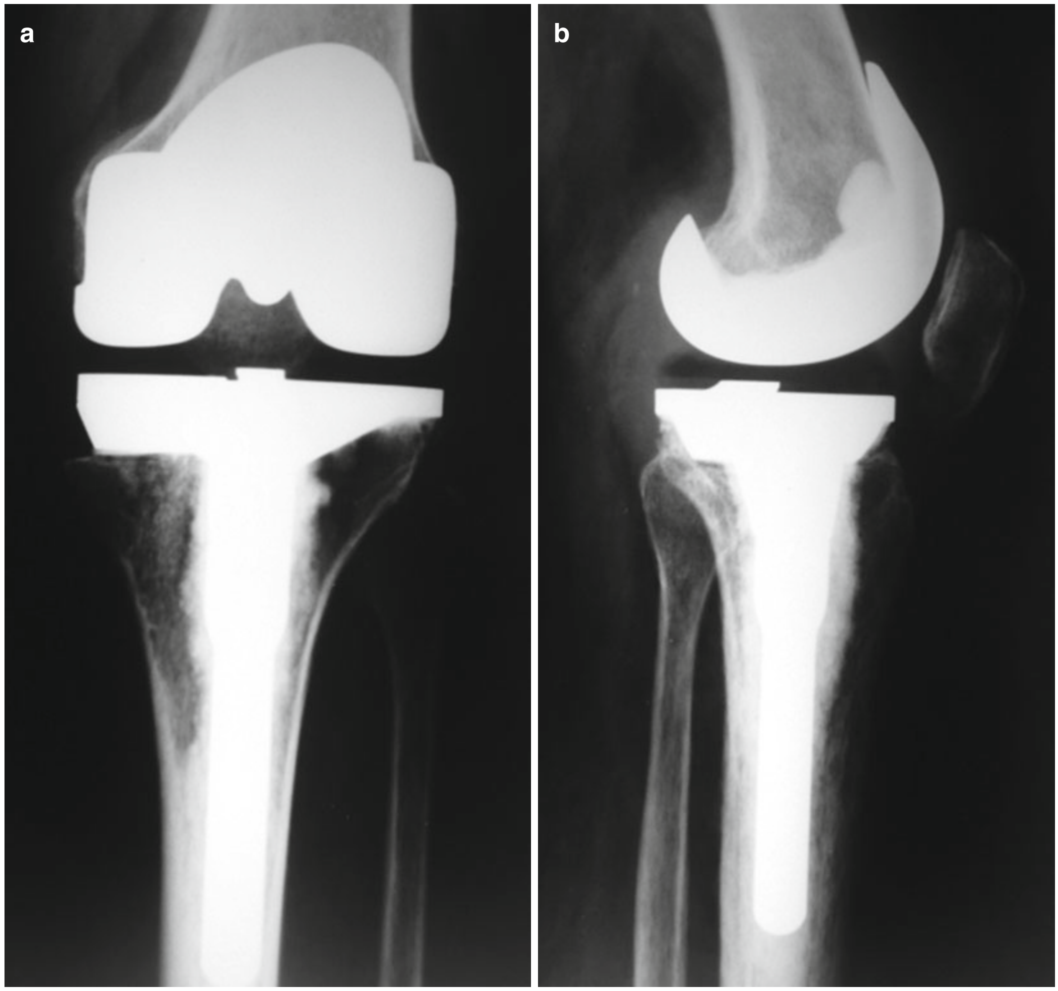


Fig. 28.18 Postoperative X-rays (**a**) AP and (**b**) lateral views

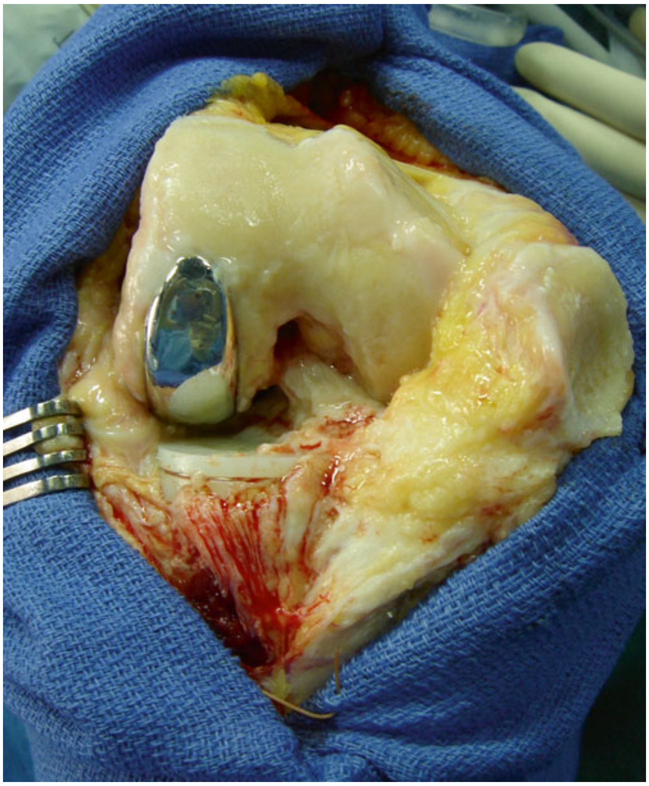


Fig. 28.19 Lateral parapatellar approach

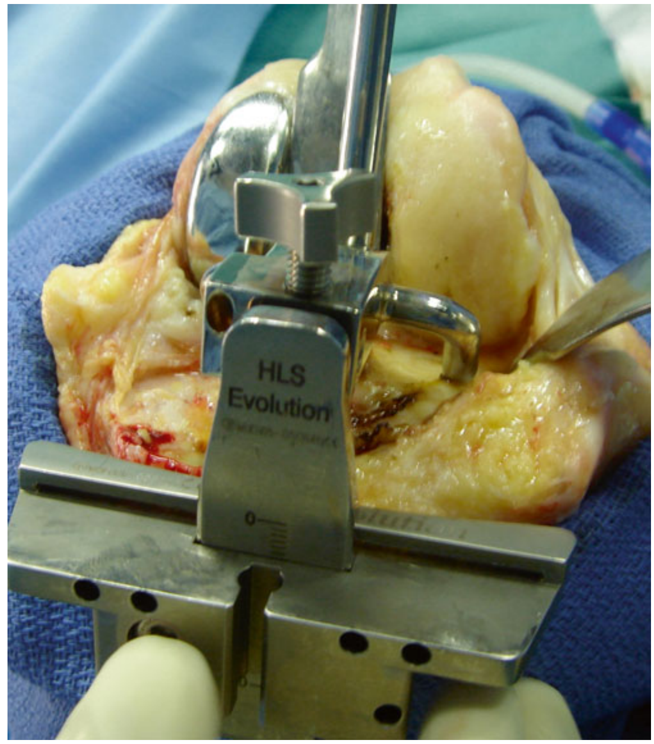


Fig. 28.21 Cutting guide positioning. The cut is 6 mm below the medial tibial plateau

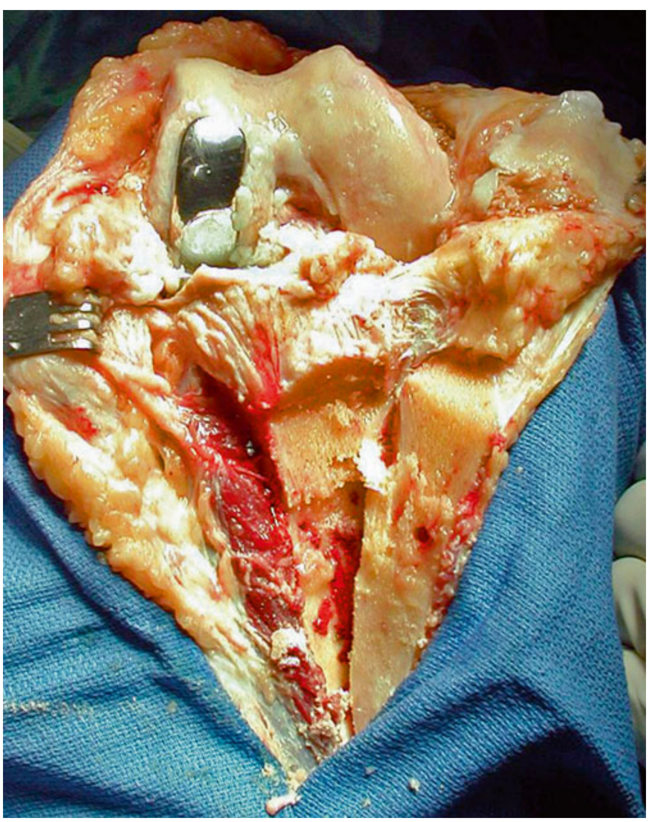


Fig. 28.20 Tibial tubercle osteotomy in case of difficult exposure

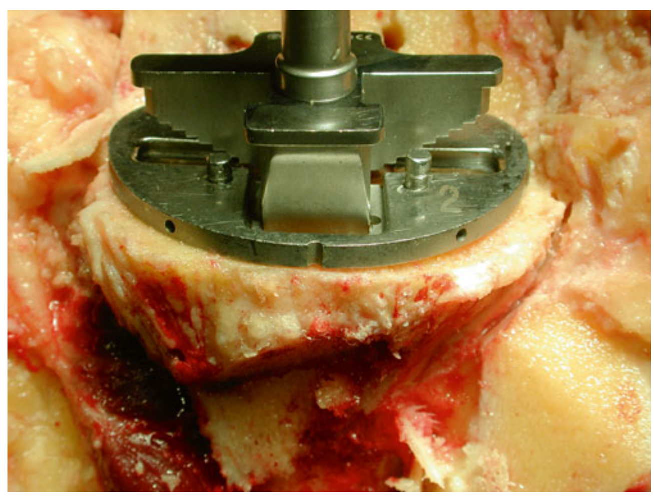
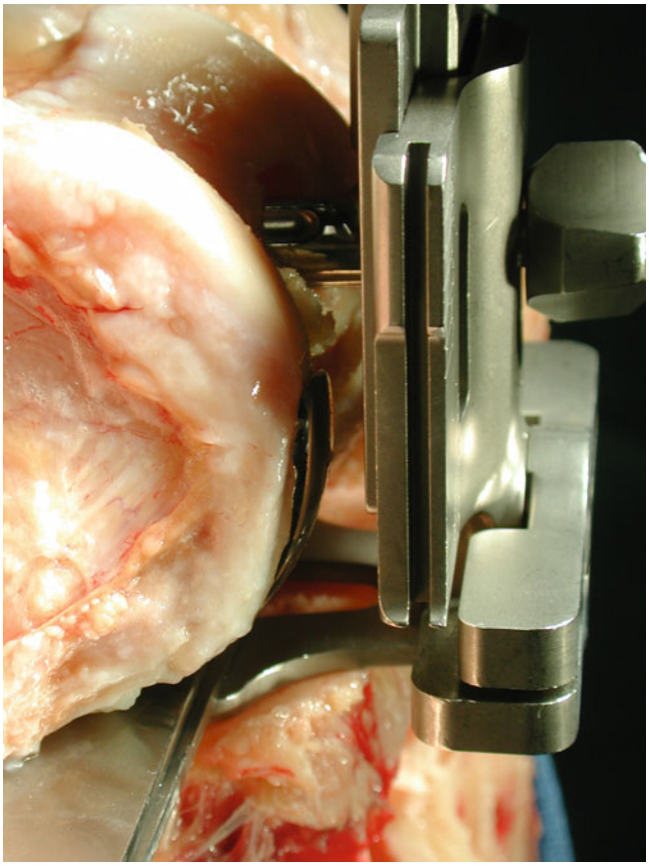
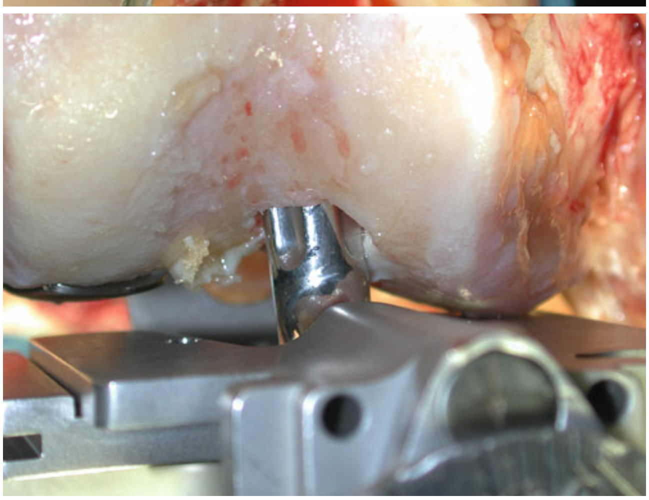


Fig. 28.22 Case of 8 mm cut below the medial tibial plateau. The tibial surface is now flat and augments are not required





Figs. 28.23 and 28.24 Femoral guide positioning: the contact is obtained between the guide and medial condyle

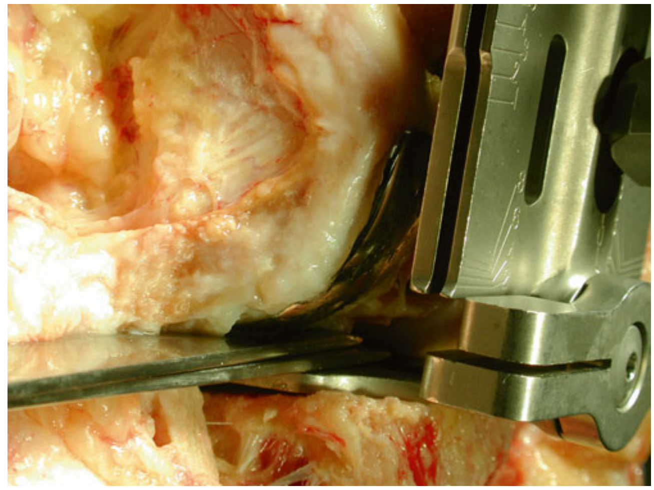


Fig. 28.25 External rotation achieved by placing one or more osteotomes between the posterior lateral condyle and the guide

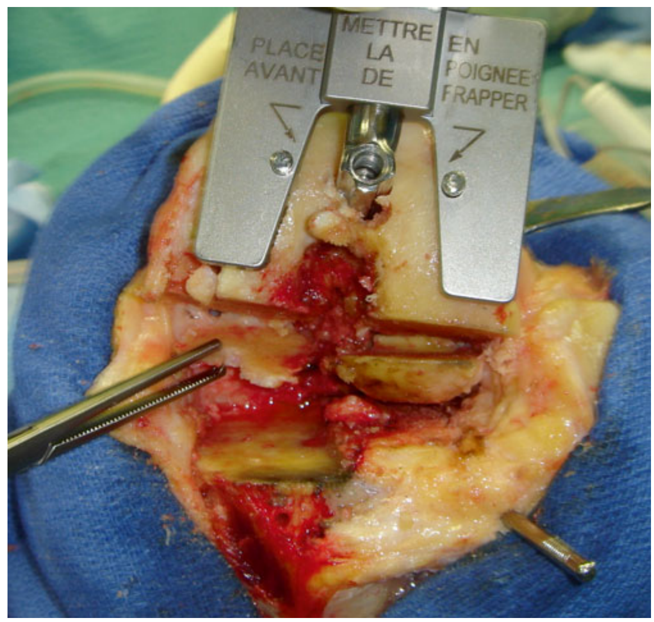


Fig. 28.26 Posterior cuts

Fig. 28.27 Distal femoral cut

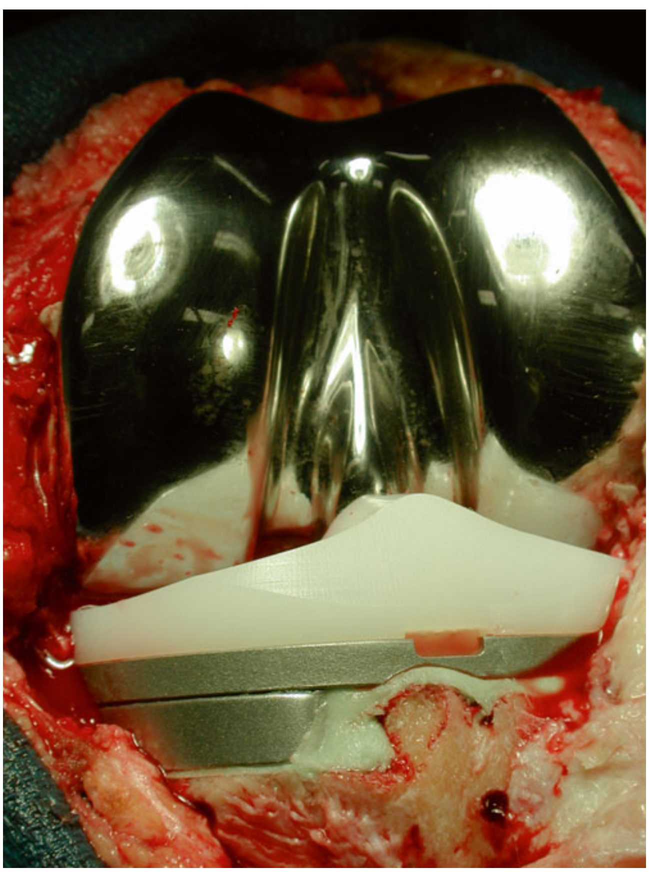


Fig. 28.28 Cemented implants

Arthroscopy and Unicompartmental Knee Arthroplasty

In case of unexplained pain after UKA, arthroscopy is a useful diagnostic and therapeutic tool. It helps diagnosis of:

- Meniscal lesions of the opposite compartment
- Impingement between the femoral implant and anterior tibial spine or patella
- Arthritis of native patellofemoral or tibiofemoral compartments (Fig. 28.29)
- Pain due to neo-meniscal formation
- Metallosis
- Integrity of the polyethylene

It also allows removal of extruded cement, fibrous scars, meniscal tissue (residual or neo-meniscus) (Figs. 28.30 and 28.31), or hypertrophic synovitis. Flexion and extension kinematics are also checked.

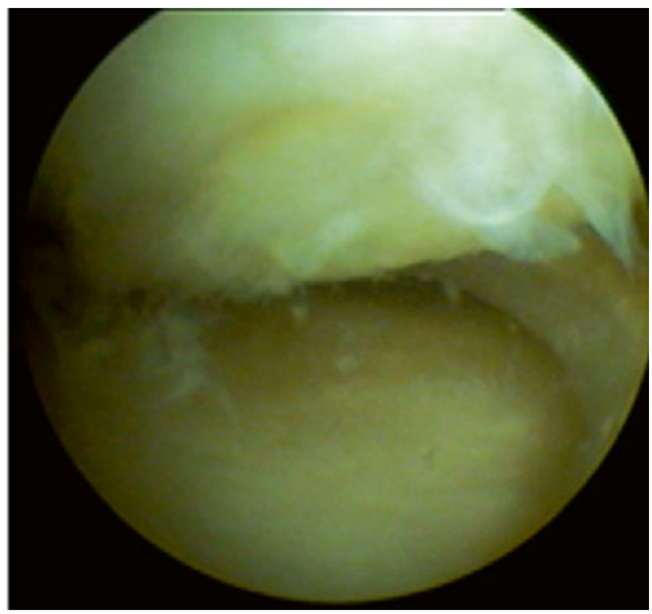


Fig. 28.29 Degenerative lesions of the contralateral compartment (arthroscopic view)

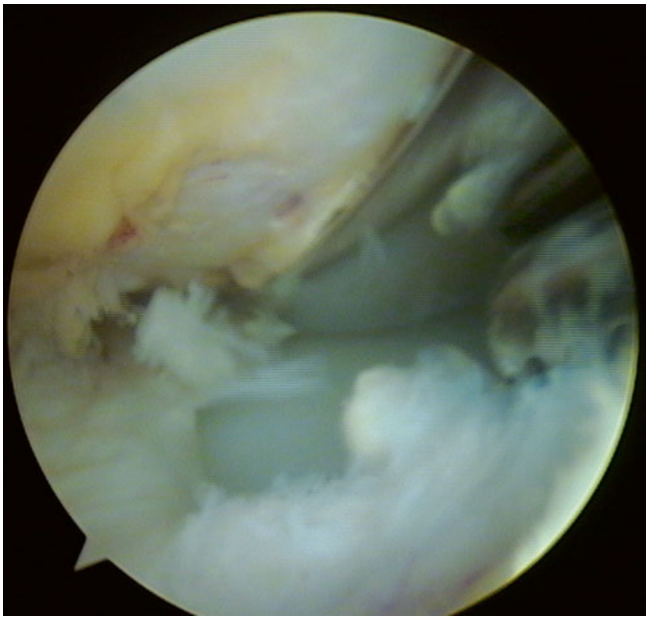


Fig. 28.30 Neo-meniscus (arthroscopic view)

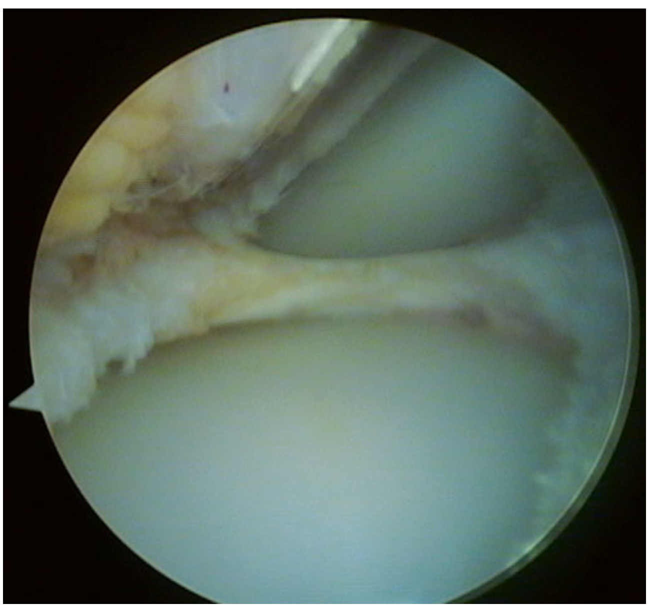


Fig. 28.31 Resection of the neo-meniscus (arthroscopic view)

Technique

The technique has been described in the chapter on Arthroscopy. Portal should be created carefully to prevent damaging the femoral component. Patellofemoral compartment exploration is done first to look for cartilaginous lesions, synovial hyperplasia, or impingement between the femoral component and patella. Care must be taken not to damage the tibiofemoral components with the arthroscope or the instruments.

The second step is exploration of the notch, with 90° of knee flexion. The ACL is palpated, and if Hoffa's fat pad is hypertrophied, it can be partially excised. The medial and lateral tibiofemoral compartments are explored by positioning the knee in valgus and then in the "figure of four" position.

Wear or metallosis may be present. Metallosis is very difficult to diagnose: indirect signs are synovial hypertrophy and polyethylene wear. It is very rare to see black synovium or synovial fluid. Component fixation and excess cement are checked. Loosening is sometimes obvious. However, it is difficult to know by palpation what moves: the implant alone (loosening) or the implant plus whole bone segment to which it is fixed. Anterior fibrosis is excised in order to check for any micromotion at the bone-implant tibial junction.

A contralateral meniscal lesion or meniscal proliferation (neo-meniscus previously described after total meniscectomy) can be excised. Care must be taken not to damage the polyethylene with the shaver. Postoperative care includes full weight bearing and early mobilization.

Revision of Unicompartmental Knee Arthroplasty to a Second Unicompartmental Knee Arthroplasty

Replacement of one of the two components only can be done in case of obvious malpositioning (Fig. 28.32) or oversized components creating joint pain (Fig. 28.33). However, the literature suggests a high rate or poor outcomes from such procedures and the patient should be informed of the risk of persistent pain.

Fig. 28.32 Malpositioning of the femoral component in varus

Fig. 28.33 Tibial component overhang

Technique

The initial surgical approach is reused. Biopsies are done to rule out infection. Look for wear or metallosis signs. The malpositioned implant is removed with an osteotome (Fig. 28.34), minimizing bone loss. Correction of malpositioning may require technical tricks such as the use of screw or augments (Figs. 28.35, 28.36, and 28.37). A TKA (with an augment and long keel) must be available in the operating room and the patient must be informed that revision may require a TKA.

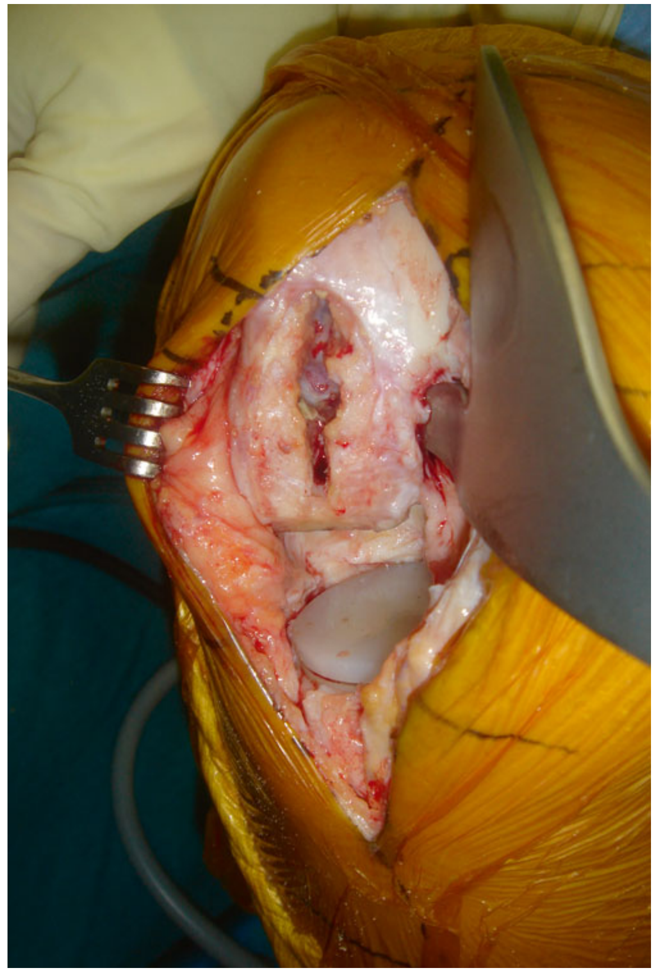
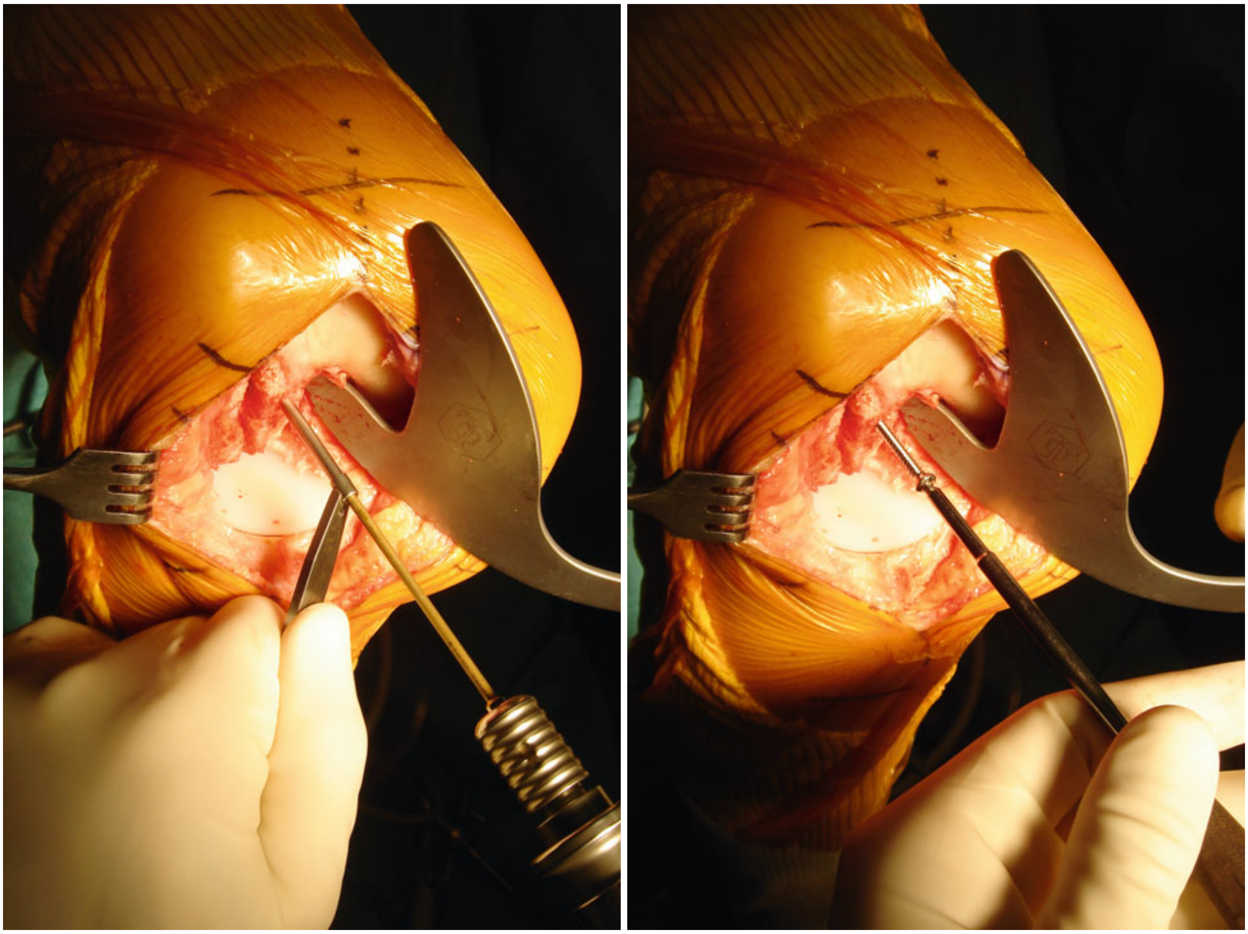


Fig. 28.34 Removal of the malpositioned implant with minimal bone loss



Figs. 28.35 and 28.36 Use of screw to correct the malpositioning (technical tricks)

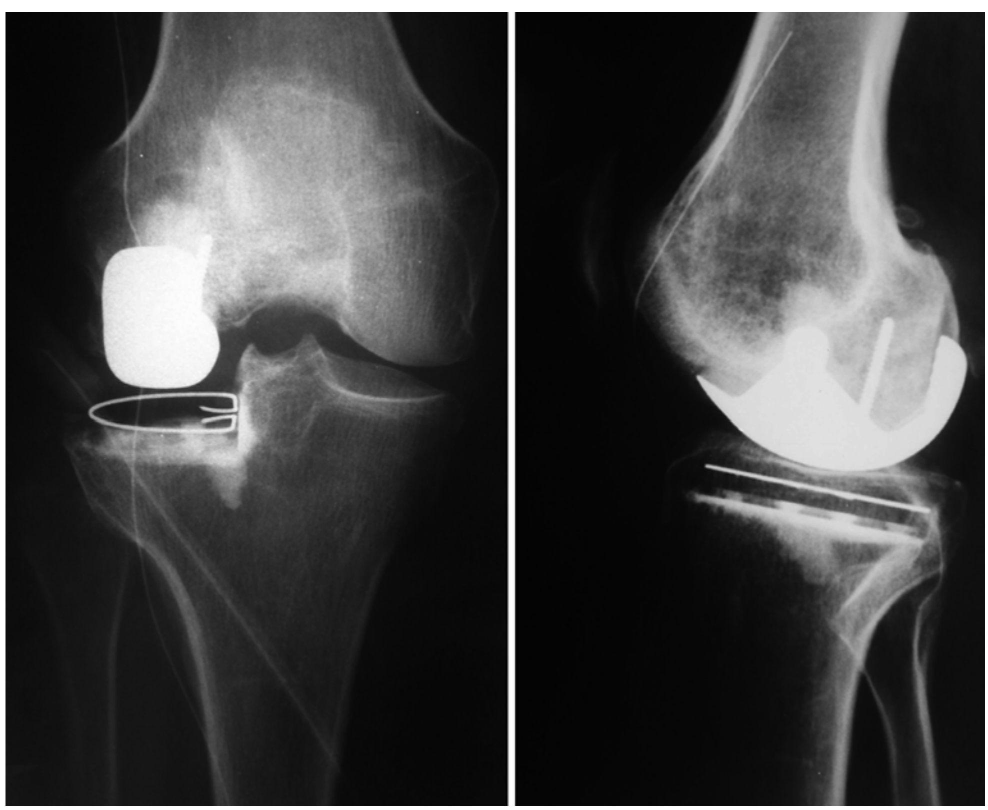


Fig. 28.37 Postoperative X-rays (see case Fig. 28.32)

Revision Total Knee Arthroplasty: Planning and Technical Considerations

29

S. Lustig and Robert A. Magnussen

Planning

Preoperative planning is essential and must include understanding the cause of failure of the first arthroplasty.

Screening for Infection

The search for possible infection is necessary with laboratory tests (white blood cell count, ESR, CRP), joint aspiration, bone scan (possibly supplemented by scintigraphy with labeled neutrophils), radiographic evaluation, and clinical history (local swelling, pain, or symptoms in the joint contemporaneous with an infection in a different location).

Evaluation of Bone Loss (Radiographic ± Contralateral, CT Scan)

Plain radiographs are not always an accurate assessment of bone loss. We obtain a CT scan when preoperative metallosis is suspected in order to better objectify the bone loss that is often more significant than is seen on plain radiographs.

Assessing the Size of the Implants (Contralateral Side)

Knowing the size of the implants previously used from operative reports or through the use of templates is critical. Templates can be used to size the contralateral knee as well as to provide insight into whether the implants are appropriately sized.

Need for Custom Implants and/or Specific Hardware in Order to Remove the Implants

Need for custom implants (keels with offset):

It is important to know the type of implant in order to provide the specific ancillary equipment for removal when needed. This is particularly true in cases of hinge prostheses, which require knowledge of the mechanism in order to separate the femorotibial implants.

Evaluation of the Collateral Ligaments (Stress Radiographs)

This step is essential. AP stress radiographs are performed routinely to assess the state of collateral ligaments. Excessive laxity (especially due to impairment of medial collateral ligament) requires the use of a constrained prosthesis for the revision. In the event of mechanical failure of a hinge prosthesis, these views can also show a frontal plane mobility, which is always abnormal for such implants.

Assessment of the Joint Line

An AP full leg length weight-bearing radiograph (showing both lower limbs in full) is required. One can thus measure the level of the contralateral femorotibial joint line (ratio between length of the total lower limb and femoral length) and compare the joint line with the operated knee. We can also use initial radiographs (when available) prior to the first prosthesis in order to assess joint line modification relative to the initial joint line. The analysis is unreliable in case of flexion contracture.

S. Lustig, MD, PhD (✉)
Albert Trillat Center, Croix Rousse Hospital,
103 grande rue de la Croix Rousse, Lyon 69004, France
e-mail: sebastien.lustig@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and Performance Institute, The Ohio State University,,
Suite 3100, 2050 Kenny road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_29, © Springer-Verlag London 2014

Choice of Constraint

Use of an unconstrained prosthesis (posterior stabilized (which we favor), "deep dish," or PCL retaining) is determined by the quality of the collateral ligaments. This choice will then depend on several anatomical factors, but must also take into account the age and motivations of patients. Too much varus/valgus laxity or impossibility to obtain a balance between flexion and extension gaps requires the use of a prosthesis with more constraint. Collateral laxity (evaluated before surgery or anticipated due to the reoperation) is for us the main element that raises the question of whether a rotating hinge prosthesis is needed.

Items that can lead us to consider a hinge prosthesis as a first choice are:

- Major preoperative stiffness because it may require a significant release of the collateral ligaments
- A significant frontal laxity or recurvatum, including that is associated with neurological disease
- Cases in which distraction in order to compensate for laxity would induce a significant change in the joint line and patella baja
- The revision of a hinge prosthesis

  We also prefer to use a rotating hinge for very elderly patients.

We must anticipate these needs before the surgery, and each time doubt exists we must be able to use a more constrained prosthesis. In all cases, we recommend that surgeons less experienced in this surgery have a more constrained prosthesis in the operative room before starting the revision surgery.

Choice of the Modularity

It is necessary to have a modular implant, that is to say, longer stems and tibial and femoral augments. Often, appropriate templating can anticipate needs. However, removal of the implants can lead to defects larger than those initially present. We draw attention to the fact that the bone defects are systematically underestimated in cases of metallosis. We should keep this idea in mind and know when to order a CT scan that can give more details as to the extent of lesions.

Technical Principles

In order to make it easier to understand, we will describe the surgical technique in two parts: the phase of explantation and the phase of implantation of the new components. However, although these two sequences follow one another chronologically, with respect to a "functional" surgery, one cannot conceive one without thinking of the other. However, in case of revision for infection, one dissociates these two phases more formally.

Explantation

Setup

Setup does not differ from that used for a primary TKA. The patient is placed supine with a tourniquet at the top of the thigh. A distal wedge keeps the knee to 90° of flexion during the procedure. Once antisepsis preparation is done, a jersey and a sterile field are set.

Surgical Approach and Exposure

Prior incisions are marked with a marking pen as is the planned incision for the revision procedure. The skin incision used for the first prosthesis is generally reused and is often enlarged on both ends. If there are multiple prior incisions, the most lateral is used.

We will describe the first approach with a medial arthrotomy; however, the technique with a lateral arthrotomy is quite similar. No subcutaneous undermining should be undertaken before opening the superficial fascia. When this subfascial plane is reached, the dissection can be continued without any risk. One releases the anterior surface of the patella but should not continue laterally beyond than the lateral edge of the patella. One must locate the quadriceps tendon and the medial edge of the patellar tendon.

A medial arthrotomy is performed using a 23 blade. It begins with the longitudinal opening of the quadriceps tendon on its medial border (sometimes difficult to identify), leaving a thin strip of tendon next to the vastus medialis muscle, which will allow a solid closure.

The arthrotomy continues adjacent to the patella and along the patellar tendon to its insertion at the superomedial edge of the anterior tibial tuberosity. The medial capsule is then released directly off of the bone on the anteromedial surface of the tibial plateau. This is a triangular-shaped release of the medial capsule.

The deep fibers of the MCL are released with a Trillat elevator to the top edge of the tibial implant along the joint line.

The knee is placed in extension and the extensor mechanism is dislocated laterally by everting the patella with a retractor (Fig. 29.1). This maneuver can sometimes be tricky, so care must be taken to release adhesions in the infrapatellar region and condylar recesses. Superiorly, the synovium abutting the anterior aspect of the femur is widely resected in order to expose the area above the trochlea of the prosthesis.

The Hoffa's fat pad, if it had been preserved during the previous surgery, may also be resected.

One rarely needs to section of the lateral retinaculum to facilitate eversion of the patella. The knee is then flexed with the patella everted. This part of the procedure time can be dangerous. Care must be taken not to avulse the insertion of the patellar tendon. We sometimes use a technical trick described above, which is to put a pin in the insertion of the patellar tendon on the tibial tuberosity (Fig. 29.2).

If the stiffness is significant (<70° of flexion) or if the patella is very low, one must sometimes perform an osteotomy of the anterior tibial tuberosity early in the procedure. We usually prefer to perform a quadriceps snip (oblique section superiorly and laterally). If we are unable to expose the knee by retraction of the extensor mechanism, an osteotomy of the tibial tuberosity may be necessary. We perform it from lateral to medial, the knee at 90° of flexion, with an oscillating saw (ideally with an osteotome) over a minimum length of 6 cm, leaving it pedicled muscle on the anterolateral musculature and fascia. The osteotomy is completed by releasing the top of the tibial tuberosity behind the patellar tendon in extension with a Lambotte osteotome.

Synovial Biopsies

Biopsies are always performed to rule out infection. This screening includes a frozen histologic section to quantify neutrophils as well as bacterial cultures. More than ten neutrophils per high-power field are suggestive of infection.

Tracking the Level of the Joint Line (Implants in Place)

The level of the prosthesis is recorded on both the femur and the tibia. One can use specific devices for this step or simply mark the femur and tibia a set distance from the prior joint line (generally between 6 and 10 cm) (Figs. 29.3 and 29.4). One can then quantify any change in joint line location caused by changing implants.

Implant Removal

Removal of the polyethylene is the first step (Fig. 29.5). It is opened with a twist with a Lambotte and then removed with a Kocher with the knee flexed to 90°. Sometimes it is necessary to extend the leg in order to get more space and facilitate the extraction. We note the degree of wear and location of such wear.

One then focuses on the femoral implant. The bone-implant interface is detached gradually with a Lambotte osteotome if it is not loose (Fig. 29.6). We can use osteotomes of different widths. It should not be elevated with the osteotomes as this technique would impact the bone. The Gigli saw, preferred by some to free the anterior part of the femoral component, is not easy to use in our experience. The femoral component is then removed from the femur using a Kocher (Fig. 29.7).

The tibia is then exposed with two retractors, one behind the tibia to dislocate the tibia forward and a second laterally on the tibial plateau, retracting the everted patella. Removal of the tibial implant is sometimes difficult. The tendon patella may impede the passage of the Lambotte osteotome under the lateral portion of the tibial implant.

To reduce the impaction of the tibia, it is possible to insert a second Lambotte blade between the base metal and the first blade and then repeat the same exercise, alternating from the medial to the lateral side (Fig. 29.8). If an all-polyethylene tibial component is present, one can sometimes use a saw for removal.

Removal of cemented implants requires time and patience. Removal of the tibial cement should be performed with the Lambotte osteotome. One can crack in the cement into pieces that can be removed more easily. The cement plug is then removed with forceps easily. If a cemented prosthesis with long stem is present, it is sometimes necessary to puncture the cement cap distally and then flexible reamers of increasing size to gradually remove the cement. A cortical window is used as a last resort.

When removing cementless implants, one must be cautious, methodical, and patient because there is a risk of removing a significant amount of bone attached to the implants during the extraction of the prosthesis. Working with the osteotome, one seeks to free the bone surface from the implants as much as possible before attempting their removal.

In all cases, it is worth taking the time to observe the implants and note any particular wear of polyethylene. These observations can provide insights into reasons for implant failure and should be included in the operative report.

Patellar Button

The removal of the patellar button is not always necessary as it can weaken the patella or lead to an excessive thinning (less than 12 mm) thereof. We must therefore take into account the presence of a wear or loosening, either of which may impose the need to change the patellar component. Other factors can influence the decision, including the shape of the prior patellar implant (domed, policeman hat, etc.) and its congruence with the future trochlea.

The decision is sometimes and "better" is sometimes the enemy of "good." One should leave the original button in place when the situation is acceptable and infection absent. When deciding on removal, one should know that it is difficult to remove metal-backed implants. We seek to use thin, narrow osteotomes, but fracture of the patella is always a risk. We can try to create a plane of detachment by sliding a thin saw blade behind the metal component and complete the separation using a thin Lambotte osteotome. Removal is much simpler when the patellar button is all-polyethylene. A saw is used to remove the implant. The remaining pegs are removed with a drill. A small drill (2.7 mm) is placed in the middle of each peg and drilled. The plug comes out sometimes or is just weakened, in which cases it is necessary to use a very small curette in the channel formed by the drill bit to remove the remaining polyethylene of the peg.

Cleaning (Cement, Granuloma)

All remaining cement must be carefully removed at this time along with all soft tissue adherent to areas of the femur to which the new implant will be applied. One must take special care to clean the posterior aspect of the femoral condyles. Maximally flexing the knee and pulling the femur forward facilitate this cleaning. A good assessment of bone loss can only be performed after this cleaning is completed.

Principles of Reconstruction

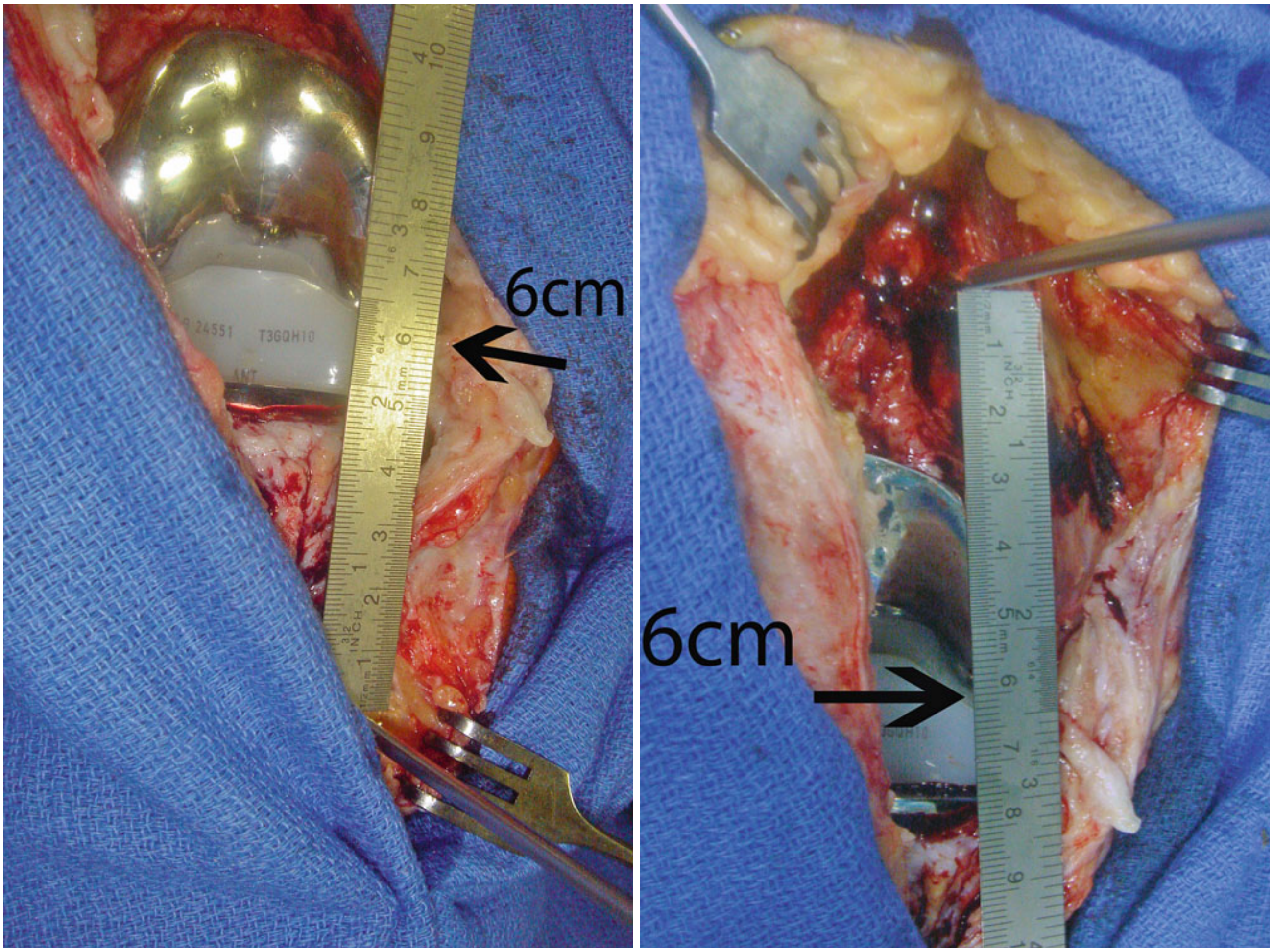
Once implants are removed, the key concerns are addressing bony defects and ensuring correct alignment of the new implants.

Two approaches exist:

- The use of intramedullary rods to establish the mechanical axes and fix the cutting guides. The components are then placed on these rods.
- Reconstruction of the joint surfaces first (with intra- or extramedullary guides) and the use then of intramedullary rods to improve fixation. This second option has been our preference.

Fig. 29.1 Medial parapatellar arthrotomy and lateral dislocation of the patella

Fig. 29.2 The use of pin (*arrow*) to secure the distal insertion of patellar tendon



Figs. 29.3 and 29.4 Tracking the level of the joint line: two 3.2 mm holes are drilled on the tibia (Fig. 29.3) and femur (Fig. 29.4)

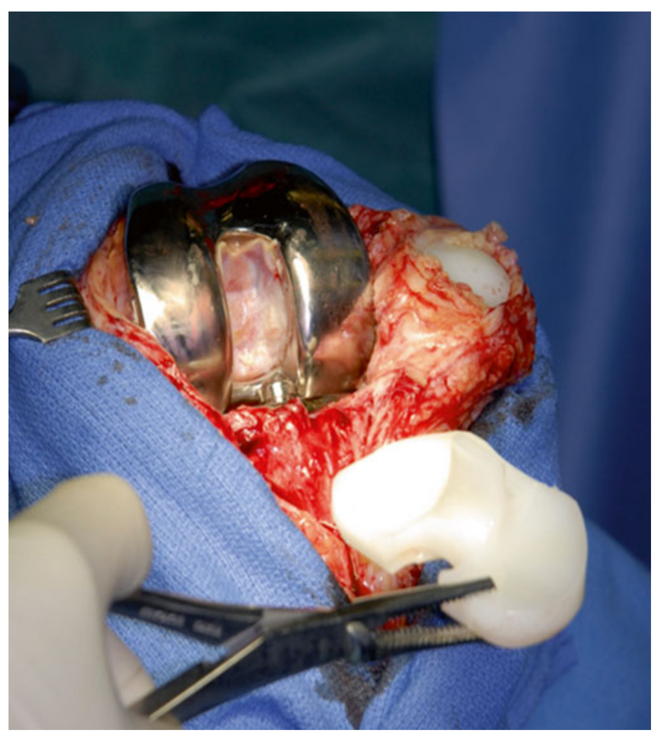


Fig. 29.5 Removal of the polyethylene

Fig. 29.6 The bone-implant interface is detached with a Lambotte osteotome

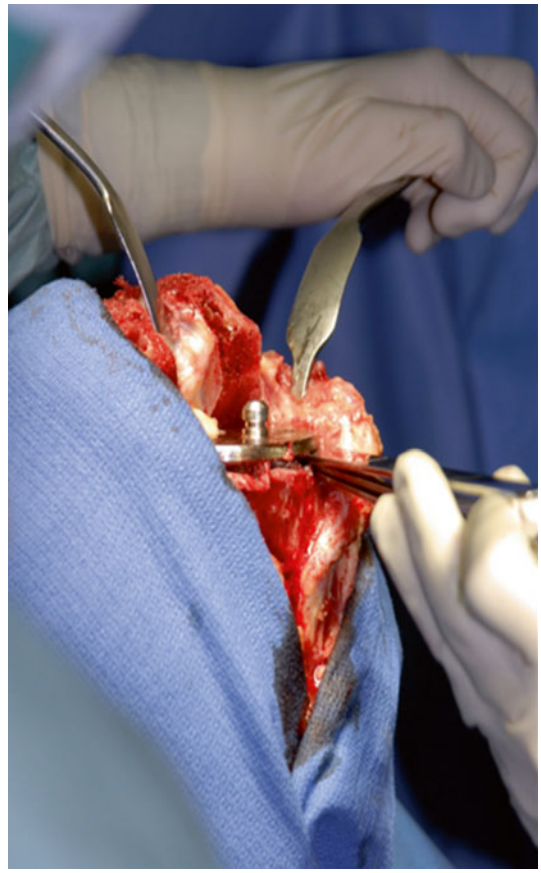


Fig. 29.8 Removal of the tibial component

Fig. 29.7 Removal of the femoral component

Reconstruction of the Tibia

We first reconstruct the tibial side (concept introduced by B. Mandhuit). A cut to ensure a clean tibial plateau is carried out first using a specific tibial guide (Fig. 29.9). An intramedullary guide sets the slope at 0° and an extramedullary guide sets the mechanical axis at 90° in the frontal plane. We fix the cutting guide with pins after making predrilled holes. A minimal resection (1 mm may be sufficient) provides a regular bone surface (Fig. 29.10). In case of significant medial or lateral segmental defect, the tibial cutting guide allows a lateral or medial cuts of 4, 8, or 12 mm from the initial cut. Removing the cutting guide, the size of the plateau is evaluated using trial implants of increasing size. Metal augment trials of 4, 8, or 12 mm thick can also be placed on the trial tray if necessary. The heights of the wedges and polyethylene are already estimated, taking into account the new length for the tibial implant obtained by measuring the new distance between tibial drill hole and tibial implant.

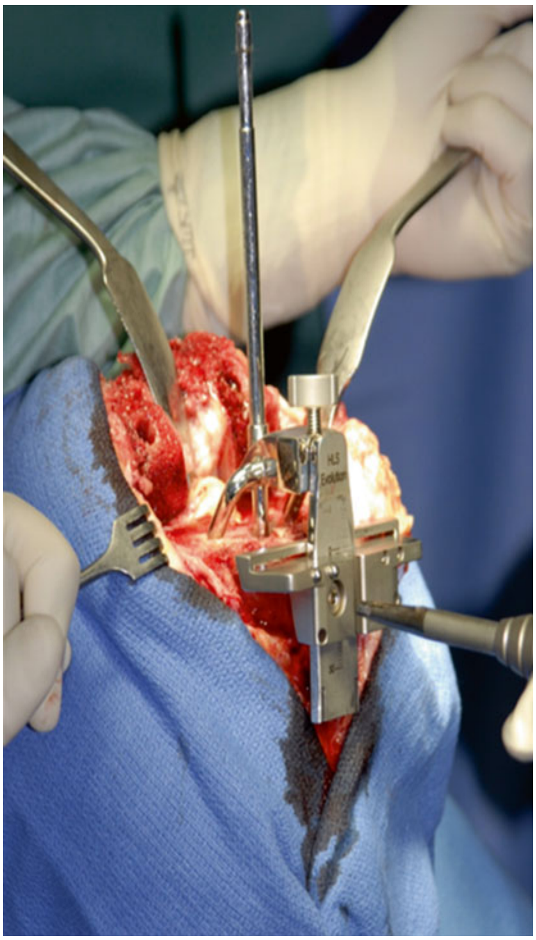


Fig. 29.9 Tibial cutting guide fixation

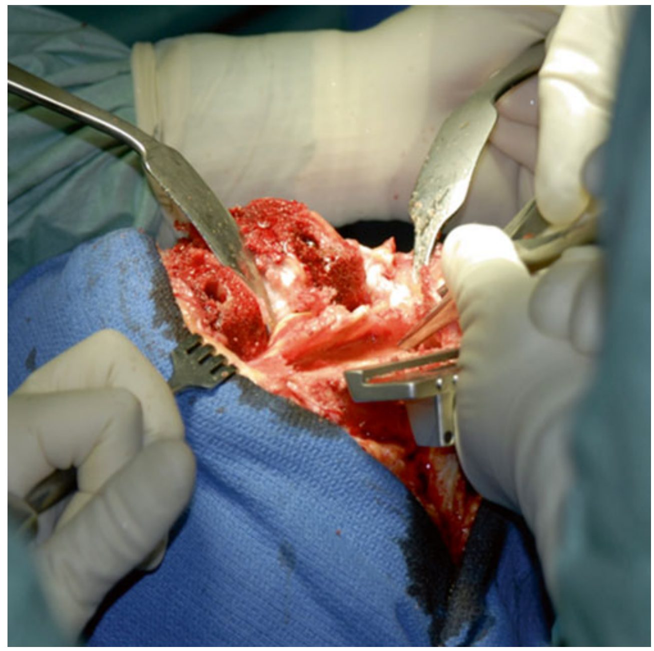


Fig. 29.10 Minimal resection to obtain a regular bone surface

Reconstruction of the Femur

A femoral component trial (specific to the revision of prosthesis) is then placed (Fig. 29.11). Its size is determined by integrating:

- The size of the previous implant
- The templates placed on radiographs of the contralateral knee or index knee before the first prosthetic implantation
- The size of the tibia (to avoid a mismatched femur and tibia) (Fig. 29.12)
- The mediolateral size of the femur
- The anteroposterior dimension of the femur

The femoral mechanical axis is measured by placing an intramedullary guide set with 7° of valgus. A trial femoral component is then placed, ensuring that it contacts the mediolateral condyles equally (it is also necessary that this femoral trial includes a hollow cage that allows the passage of the intramedullary rod) (Fig. 29.13).

If support is not obtained on the two condyles, we add a wedge distally (or perform resection) until good support of the distal femoral cutting guide on the two condyles of the femoral trial. This assessment of femoral valgus does not lock in the level of the distal femoral joint line.

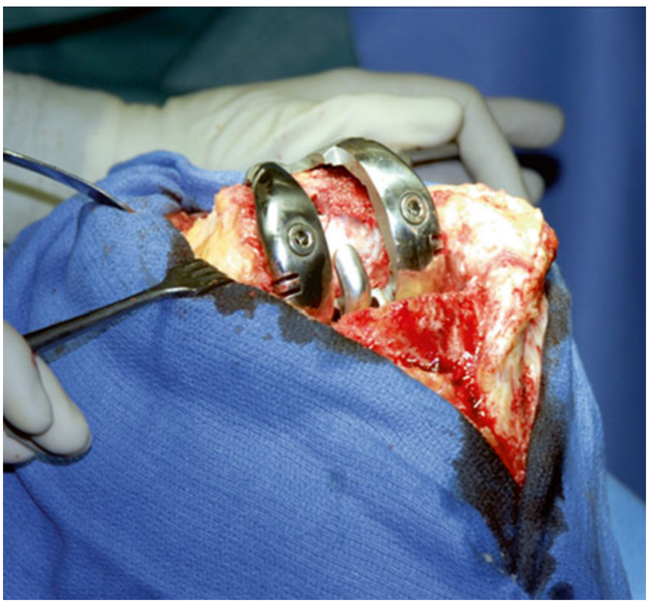


Fig. 29.11 Femoral trial positioning

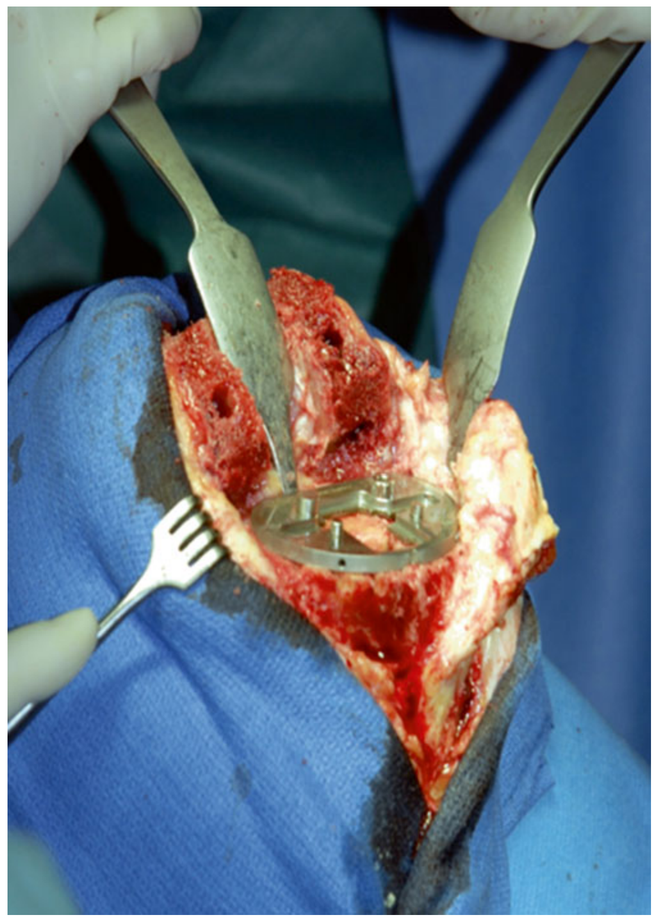


Fig. 29.12 Tibial trial positioning

Fig. 29.13 Passage of the intramedullary rod to control the femoral mechanical axis

Flexion Gap Management

The second is to balance the flexion gap. It is not done through ligament release, but by filling gaps with the implant. This is what T. Ait Si Selmi called "bone balancing." To do this, we must lower the prosthetic posterior condyles onto the tibial plateau. It is uncommon to have to recut the posterior condyles except to change the rotation or if the posterior femoral offset was too large and contributed to the knee for revision. This anteroposterior dimension will guide the final choice of the size of the implant. However, in case of mismatch in the mediolateral plane, we can discuss the compromise of retaining a femoral component of a smaller size and a somewhat thicker polyethylene.

Nevertheless, this compromise is limited by changing the height of the new joint line and by the risk of patella baja.

Rotation is controlled by referencing off of the epicondyles, which is often difficult in revision surgery. Therefore, preoperative measurement of rotational positioning of the femoral component is useful (Fig. 29.14). One can correct internal rotation diagnosed preoperatively using a CT scan by adding a posterolateral metal augment (or by a posteromedial bone resection).

We then check the balance in flexion (Fig. 29.15). A symmetric gap of a few millimeters in flexion is acceptable. In case of asymmetric laxity, we can use a posterior wedge on the femoral condyle (be careful of the rotational changes generated) or tighten peripheral structures, but a more constrained implant may be necessary. In case of symmetric laxity, our preferred option is to add a shim posterior mediolaterally rather than using a thicker polyethylene, but again, you may have to use a more constrained prosthetic system in such cases.

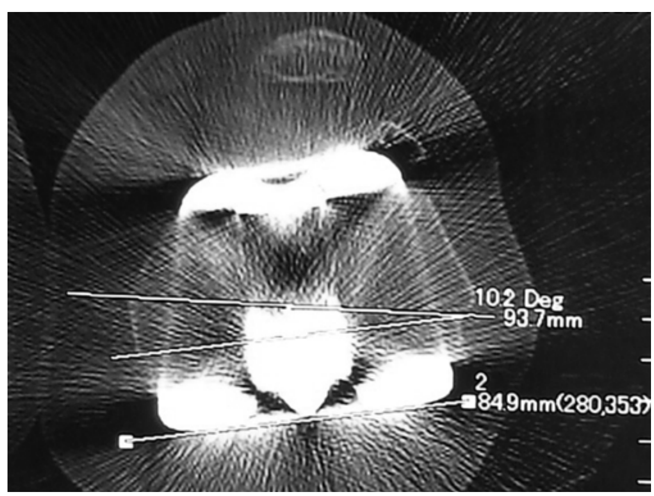


Fig. 29.14 Preoperative measurement of rotational positioning of the femoral component using CT scan

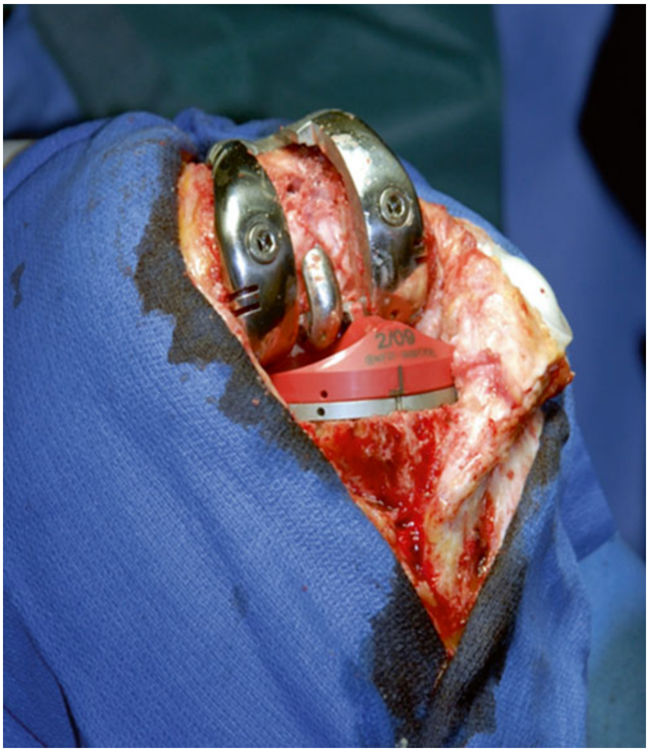


Fig. 29.15 Ligament balancing in flexion

Extension Gap Management

The third step is to balance the extension gap.

Again, this is not done through ligament release, but by filling gaps with the implant. Rarely, it is necessary to recut the distal condyles except for to correct a flexion contracture.

To assess the need for lowering the distal femoral condyles, we can use preoperative (presence of a recurvatum or flexion contracture, templates, etc.) but also intraoperative findings. The assessment of laxity intraoperatively is difficult but essential to differentiate symmetric from asymmetric frontal laxity and detect any hyperextension. Measuring the level of the new joint line relative to prior marks is key to knowing accurately the changes in the level of the joint line. We also use the meniscal wall as anatomical landmark if it is present. A change in the joint line of more than 8 mm is associated with a worse functional outcome, and one must consider a more constrained prosthesis allowing one to maintain the femorotibial joint line nearer the original one.

In case of significant symmetric laxity, our choice is to "distalize" the femoral implant (using two distal blocks) or to use a thicker polyethylene (but then attention must be paid to the impact on the flexion space). We set to 8 mm the acceptable limit of lengthening the femur.

In case of asymmetric laxity, one can consider balancing the laxity by releasing the less distended structures, more rarely to tighten distended structures. We can use the same medial or lateral releases used in primary TKA ("pie crusting" or release the tibial insertion of the distal medial collateral ligament in case of varus and "pie crusting" the IT band or osteotomy of the lateral condyle in valgus cases).

We verify that the joint line has been returned from bony landmarks taken before implant removal.

Adaptation of the Choice of the Implant During the Intervention

Long Keels

The use of wedges or insufficient bone support necessitates the use of long keels to stabilize the implants. After the passage of rigid reamers of increasing size, we check the stability of the implants with the keel chosen. The primary stability should be good before cementing.

Fixation (Fig. 29.16a, b)

We always use antibiotic cement (Palacos Genta®) fixation in revision TKA. Cementation is most often done in a single stage for all of the components. The knee is kept in full extension until the cement is fixed; the tourniquet is released only once the cement cures. Then we carry out a selective hemostasis with electrocoagulation.

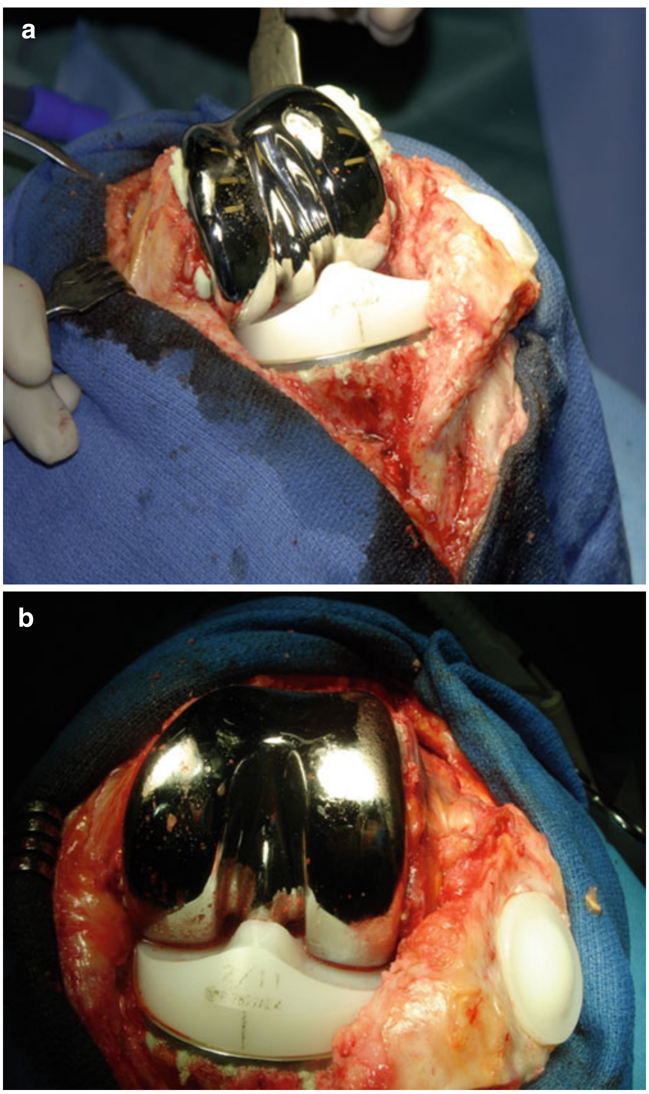


Fig. 29.16 (**a**, **b**) Cemented implants with antibiotic cement

Constraint

As we have noted, during the operation, the surgeon may be faced with an inability to balance the gaps, avoid a mismatch between gaps (flexion-extension), and avoid a significant change in the joint line. We then have to choose a more constrained prosthesis (Fig. 29.17).

Closure

The closure is done in three layers with the knee flexed to 90°. The deepest layer is closed first with figure of eight sutures using number 2 Vicryl®. A drain is placed in the joint. The subcutaneous layer is closed with 0 Vicryl®. The skin is closed with staples.

Fig. 29.17 Hinge prosthesis

Special Case of Sepsis

We perform most often a two-stage revision with a free interval of 6 weeks during which an articulating spacer is in place.

Multiple deep samples (joint fluid, synovial, localized in different areas around the implants, cement, etc.) are performed during the removal of the implant and are analyzed in the bacteriology and pathology department.

In cases of sinus, care is taken to excise it during explantation. The exposure is sometimes difficult because of tissue inflammation, but we try not to perform a tibial tubercle osteotomy during explantation. If it is needed, we fixed the tubercle temporarily at the end of the explantation stage with absorbable sutures through the screw holes and corresponding 3.2 drill holes on the tibial shaft (Fig. 29.18).

It is essential to maintain the joint space during the free interval between the two stages, including the back of the condyles and between the patella and femur. We use molds to obtain articulated spacers of appropriate size. The cement used contains antibiotics (Palacos Genta®). Weight bearing is not permitted, but mobilization is possible, depending on the stability of the implants during surgery.

For the second stage (reimplantation), it is very useful to check the joint line with the "drill hole pinpointing" method described above.

Postoperative Course After Reimplantation

Weight bearing is authorized from day 1. Flexion is limited to 95° for 45 days and then without limitation. An extension splint is maintained for walking until the quadriceps has recovered. If an elevation of the tibial tubercle has been performed, the splint is retained between rehabilitation sessions for two months.

Fig. 29.18 Case of sepsis: articulated spacer of appropriate size

Special Cases

Proximalization of the Tibial Tubercle

If there is a significant limitation of the flexion preoperatively, it is sometimes necessary to set the tibial tubercle more proximal (Fig. 29.19a–c). In this case, one can use two screws and reinforce the attachment with a metal wire, which is passed through a hole in the distal part of the bone and fixed with a screw distally. This additional distal fixation is intended to prevent proximal migration of the tubercle (Fig. 29.20).

Sometimes, in case of massive tibial keel, we must fix the TTA only with metal wires. In this case, we must avoid going behind the tibia because of significant vascular risk, but prefer to pass the wire just behind the tibial keel itself before its introduction (Fig. 29.21).

In all cases, one should use a splint in extension for walking and resting between rehabilitation sessions during the period of consolidation of the osteotomy (2 months).

Using a Customized "Tulip-Shaped" Implant

In case of significant metaphyseal defect, but with preservation of the cortical envelope, we use a tulip-shaped tibial implant based on a long keel. The interest is to preserve the insertion of the collateral ligaments even in cases of major bony defects. It then becomes possible to use a posterior stabilized prosthesis with minimal constraint.

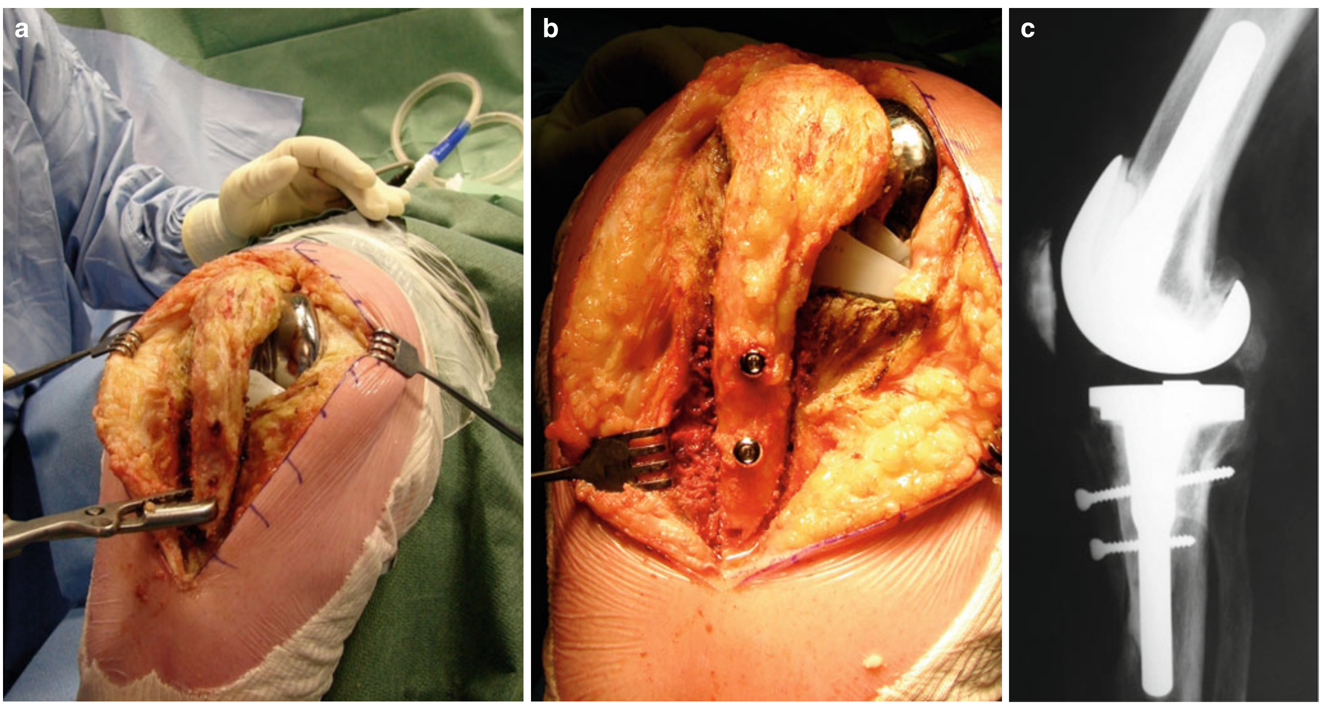


Fig. 29.19 (**a–c**) Proximal transfer of the tibial tubercle and fixation by two 4.5 mm screws

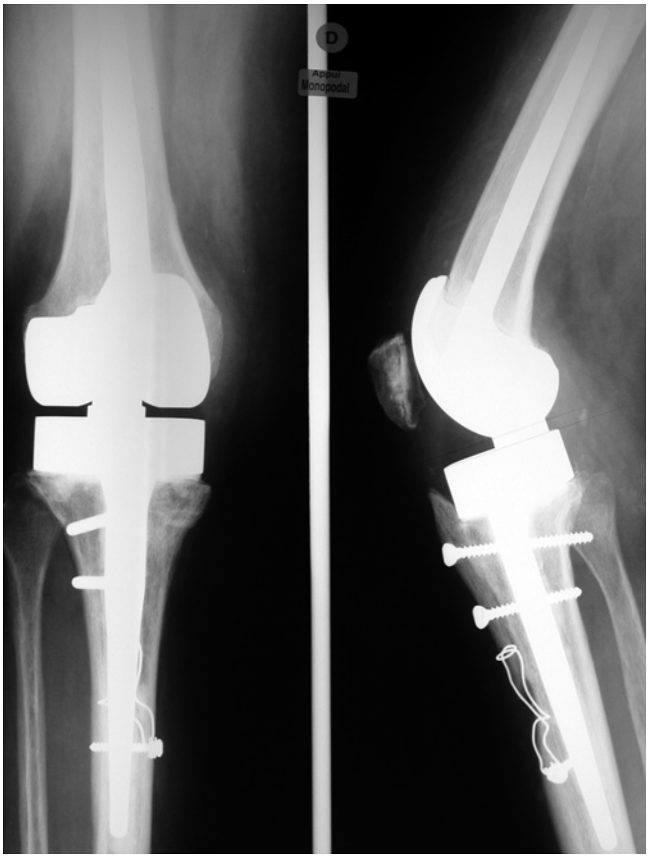


Fig. 29.20 Additional distal fixation of the tibial tubercle to prevent proximal migration

Fig. 29.21 Metal wires passed behind the tibial keel before its introduction

Episodic Patellar Dislocation

30

E. Servien and P. Archbold

Background

Episodic Patellar Dislocation Is Also Termed Objective Patellar Instability or Occasional Patellar Dislocation

This condition is defined by a history of one or more episodes of patellar dislocation confirmed by the patient or the physician and/or a radiographic abnormality due to a dislocation (fracture of the medial border of the patella or fracture of the lateral condyle).

This terminology avoids the term of instability. H. Dejour highlighted the different meaning of instability and separated objective "laxity" from subjective "instability." Nevertheless, instability is a symptom and not a syndrome. Moreover a misunderstanding still exists with the terminology of objective patellar instability in the English-speaking world. With *Dan Fithian*, after his visit to Lyon for 4 months, we came to this suggestion that clarifies the situation: episodic patellar dislocation (EPD).

Morphological Abnormalities

In the EPD group, we have identified several morphological anomalies that facilitate or allow patellar dislocation. In more than 96 % of the cases of EPD, the radiographic examination will reveal at least one of the following anomalies:

Trochlear dysplasia
Patella alta
Tibial tubercle-trochlear groove distance (TT-TG) >20 mm
Patellar tilt >20°

Fundamental Factor

Trochlear Dysplasia

Trochlear dysplasia, according to the literature and our experience, is present in more than 90 % of patients in whom a patellar dislocation has occurred. It is the principal anatomical feature of EPD and consists in a flattening or convexity of the upper part of the trochlear groove.

Imaging features: crossing sign and a prominence ("bump," "boss," or "eminence") of the floor of the groove on the lateral radiograph.

Main Factors

These factors are called *main factors* for several reasons. They are very often present in the EPD group and absent in a control group (patient without any history of patellar dislocation). We were able to measure them radiographically and a threshold has been defined so that they can be corrected.

Tibial Tubercle-Trochlear Groove (TT-TG) Distance

The TT-TG distance is used to assess rotational alignment of the extensor mechanism. It is obtained by superimposing CT images of the summit of the trochlear groove (coronal cut where the femoral notch resembles a roman arch) and the tibial tubercle in a fully extended knee. The deepest point of the trochlear groove and the highest point of the tibial tuberosity are projected perpendicularly on the line tangent to the posterior condyles. The distance between these points is defined as the TT-TG.

Abnormal when the TT-TG Is >20 mm in CT Coronal Images

E. Servien, MD, PhD
Albert Trillat Center, Croix Rousse Hospital, Lyon 69004, France
e-mail: elvire.servien@chu-lyon.fr

P. Archbold, MD (✉)
The Ulster Independent Clinic, 245 Stranmillis road, Belfast BT95JH, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_30, © Springer-Verlag London 2014

Patellar Height

The patella engages in the trochlea in the first degree of flexion. If the patella is too high in relation to the trochlea, this engagement will occur too late, with an increased risk for dislocation.

Abnormal when the Caton-Deschamps Index Is > 1.2 on the Lateral Radiograph

Patellar Tilt

The patellar tilt is the inclination of the patella in its transverse plane in relation to a line tangent to the posterior femoral condyles. Several factors may result in patellar tilt: dysplasia of the quadriceps muscle, dysplasia of the trochlear groove, and patella alta. It can be addressed by a soft tissue reconstruction, e.g., medial patellofemoral ligament reconstruction or vastus medialis obliquus plasty.

Abnormal when the Patellar Tilt Is >20° on CT Images

Secondary Factors

We call them *secondary factors* because they are present in the EPD group at a lower frequency and we were not able to establish a threshold. We must consider them as potential factors and it is uncommon to propose a surgical act to correct them.

- Genu valgum
- Genu recurvatum
- Excessive femoral antetorsion
- Female sex

Clinical Examination

The clinical findings are less reliable in the evaluation of EPD.

Smillie Test (The Apprehension Sign)

With the patient in the supine position and the knee extended, the patella is forced laterally by the examining physician. To be positive, the patient and the physician must have the impression of imminent dislocation. A negative Smillie is much more helpful than a positive sign; a negative Smillie sign rules out a dislocatable patella, while a positive Smillie sign does not confirm a dislocatable patella.

"J" or "Comma" Sign

Lateral subluxation of the patella in terminal knee extension due to the nonlinear path of the patella during the first 30° of flexion.

Lateral "Squint" of the Patella

The so-called "grasshopper" sign, due to the appearance of the high-riding and laterally subluxated patella at the upper outer corner of the knee at 90° of flexion.

Increased Q-Angle

Also known as "bayonet sign." The distal insertion of the patellar tendon is too lateral with respect to the patella itself and the quadriceps muscle. It is a clinical finding that is difficult to quantify. It is an indication of a potential excessive TT-TG. To quantify the exact position of the tibial tubercle with respect to the trochlear groove, a TT-TG measurement should be performed.

Other aspects of the physical examination, such as effusion and tenderness, recurvatum, and lower limb alignment, are secondary or indirect signs and do not contribute strongly to treatment decisions.

Imaging Studies

Trochlear Dysplasia

Crossing Sign

On the *strict lateral radiograph* (the posterior portions of the femoral condyles are aligned), the floor of the normal groove is visible in profile as a distinct sclerotic line curving distally and posteriorly, starting from the anterior cortex and ending at the anterior end of Blumensaat's line. In its entire course, this line should never pass anterior to a tangent line extending down the anterior femoral cortex.

Patients with trochlear dysplasia have an abnormally prominent groove which passes anteriorly to the anterior cortex and eventually crosses the medial-lateral trochlear walls (Fig. 30.1a, b). The more distal the crossing, the worse is the trochlear dysplasia.

Prominence

Also called the trochlear "boss," "bump," or "eminence" of the floor of the groove with respect to the distal 10 cm of the anterior femoral cortex. Values superior to 3 mm are considered pathological (Figs. 30.2 and 30.3).

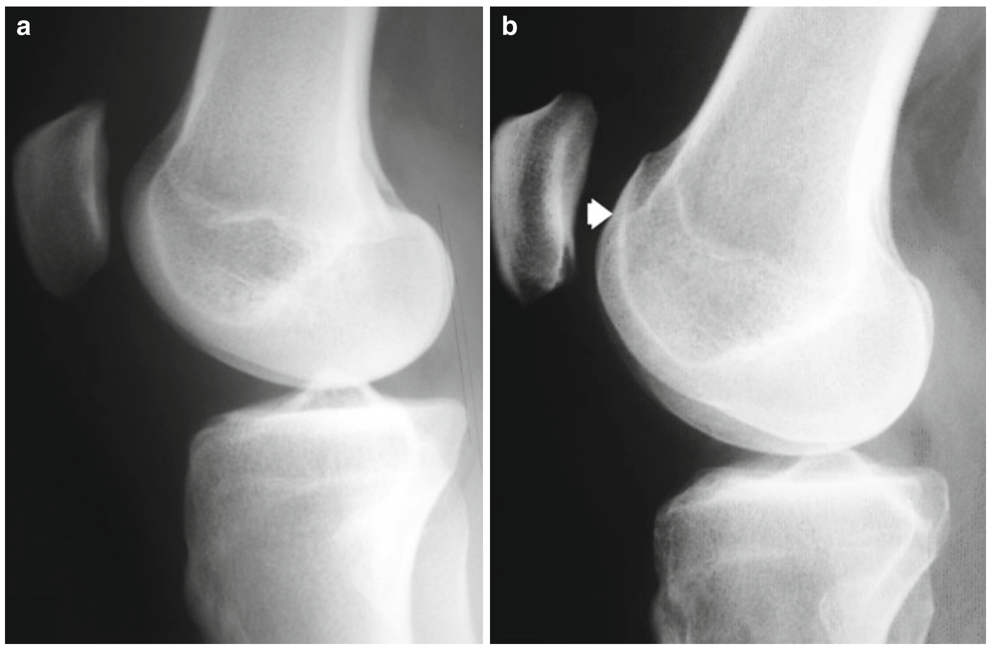


Fig. 30.1 Lateral view. (**a**) Normal knee. (**b**) Trochlear dysplasia with crossing sign (*arrow*)

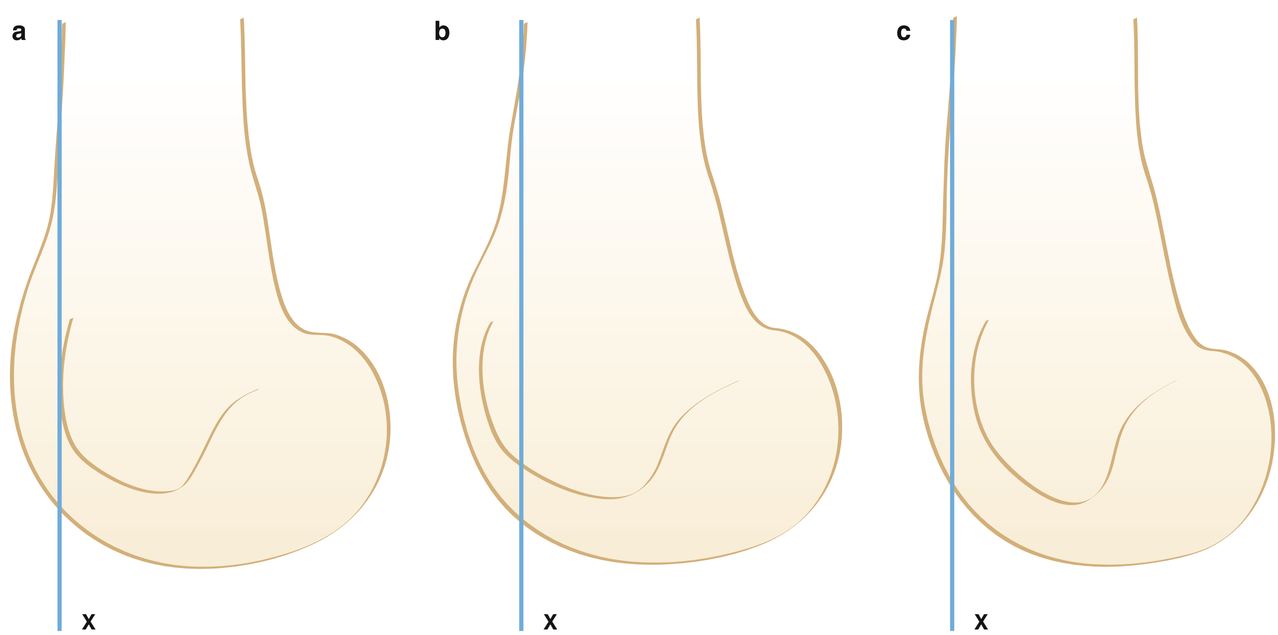


Fig. 30.2 Prominence. (**a**) No prominence. (**b**) Positive prominence. (**c**) Negative prominence

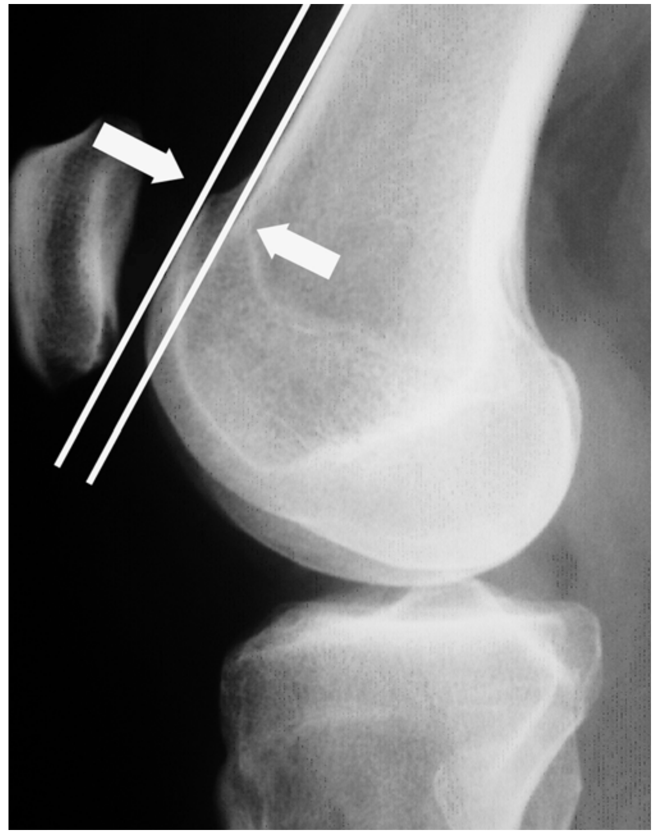


Fig. 30.3 Radiological measurement of the prominence on lateral view x-ray

Trochlear Depth

Dejour

A tangent to the posterior cortex of the femur and its perpendicular passing through the posterior condyles are traced. The trochlear depth is measured in a line 15° from the perpendicular, crossing the trochlear groove line, where the trochlear depth is measured. Values below 4 mm are considered abnormal (Fig. 30.4).

Tibial Tubercle-Trochlear Groove (TT-TG) Distance

The TT-TG distance is used to assess rotational alignment of the extensor mechanism. It is obtained by superimposing CT images of the summit of the trochlear groove (coronal cut where the femoral notch resembles a roman arch) and the tibial tubercle in a fully extended knee. The deepest point of the trochlear groove and the highest point of the tibial tuberosity are projected perpendicularly on the line tangent to the posterior condyles. The distance between these points is defined as the TT-TG.

Measurements greater than 20 mm are considered abnormal (Fig. 30.5).

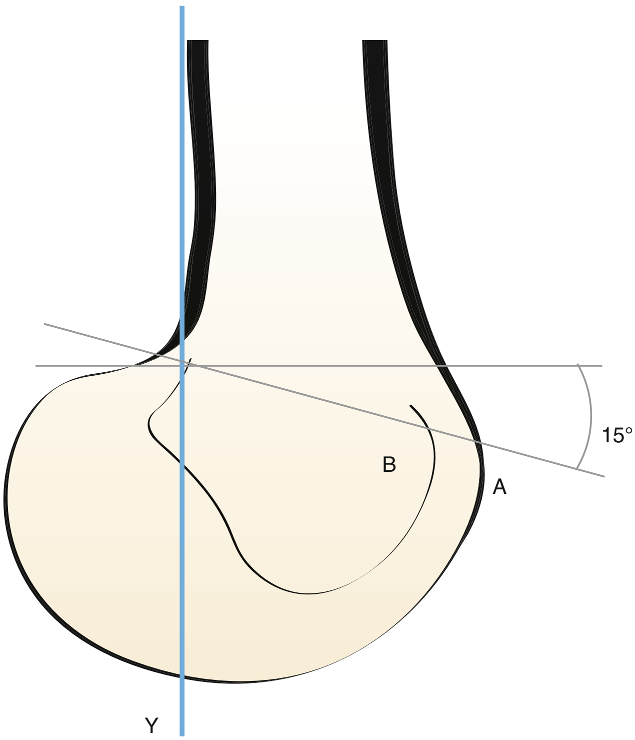


Fig. 30.4 Trochlear depth (=BA)

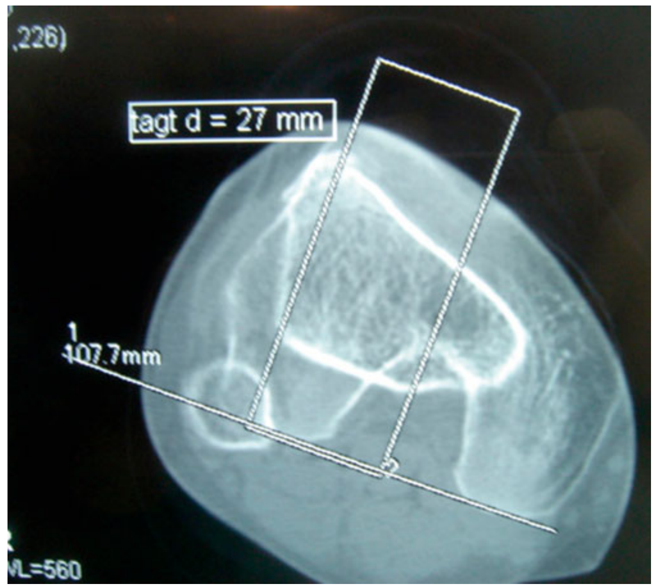


Fig. 30.5 TT-TG distance measurement on CT scan = 27 mm

Patella Alta

There are several indices to measure patellar height. These indices can be categorized into those referencing the tibia (e.g., Insall-Salvati, Caton-Deschamps, Blackburne-Peel) and those referencing the femur (e.g., Blumensaat, Bernageau).

Theoretically, referencing the patellar height to the femur is more logical because what matters is how the patella engages in the femoral groove. But femoral referencing is less reproducible. For this reason, tibial referencing is the standard method to measure patellar height.

Caton-Deschamps Index

It is measured on a strict lateral view. It is the ratio between the distance of the inferior border of the patellar articular surface to the anterior border of the tibial plateau and the patellar articular surface length (Fig. 30.6). It is simple to trace and it is not altered by knee flexion on the radiograph. Values greater than 1.2 characterize patella alta.

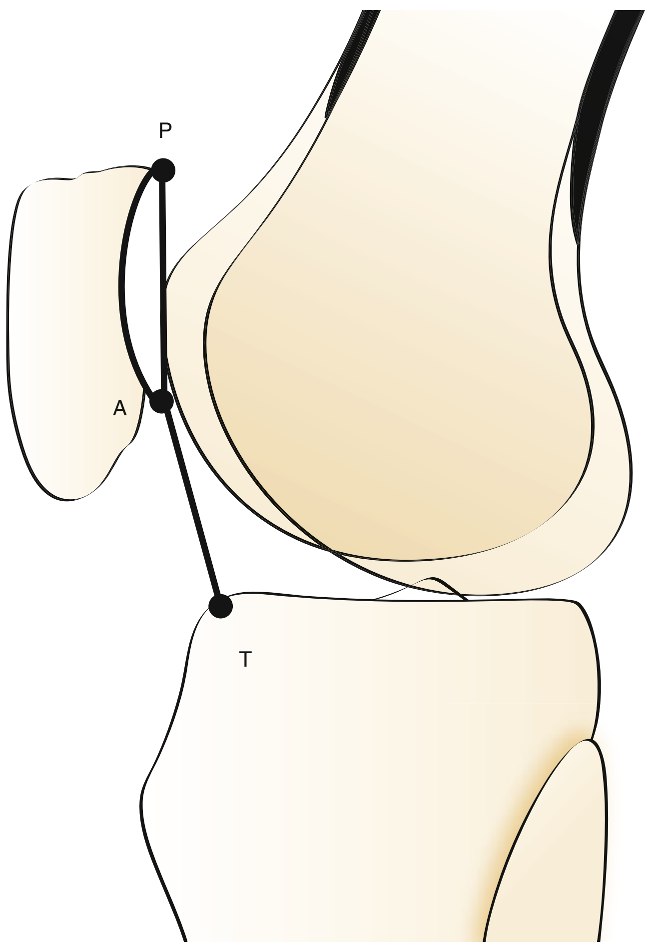


Fig. 30.6 Caton-Deschamps index measurement = AT/AP

Patellar Tilt (Maldaghe and Malghem)

Studied from strict lateral radiographies with the knee flexed to 30° (Fig. 30.7).

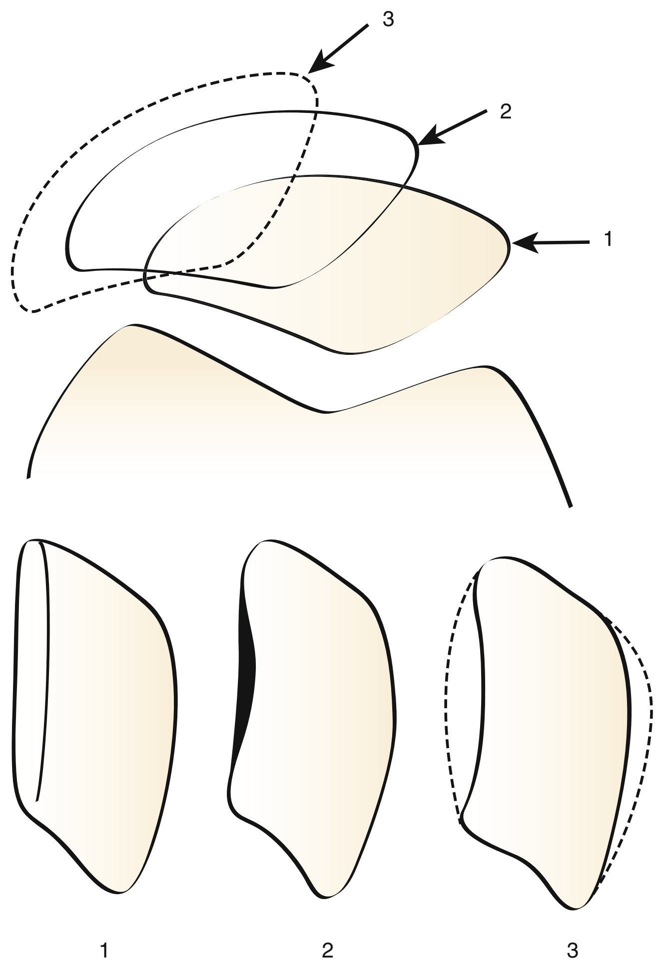


Fig. 30.7 Patellar tilt (Maldaghe and Malghem). *1* Normal. *2* Moderate tilt. *3* Severe tilt

Merchant Angle

It is calculated on axial radiographic views of the knee at 45° of flexion. The bisecting line of the angle between the lateral and medial trochlear facets is traced. A second line is then traced between the deepest portion of trochlear groove and the most posterior (inferior) portion of trochlear ridge. The angle of Merchant is the angle between both lines. If the angle is medial to the bisecting line, it has a negative value; if it is lateral, its value is positive. Normally the angle is −6°. Merchant considered an angle superior than +16° abnormal (Fig. 30.8).

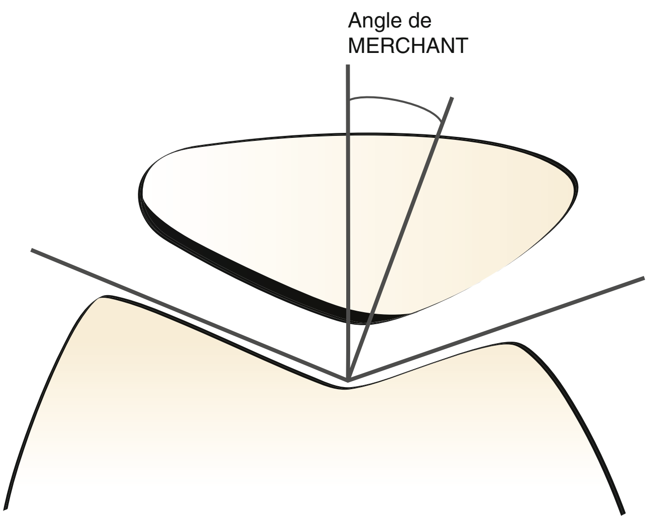


Fig. 30.8 Merchant angle

Patellar Tendon Length

Measured on MRI, it is more specific and sensitive than the patellar height index measured on profile x-rays for the study of patellar instability (Fig. 30.9). The patellar tendon is excessively long (generally greater than 52 mm) in patients with patellar instability.

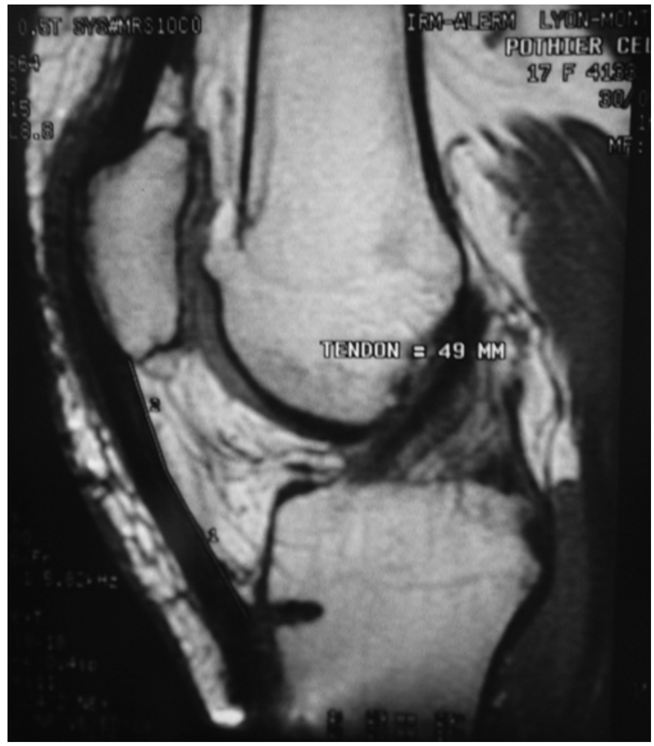
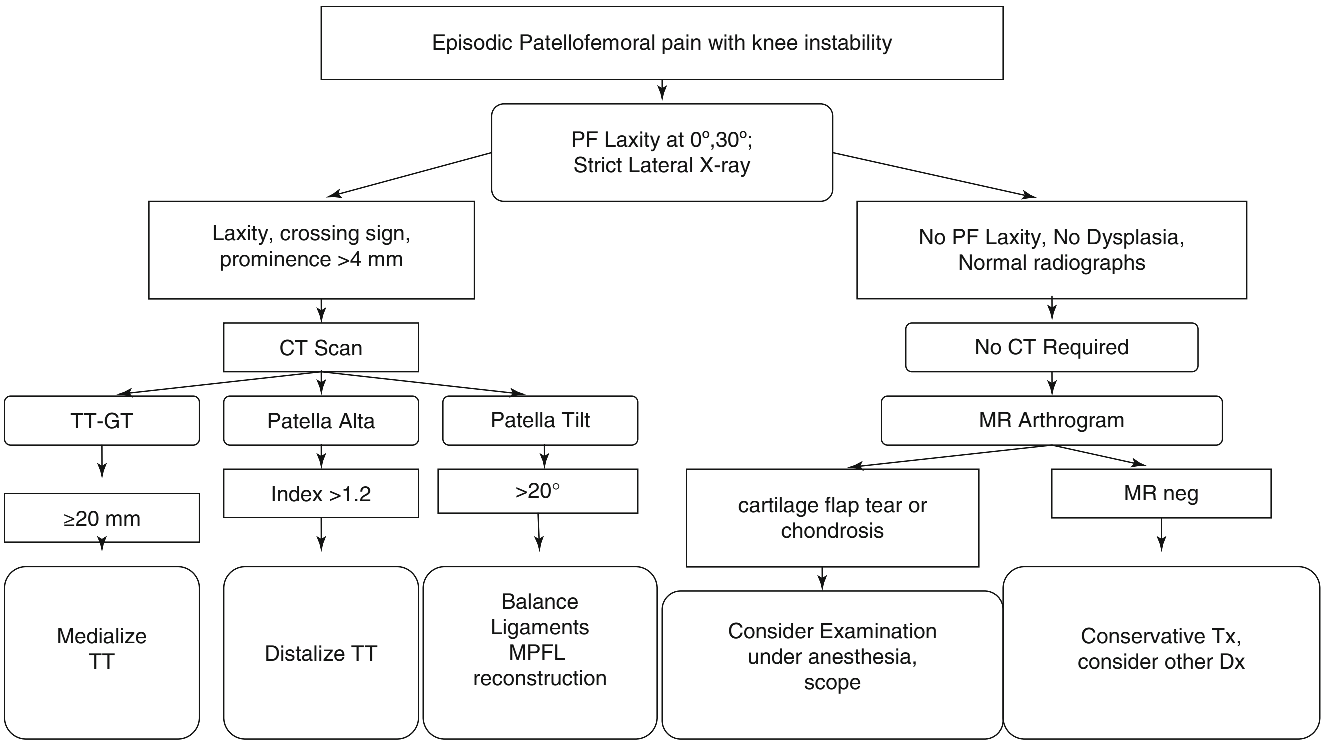


Fig. 30.9 Patellar tendon length after tenodesis measuring 49 mm on MRI

Treatment

Algorithm



Font: D. Fithian, Ph Neyret:Patellar Instability: The Lyon Experience

Conservative Treatment

Nonsurgical treatment is not the objective of this chapter and will not be developed here.

Unlike in painful patella syndrome, where conservative treatment is the rule and surgical treatment usually worsens symptoms, conservative treatment has a less important role in EPD management. This is particularly true when a threshold can be established due to a factor such as patella alta, augmented TT-TG, or patellar tilt and the patient presents with repetitive episodes of patellar dislocation.

In cases of infrequent instability in which no threshold abnormality has been identified and pain is the most prominent symptom, a course of physiotherapy can be prescribed. These exercises consist of quadriceps and hamstrings muscle stretching and quadriceps reinforcement (specially VMO muscle).

Surgical Treatment

Surgical treatment is indicated in the presence of morphological anomalies. These patients should have had at least one or more episodes of patellar dislocation AND one or more main factor (patella alta, excessive TT-TG, or patellar tilt).

In this chapter, we do not describe the trochleoplasty as proposed by H. Dejour and G Walch in 1987. We do not treat the trochlear dysplasia in a primary setting, the fundamental factor responsible for EPD, for several reasons. Most frequently, the trochlear dysplasia is mild and well tolerated by the patient. Deepening of the trochlear groove is in our hands is only effective in severe cases with abnormal patellar tracking. It remains a very technical and demanding procedure with a variable outcome. Therefore, in our department a deepening trochleoplasty is only indicated for severe trochlear dysplasia (with a bump of >6 mm, abnormal patellar tracking, or failure of previous surgery).

Techniques

The following procedures are generally easy, but can lead to significant complications if not carried out with prudence and for the correct indications. These techniques are not indicated for painful patella syndrome, which can be worsened by these procedures.

Distal Tibial Tubercle Transfer (TTT)

This technique is indicated to correct patella alta. The patient is prepared and a tourniquet is applied high on the proximal thigh. An arthroscopy can be performed in combination in order to verify patellar tracking and look for possible chondral lesions.

The objective of the procedure is to bring the tibial tubercle (TT) to a more distal position in order to obtain a Caton-Deschamps index of 1. For example, in a patient with a Caton-Deschamps index of 1.3, with AT distance of 39 mm, and an AP distance of 30 mm, the distalization necessary is 9 mm to reach an index of 1. Two extra millimeters should be added due to possible proximal movement of TT during screw fixation, resulting in a total of 11 mm of distalization.

An 8 cm medial parapatellar skin incision is made, centered on the TT. The subcutaneous tissues are dissected (Fig. 30.10). The TT osteotomy has a length of 6 cm and is marked using the electrocautery. The patellar tendon and the inferior pole of the patella are identified.

Two 4.5 mm holes are drilled in the midline of the TT. A countersink is then used in each hole in order to avoid prominence of the screw heads underneath the skin (Fig. 30.11).

The osteotomy is done with an oscillating saw and completed with an osteotome. The lateral cut is done first, in a horizontal direction, followed by the medial cut, in an almost vertical direction, and finally the transverse distal cut. Distal to this transverse cut, an additional bone block is removed of which the length corresponds to the amount of distalization. This allows the TT to be positioned distally (Figs. 30.12 and 30.13). The free TT is now transferred to its more distal position as planned and kept in position with a Farabeuf retractor. With the knee in 90° of flexion and the calf of the lower limb free, two 3.2 mm holes are made in the posterior tibial cortex through the TT 4.5 mm drill holes, perpendicular to the tibial shaft. The osteotomy is then fixed with two 4.5 mm cortical screws. It's imperative that the screws are fixed in a strict perpendicular position in relation to the tibial shaft. The screw length should be 2 mm longer than the measured length of the drill trajectory to ensure adequate fixation and to avoid postoperative detachment of the TT (Fig. 30.14). The screws should not be tightened excessively; otherwise, the TT might be positioned too posteriorly. Care must be taken to keep the TT parallel to its original bed; otherwise, a lateral patellar tilt might occur (Fig. 30.15).

The incision is closed over a drain.

Patellar Tendon Tenodesis

This is an adjuvant procedure to a distal TTT procedure. It is indicated in cases where the patellar tendon length is greater than 52 mm (Fig. 30.16).

After the TT osteotomy but prior to its fixation, two anchors with sutures are fixed on both sides of the patellar tendon, about 3 cm distal to tibial plateau level (the normal insertion level of the tendon) (Fig. 30.17). The TT is subsequently fixed at the desired position with two 4.5 mm cortical screws (Figs. 30.18 and 30.19).

After fixation of the osteotomy, the tendon is vertically incised at one third and two thirds of its width with a 23 scalpel blade. The sutures are tied across the lateral and medial one third. Thus, the length of the patellar tendon is reduced. This can be assessed postoperatively with MRI (Fig. 30.20).

The remaining steps of the surgery are the same as for a distal TTT.

Medial Tibial Tubercle Transfer

This technique is indicated in the correction of an increased TT-TG. A 6 cm medial parapatellar skin incision is made, centered on the TT. The subcutaneous tissues are dissected (Fig. 30.21). Comparable to a distal TTT, the TT bone block has a length of 6 cm. The patellar tendon, the lateral and medial attachments, the inferior pole of the patella, and the TT are identified. The objective is to bring the TT to a more medial position in order to obtain a TT-TG value of 12 mm. For example, in a patient with a TT-TG value of 20 mm, it is necessary to medialize the TT by 8 mm. One 4.5 mm hole is drilled in the center of the TT. The osteotomy is made with an oscillating saw. The cut begins laterally and exits out of the cortex medially, leaving an intact portion of inferior TT attached to the anterior tibial cortex (Fig. 30.22). Subsequently, the TT is brought to a more medial position as planned preoperatively. Different to the distal TTT, only one screw is necessary for the TT fixation. A 3.2 mm drill hole is made in the posterior cortex through the TT 4.5 mm hole, in a slightly more proximal position. The osteotomy is then fixed with a 4.5 mm cortical screw, 2 mm longer than the measured drill trajectory (Fig. 30.23). The incision is closed over a drain.

Medial Patellofemoral Ligament Reconstruction (D. Fithian's Technique)

This technique is indicated when there is excessive laxity of medial retinacular patellar stabilizers, specifically the MPFL. A laterally applied force to the patella will result in lateral displacement of more than 9 mm with the knee at 30° of flexion. After the procedure, the patella must be in a horizontal position and no longer dislocatable. An arthroscopy is done first to evaluate associated lesions and patellar tracking, which can be performed using an accessory superolateral portal. Three small incisions are needed, one for graft harvesting and two for graft fixation, on the patella and on medial femoral epicondyle (Fig. 30.24).

Harvest of the Semitendinosus Tendon

The next step is to obtain the graft for the MPFL reconstruction. A small (5 cm) longitudinal or oblique incision over the pes anserinus is made. The conjoint tendon of the hamstrings is incised in "L" shape, with its angle positioned superiorly and medially. The semitendinosus tendon is identified and its insertions to the crural fascia and posteromedial corner are cut. Absorbable sutures are placed at its free end, and the tendon is released from the tibial insertion (Figs. 30.25 and 30.26). The graft is subsequently stripped using a closed stripper.

The graft is prepared on the back table. For an MPFL reconstruction. the length of the graft should be between 16 and 20 cm. Whipstitches are placed in the other free and the tendon is looped in two and the folded end is sutured together over a distance of 2–3 cm (Fig. 30.27).

Patellar Tunnels

A longitudinal incision of about 4–5 cm is made over the patella, in between its medial border and the midline. The medial third of the patella is exposed by subperiosteal dissection (Fig. 30.28). The dissection extends medially between the original MPFL and the capsular layer.

A 3.2 mm drill and subsequently a 4.5 mm drill are used to drill two tunnels in the proximal one third of the patella. These tunnels start on the medial border of the patella, horizontally, and the exit holes are made on the anterior surface of the patella, 8–10 mm lateral to medial border (Fig. 30.29).

The Medial Epicondylar Tunnel and Its Dissection

A 5 cm longitudinal incision is made over the ridge connecting the medial epicondyle to the adductor tubercle (AT). Dissection is carried to the bone surface. From the patellar incision, in between the original MPFL and capsular layer, dissection scissors are driven toward the medial epicondyle, uniting both epicondylar and patellar incisions. A guide pin is passed just proximally to the medial epicondyle, distal to the AT toward the lateral epicondyle, under fluoroscopic guidance (Figs. 30.30 and 30.31). MPFL ligament isometry can be tested now, passing a #5 braided polyethylene suture around the guide pin through the patellar tunnels. If lengthening occurs in extension, the pin is placed more proximally, closer to the AT. If lengthening occurs in flexion, the pin is placed more distally, closer to the medial epicondyle. A blind bone tunnel is created on the medial epicondyle, 7 mm in diameter and 25–30 mm in length (enough to receive the folded end of the graft). The graft is pulled into the tunnel by a perforated pin and then fixed with an interference screw (Habilis 7 mm, Phusis) (Figs. 30.32 and 30.33). The two free extremities of the graft are passed under the original MPFL between the two incisions, to enter the patellar tunnels medially and exit through the anterior drill holes. Each free extremity is sutured side to side onto itself with nonabsorbable sutures (Figs. 30.34 and 30.35). The patella must be centered at the time of tying the sutures, so an adequate ligament tension is obtained. It remains very difficult to define "adequate" tension. Generally, tensioning is performed at 70° of flexion.

Patellar mobility is checked. A good end point must be achieved, with patellar lateral mobility of 7–9 mm; the patella must be in a horizontal position and it should be impossible to dislocate it laterally. A 3.2 mm drain is placed subcutaneously, and the incision is closed.

Fig. 30.10 Skin incision

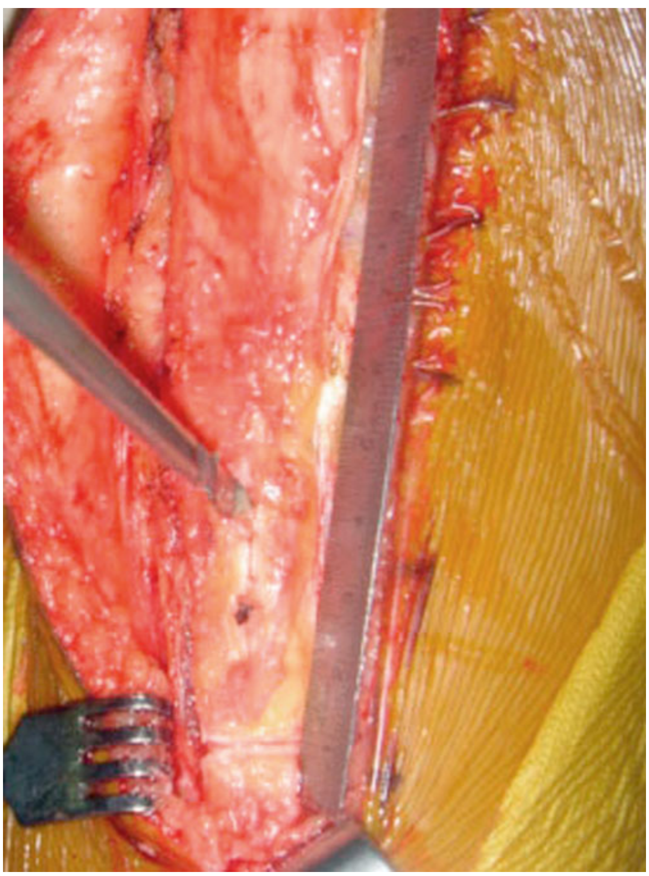


Fig. 30.11 Tibial tubercle osteotomy: 6 cm length. Two 4.5 mm holes are drilled. ATT is demarked (6 cm long) and the 4.5 mm orifice is made

Fig. 30.12 Lateral cut in a horizontal direction

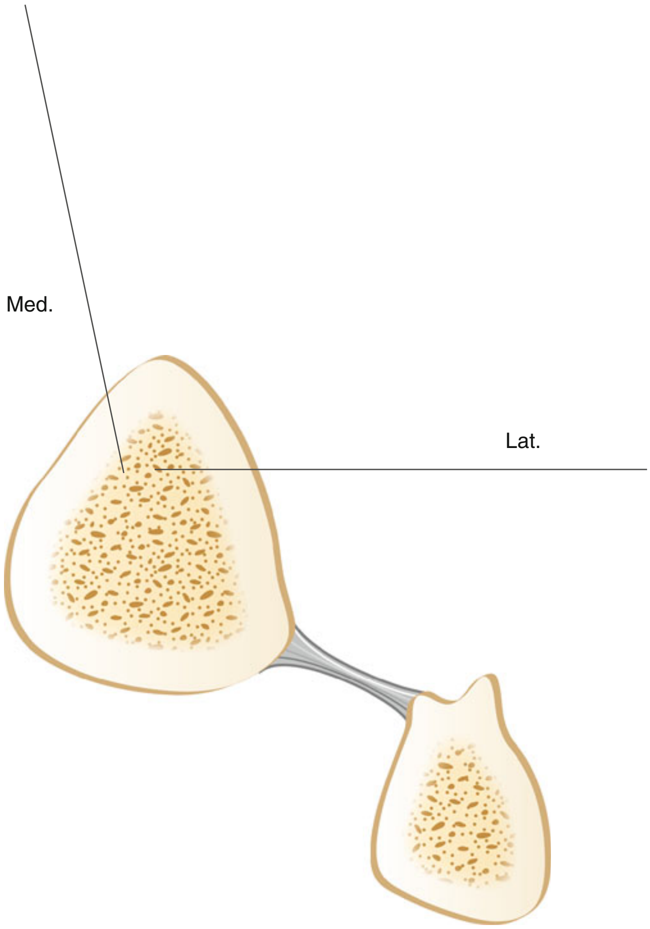


Fig. 30.13 Lateral cut in a horizontal direction and medial cut in a vertical direction

Fig. 30.14 Postoperative x-ray

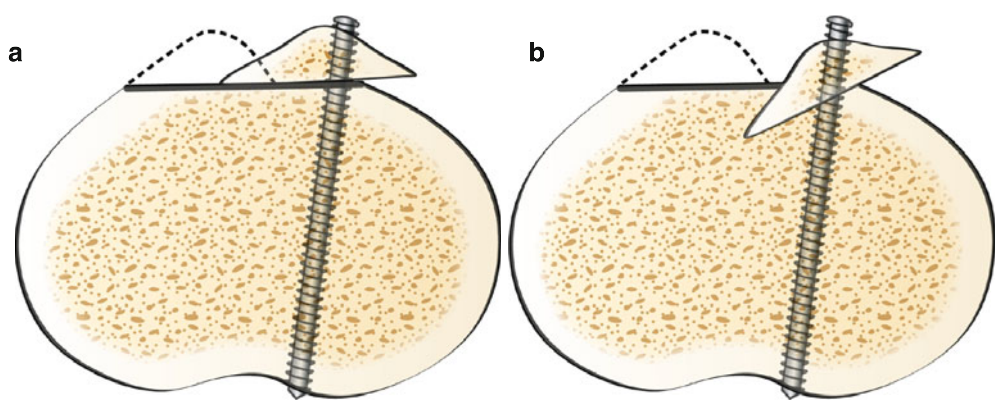


Fig. 30.15 Example of medial and distal tibial tubercle transfer with correct fixation (**a**) and incorrect fixation (**b**) with a lateral patellar tilt

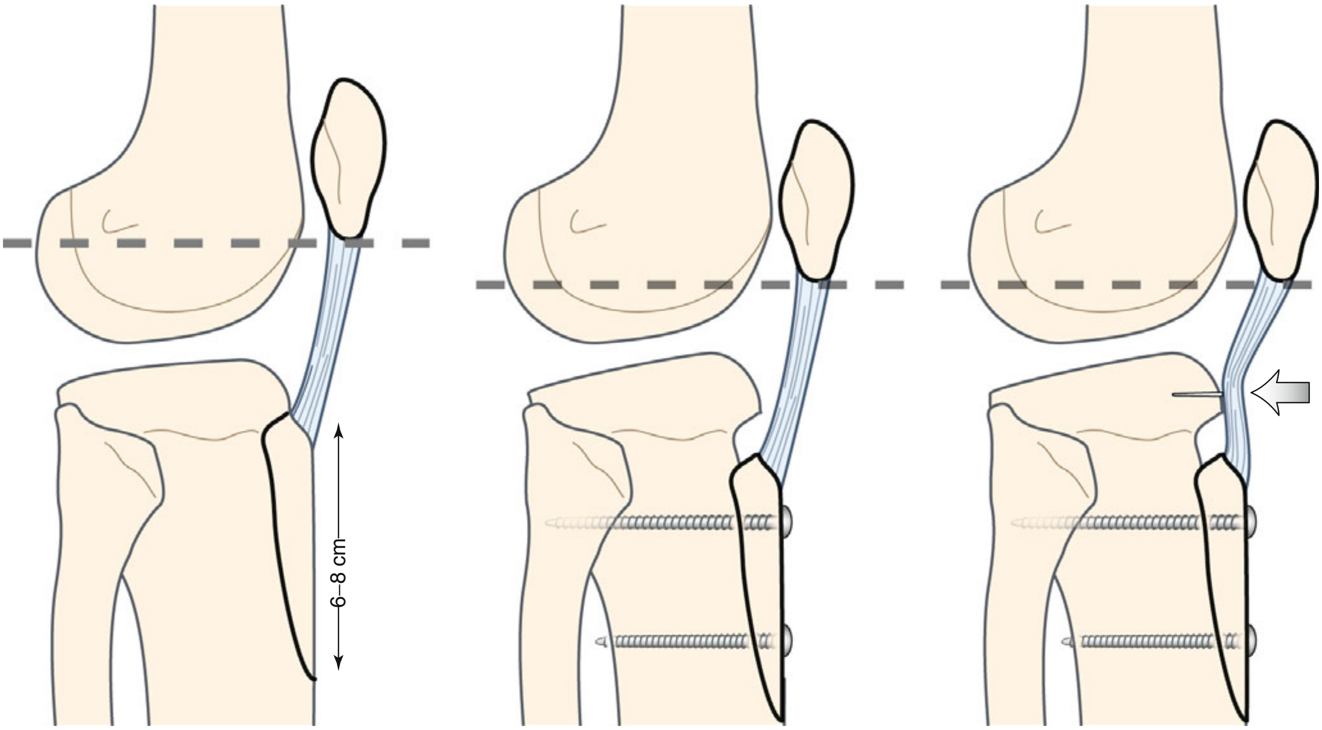


Fig. 30.16 Principles of patellar tendon tenodesis associated with distal tibial tubercle transfer

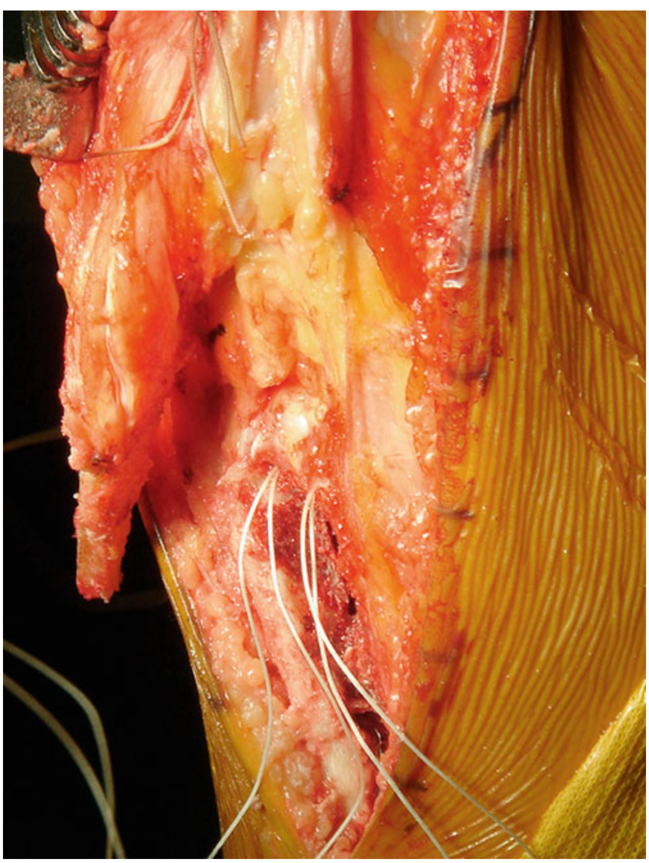


Fig. 30.17 Anchor fixation on the normal insertion level of the tendon

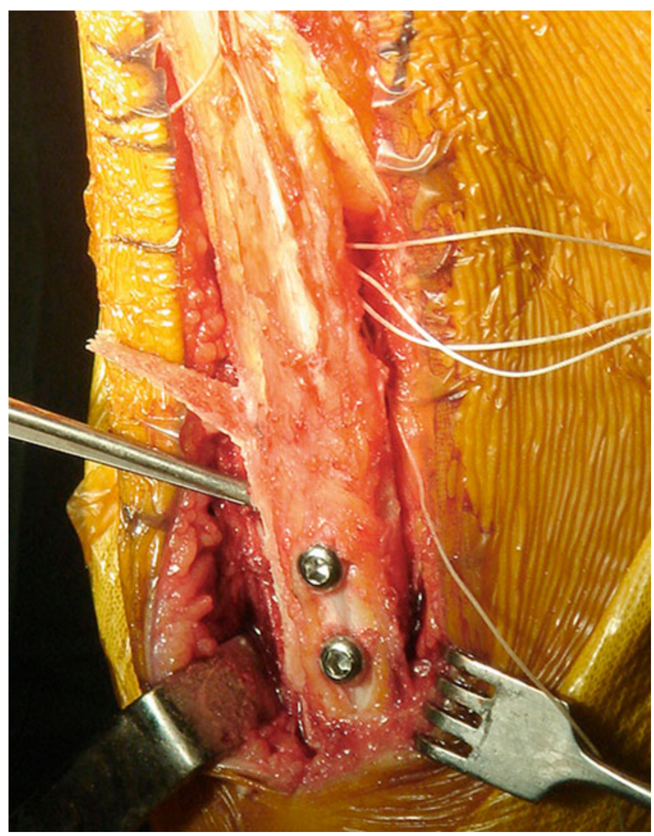


Fig. 30.18 Tibial tubercle fixation

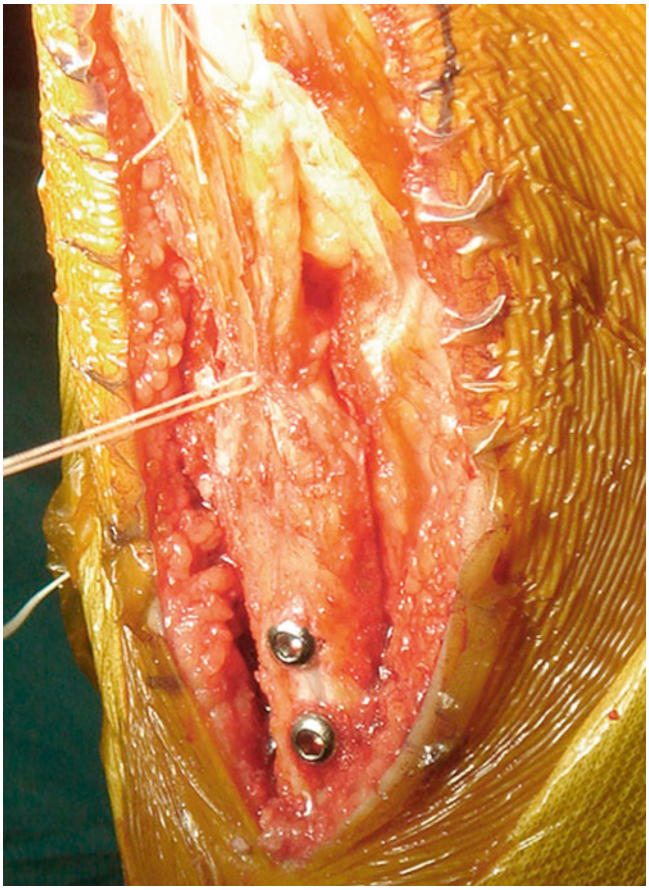


Fig. 30.19 Final aspect after suture

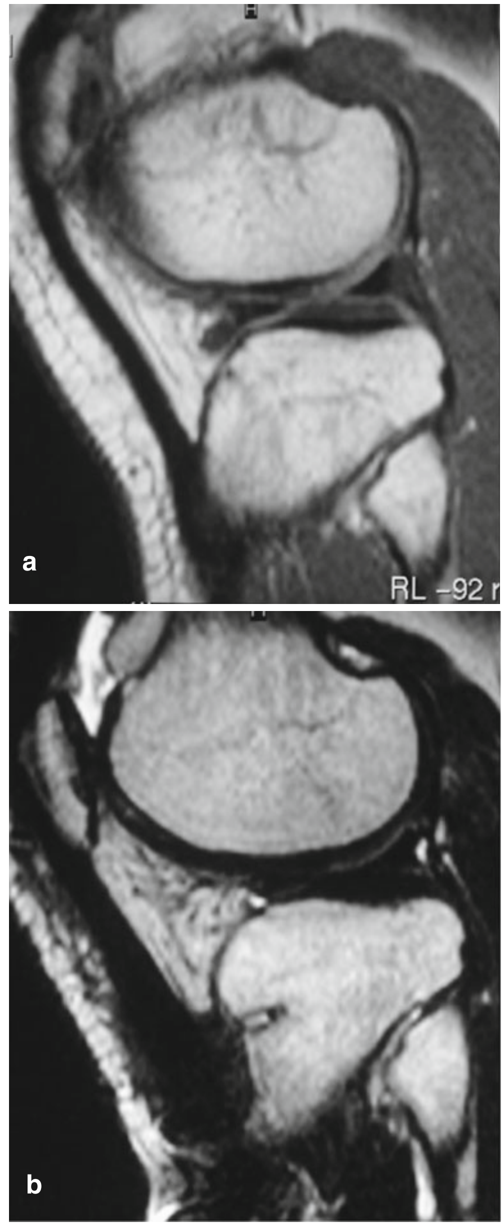


Fig. 30.20 Pre- and postoperative MRI showing length modification of the patellar tendon

Fig. 30.21 Skin incision

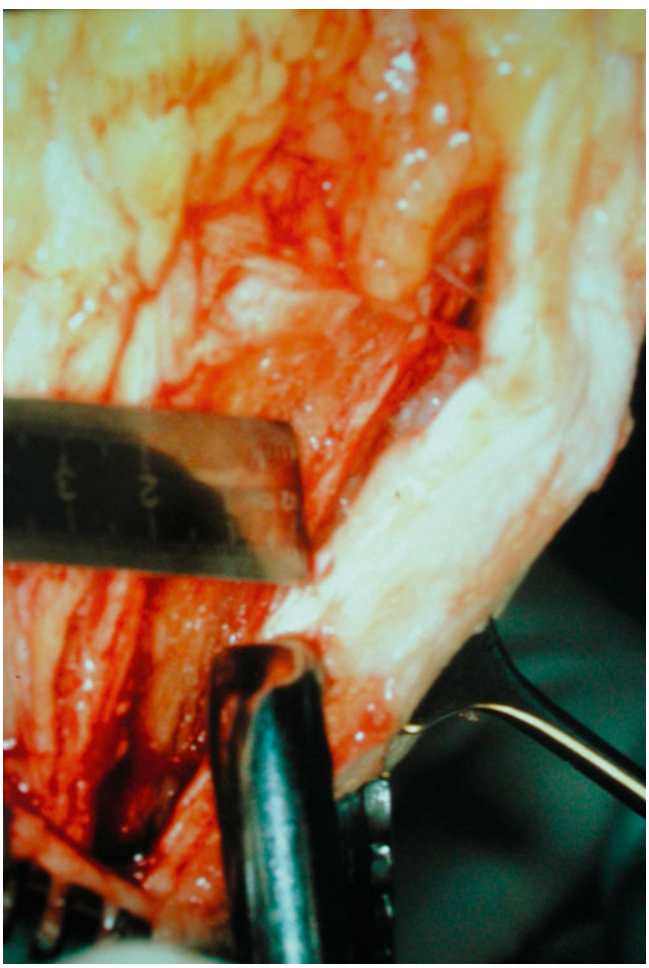
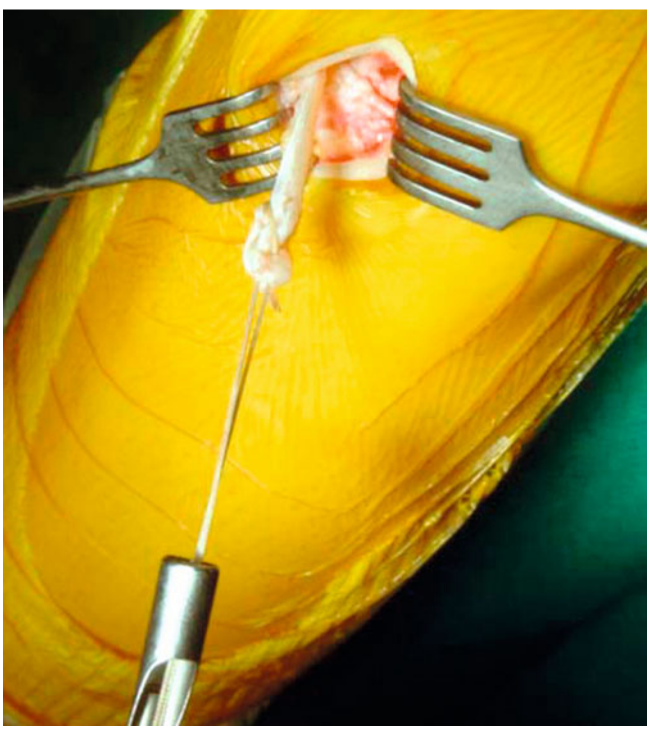
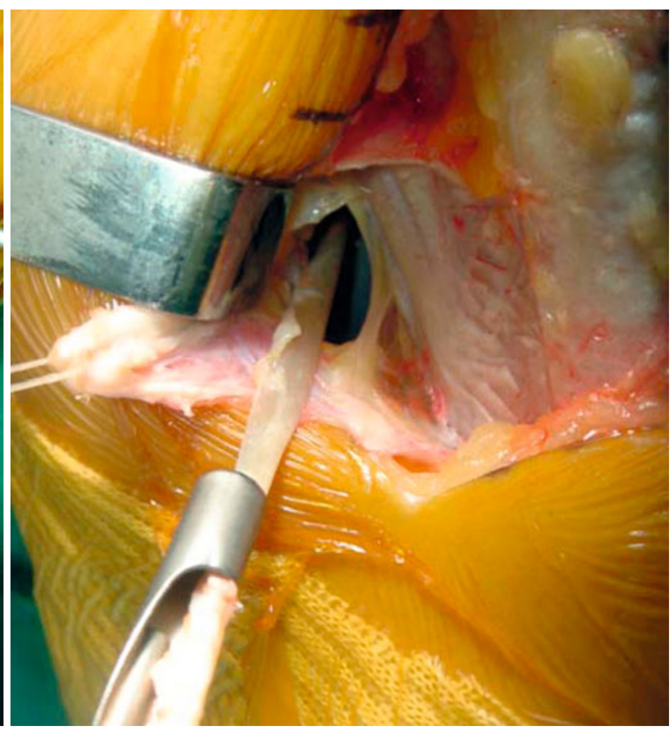


Fig. 30.22 Medial transfer measured using a ruler

Fig. 30.23 Postoperative x-ray

Fig. 30.24 Three small incisions are needed for MPFL reconstruction





Figs. 30.25 and 30.26 Harvest of the semitendinosus tendon

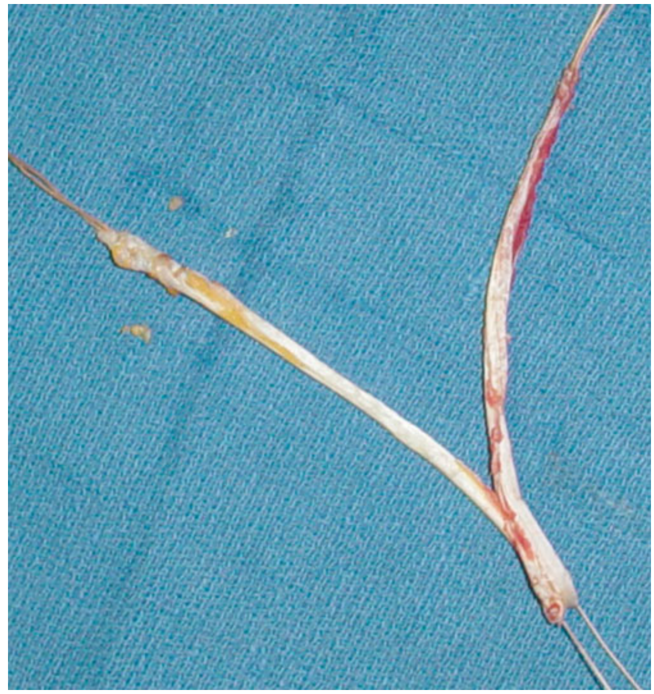


Fig. 30.27 Graft preparation

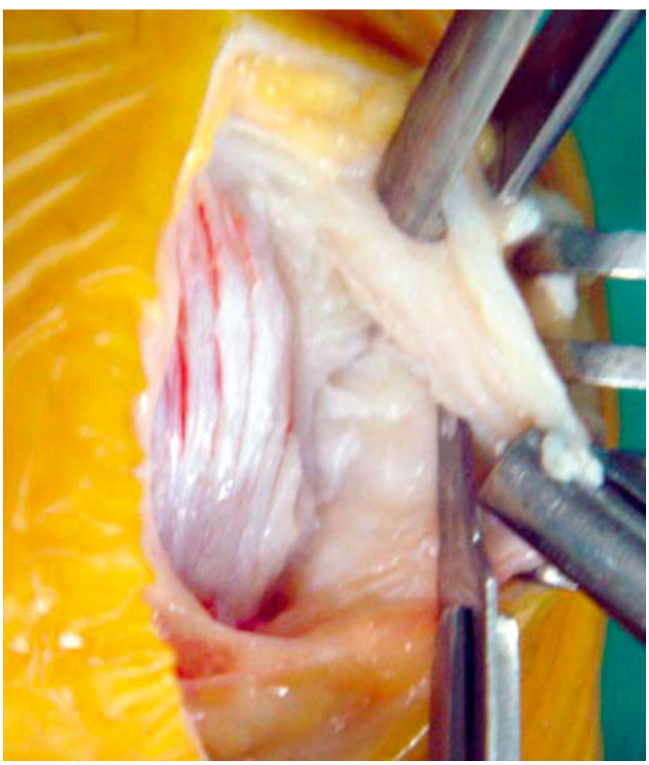


Fig. 30.28 Exposure of the medial third of the patella

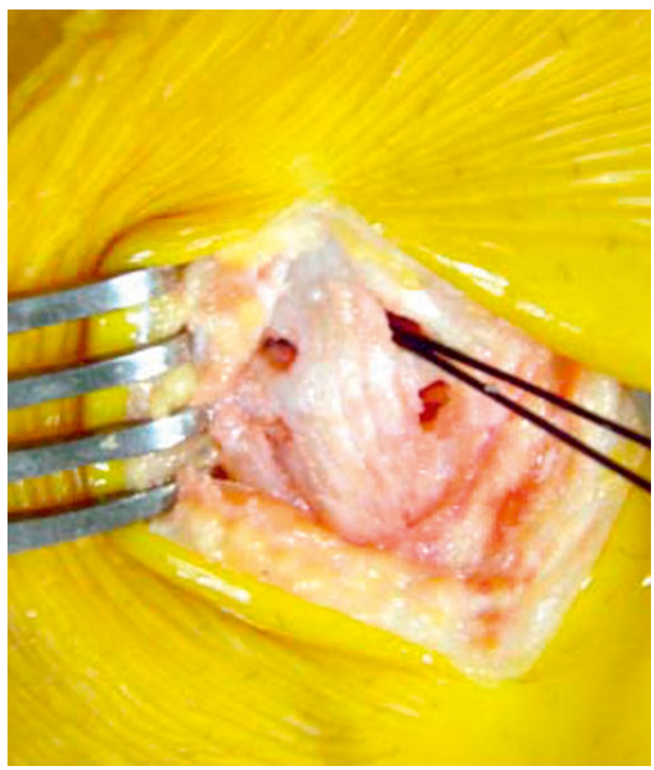


Fig. 30.29 Patellar tunnels

Fig. 30.30 Guide pin passed proximally to the medial epicondyle

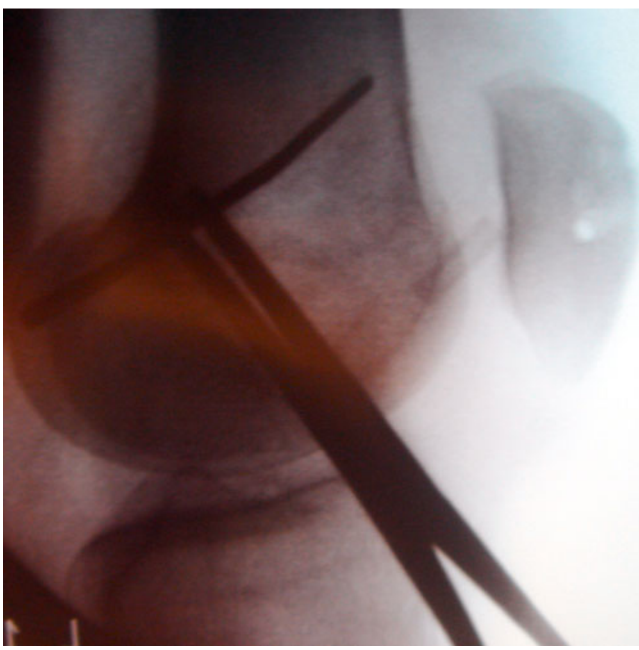


Fig. 30.31 Intraoperative fluoroscopic control

Fig. 30.32 Femoral fixation using absorbable screw

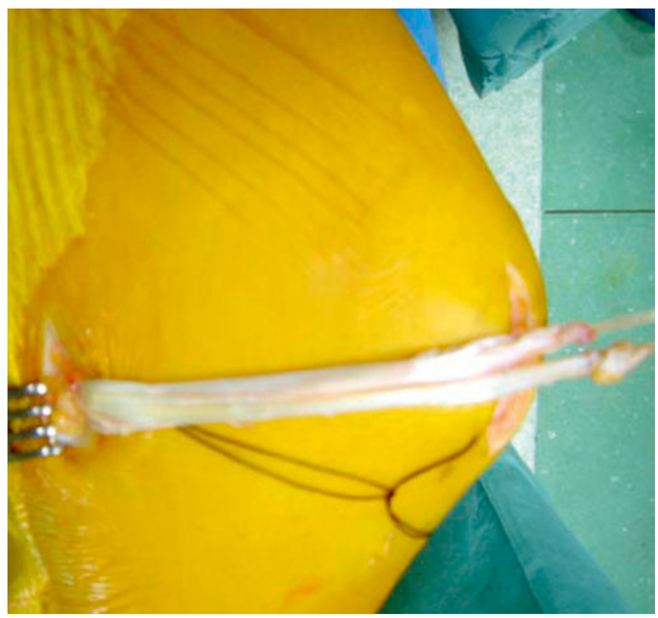


Fig. 30.33 The two bundles are long enough

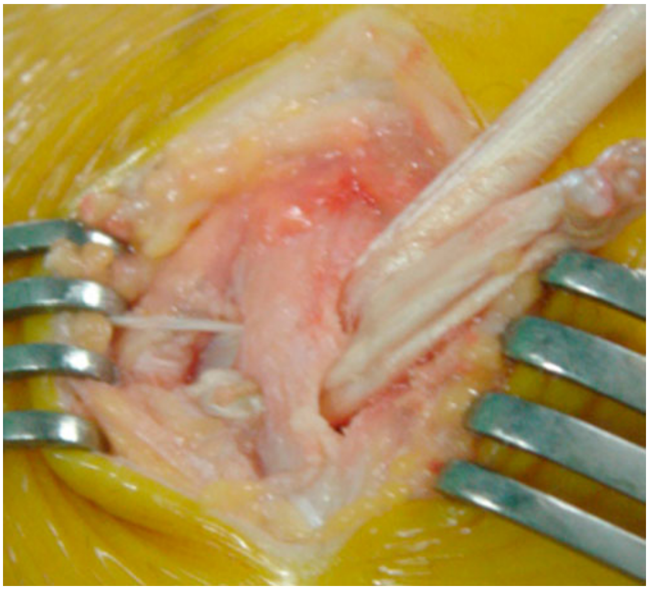


Fig. 30.34 The two free extremities of the graft are passed into the patellar tunnels

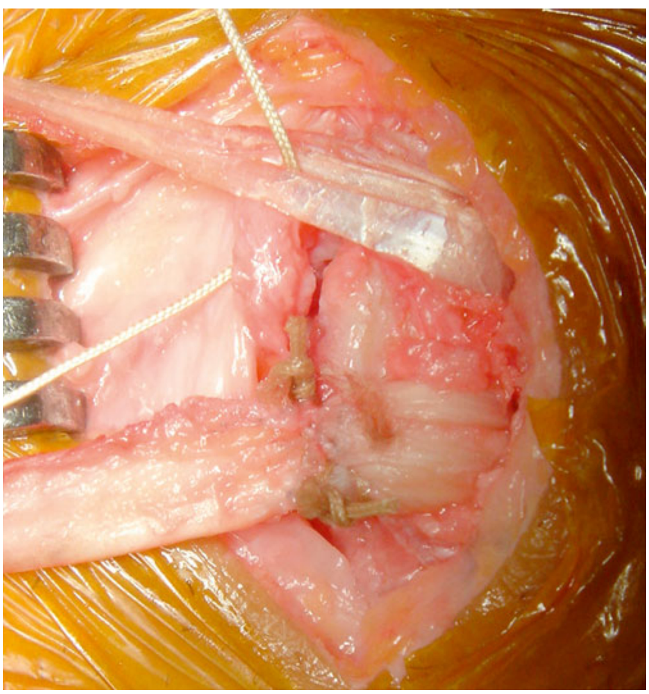


Fig. 30.35 Suture side to side

Postoperative Care

Prophylactic antibiotics are administered for 24 h. LMWH thromboprophylaxis is continued for 10 days. Ice is generally applied for 5 days, until discharge. A 30° splint is used at night and between periods of walking and physiotherapy. Protected full weight bearing is allowed immediately using crutches.

In the case of a TTT osteotomy, a locked splint in extension must be used for walking until radiographic evidence of consolidation is found. Daily physiotherapy consists of active isometric quadriceps contractions with good patellar ascension and medial-lateral patellar mobilization. Passive flexion is initiated early, but must be limited at 95°.

In case of MPFL reconstruction, protected (crutches) full weight bearing is allowed on the first postsurgical day. Knee flexion is unlimited.

After 45 days or when bone consolidation is obtained, the patient returns to normal walking, avoiding stairs. Full flexion must be recovered. After 60 days, normal activities of daily life and driving are started. Forced kneeling is avoided for 6 months. Open kinetic chain exercises are indicated. Patient can commence sports activities after 4 months. Jumping is not allowed until 6 months. In the case of a combination of procedures, rehabilitation is limited by the most demanding procedure.

Complications

The most frequent complication, inherent to all kinds of EPD surgery, is hematoma. It can cause intense pain and can lead to wound dehiscence and infection. This problem can be avoided with careful coagulation and the use of a vacuum drain. As in any surgical procedure, infections can occur in EPD procedures. Complex regional pain syndromes may arise after surgery and may result in a patella infera (Fig. 30.36). A prominent screw head usually causes discomfort or pain. Countersinking of the screw head is sufficient to prevent this problem.

Failure to obtain sufficient TT osteotomy fixation can result in migration, delayed union, or nonunion. If this is the case, a revision operation must be performed. It is of major importance to always use a screw 2 mm longer than the measured drill trajectory in order to provide adequate fixation (Fig. 30.37). Fractures of the tibial shaft can occur when the ATT osteotomy cuts are too aggressive, especially the distal cut, even several weeks after surgery (Fig. 30.38).

Undercorrection can result in persistent instability and dislocation. Insufficient distalization or medialization and suboptimal tensioning of the MPFL reconstruction or of the VMO plasty can also result in this situation.

Overcorrection can be even worse. Patients usually present with pain and with signs of medial patellar impingement. Patella baja is a further complication of overcorrection, leading to increased patellar pressures and pain. These complications frequently cause more disability than the instability itself (Fig. 30.39a, b). Procedures including a TT osteotomy can lead to nonunion. Its risk can be minimized with a TT fragment larger than 6 cm.

The MPFL reconstruction can cause an avulsion fracture of the medial border of the patella.

Fig. 30.36 Patella infera

Fig. 30.37 Tibial tubercle nonunion

Fig. 30.38 Tibial shaft fracture

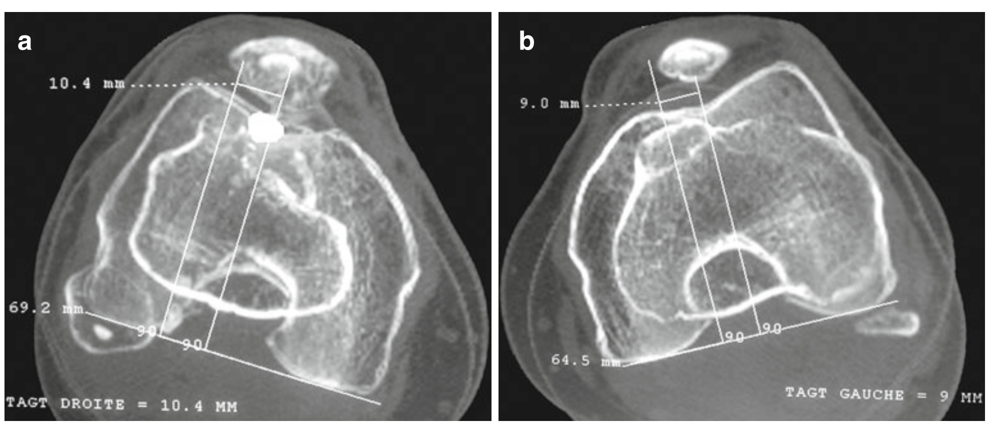


Fig. 30.39 (**a**) Postoperative TT-TG distance = 10.4 mm; (**b**) on contralateral side, overcorrection with a TT-TG distance = −9 mm

Deepening Femoral Trochleoplasty

31

E. Servien and P. Archbold

Introduction

With the exception of the trochleoplasty, the management of episodic patellar dislocation (EPD) has been described in the previous chapter. The Lyon school believes that although trochlear dysplasia is the primary problem in EPD addressing the principal factors of a high TT-TG, patella alta and patellar tilt is usually sufficient to obtain stability. Trochleoplasty is a technically demanding procedure that is rarely required. Its indications include patients with habitual dislocation of the patella (Fig. 31.1) and abnormal tracking of the patella or in revision surgery. It can also correct a severe dysplasia with a femoral groove prominence of >6 mm. It is always combined with another surgical procedure to correct the other contributing factors of the instability.

Fig. 31.1 Habitual dislocation of the patella

E. Servien, MD, PhD
Albert Trillat Center, Croix Rousse Hospital,
Lyon 69004, France
e-mail: elvire.servien@chu-lyon.fr

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis road, Belfast BT95JH, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_31, © Springer-Verlag London 2014

The Principles of the Deepening Trochleoplasty

H. Dejour and G. Walch believe that the primary problem in trochlear dysplasia is a prominent trochlear floor that causes it to be flat. The technique therefore consists of a deepening trochleoplasty (Fig. 31.2). This improves engagement of the patella in the trochlear groove in the early degrees of flexion.

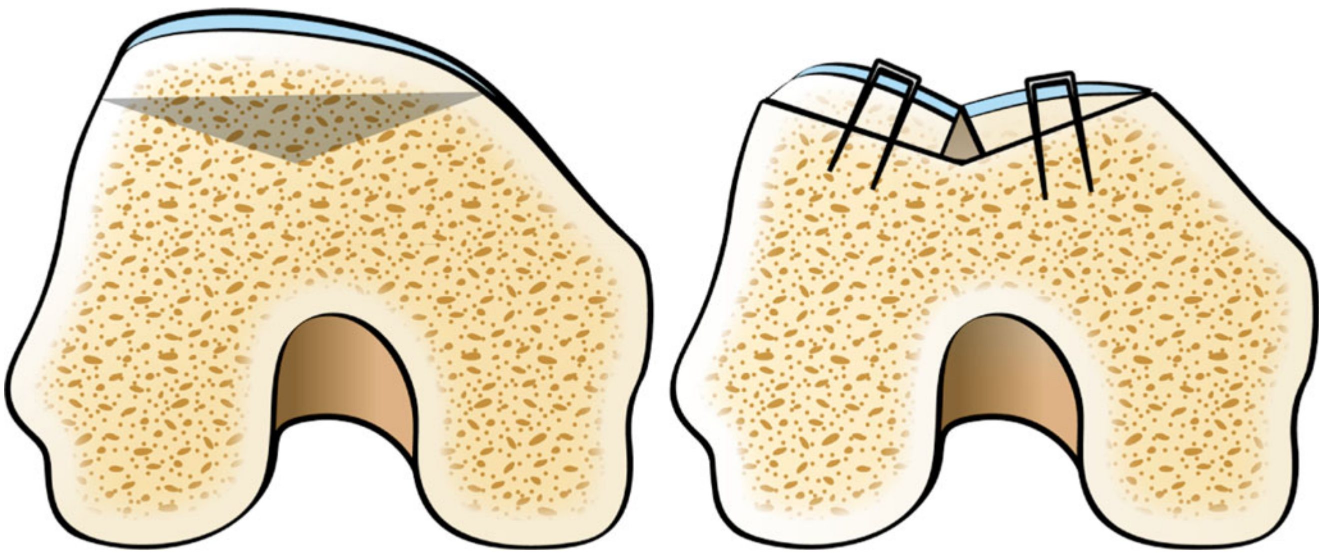


Fig. 31.2 The deepening trochleoplasty

Incision

The trochleoplasty is performed using an anteromedial approach. Following an anteromedial arthrotomy, the patella is everted.

Planning

The key to performing a successful trochleoplasty is precise intraoperative planning. Elevation of the synovium on the anterior cortex of the distal femur is performed to expose the upper edge of the trochlear groove. A marker pen is then used to define the center of the new groove, extending from the upper edge of the trochlea to the center of the notch. The medial and lateral facets are then marked (Fig. 31.3).

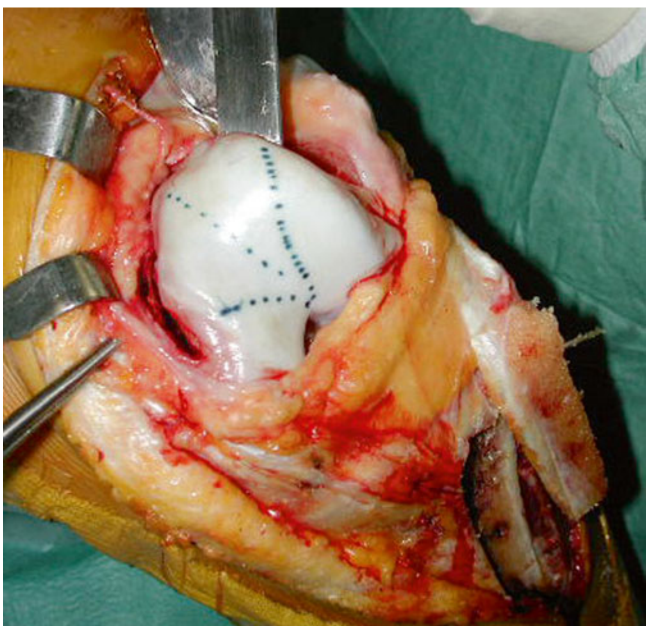


Fig. 31.3 Intraoperative planning of the trochleoplasty

Deepening

Once the walls of the trochlea have been exposed, periosteal stripping is performed around its edge. Using a 10 mm osteotome, the cortical bone is removed, to make a trench of 3–4 mm, from around the upper part and lateral and medial walls of the trochlea. This exposes the underlying cancellous bone (Fig. 31.3). The cancellous bone immediately underlying this is removed with a curette.

A power burr (Fig. 31.4a, b) equipped with an adjustable stylus is now used to complete the deepening trochleoplasty. It is used to determine the appropriate resection depth, avoid penetration of the cartilage, and avoid damage to the cartilage due to heat generation. A minimum residual thickness of about 4 mm consisting of cartilage and a thin layer of subchondral bone is recommended to achieve a bone surface that will be easy to fashion. The remaining cancellous bone is removed using a small curette. The cancellous bone bed should extend as far as to the roof of the femoral notch. Once proper trochlear depth has been achieved, attention is directed to the preparation of the medial and lateral facets.

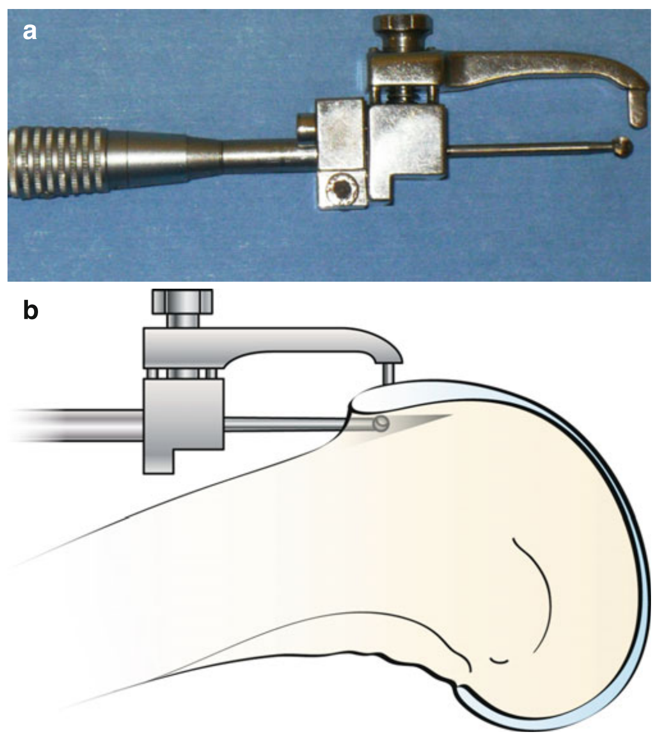


Fig. 31.4 The power burr

Trochleoplasty

A cut is made in the middle of the trochlear groove using a scalpel (Fig. 31.5). This allows bone shell impaction into the new sulcus. The new facets are then fixed with two metal staples at its upper end (Fig. 31.6a, b). Patellar tracking is checked again.

Closure

The synovial tissue is then sutured back onto the edges of the trochlea. The clips can be easily removed (usually at least 3–6 months later) under arthroscopy.

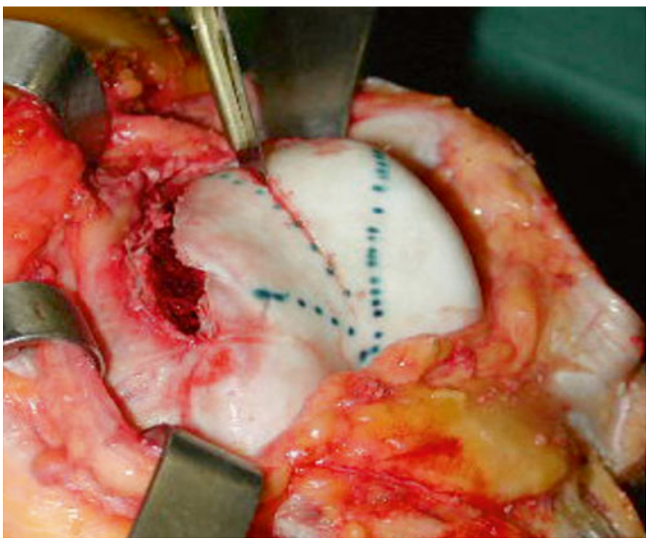


Fig. 31.5 Marking out the trochlear groove

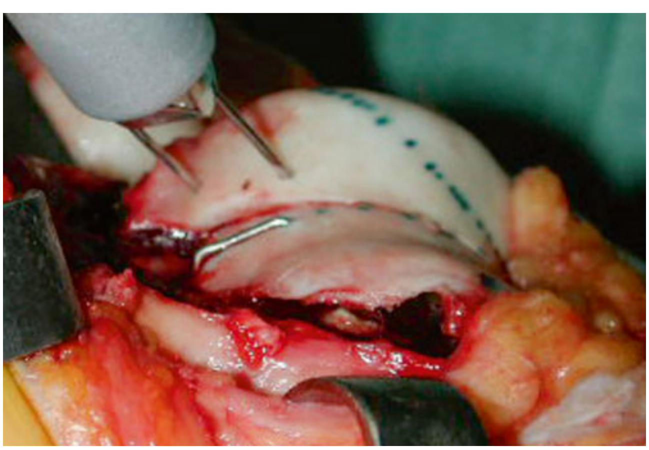


Fig. 31.6 Fixation of the trochleoplasty

Postoperative Care

The rehabilitation protocol is dictated by whether the trochleoplasty was combined with a distal transfer or medialization of the tibial tubercle (TT). In the absence of surgery to the TT, immediate weight bearing with no restriction of movement is allowed. In the presence of a distalization or medialization of the TT, flexion is limited to 95° for 45 days. Flexion beyond 95° is allowed once consolidation has been achieved (Fig. 31.7a, b).

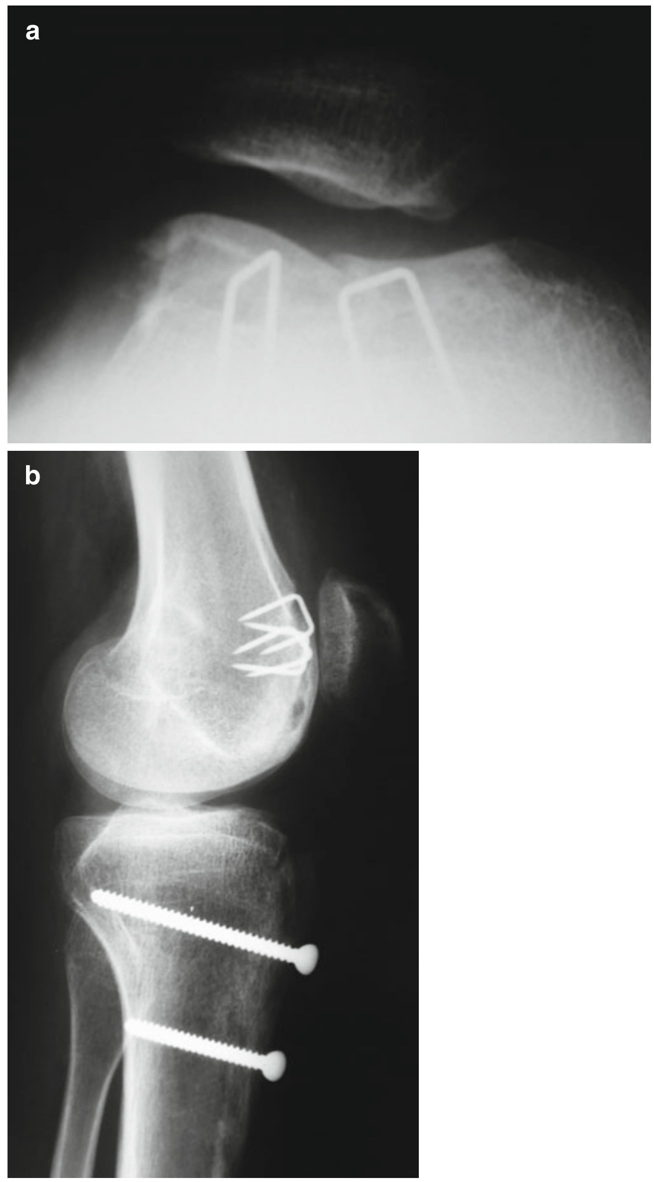


Fig. 31.7 Postoperative x-ray

Reflections on the Deepening Trochleoplasty and Future Directions

The greatest concern in the development and use of this technique over the past 20 years has been the risk of necrosis to the cartilage of the trochlea. Over this period, the technique has changed little due to the lack of industrial support and the little time invested by surgeons to improve it. This is unfortunate as this technique addresses the principal abnormality found in EPD. Its reproducibility and accuracy could be optimized by computer-assisted surgical techniques. However, at present due to the technical demands of this procedure, there remains a reluctance to perform this surgery.

Shortening the Patellar Tendon

32

E. Servien and P. Archbold

In patella alta associated with an excessively long patellar tendon, it is more logical to shorten the patellar tendon than to distalize the tibial tubercle (TT). We have therefore developed a technique to correct this anomaly. It is particularly indicated in patients who are skeletally immature in which a TT transfer would be contraindicated. However, it must be used with caution. It is not a conventional Z-plasty as it has the advantage of maintaining the integrity of the posterior half of the patellar tendon, limiting the risk of rupture postoperatively. It is often combined with an MPFL reconstruction. Jack Andrish has recently described a similar technique.

Incision

A 30–35 mm midline parapatellar incision is made. Medial and lateral full thickness flaps are elevated to fully expose the patellar tendon. The prepatellar bursa and paratenon are incised and the medial and lateral edges of the tendon are defined and it is measured (Fig. 32.1).

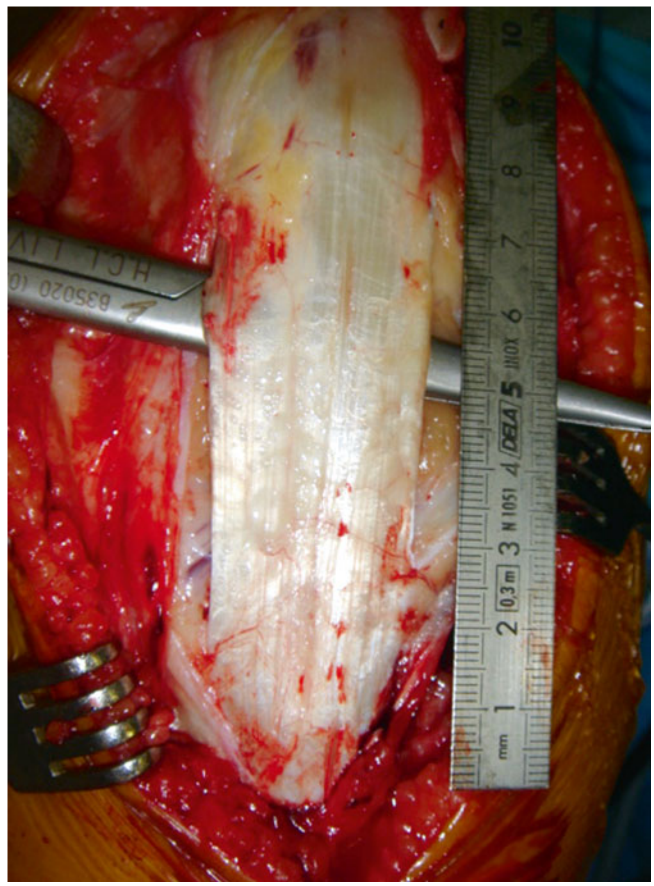


Fig. 32.1 Surgical exposure of the patellar tendon and measurement of its length

E. Servien, MD, PhD
Albert Trillat Center, Croix Rousse Hospital, Lyon 69004, France
e-mail: elvire.servien@chu-lyon.fr

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis road, Belfast BT95JH, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_32, © Springer-Verlag London 2014

Preparation of Tendon

The planned shortening is marked on the tendon at the level of the partial tenotomy (Fig. 32.2). In this example the tendon is to be shortened by 25 mm. The upper and lower boundaries are clearly marked. This tenotomy is performed in the central portion of the tendon (relative to its patellar and tibial insertions).

The tendon is cut horizontally along the distal line, perpendicular to the direction of its fibers. It is incised carefully with a scalpel to a depth of 50 % of its thickness. A tendinous sheet is then progressively raised in the direction of the fibers over a length of 25 mm (Fig. 32.3).

To repair and shorten the tendon, a nonabsorbable suture, FiberWire®, is used. Two to three sutures are passed from the proximal tendon to the distal tendon and then back into the proximal tendon under the raised 25 mm sheet of tendon.

Fig. 32.2 The planned amount of shortening

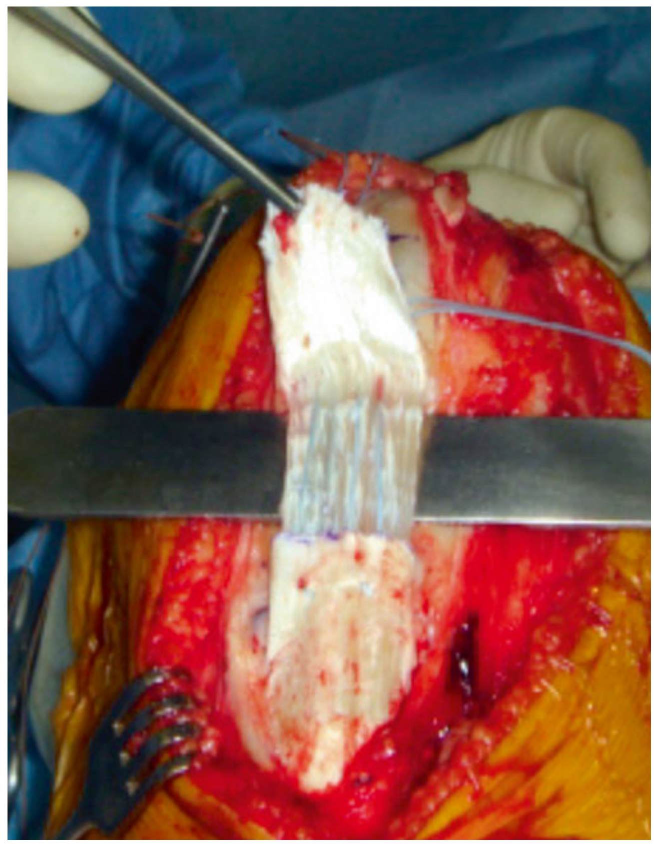


Fig. 32.3 Elevation of the sheet of patellar tendon

Shortening (Fig. 32.4)

To shorten the tendon, these sutures are pulled tight in the proximal part of the tendon and held with a Kocher (Fig. 32.5). The 25 mm raised sheet of tendon is then sutured onto the front of the distal surface of the tendon with at least three separate passes through the entire thickness of the tendon (Fig. 32.6). The sutures are tied at 90° of flexion to fix the shortening (Fig. 32.7). Patellar tracking is checked. The paratenon is closed with absorbable suture.

Postoperative

Full weight bearing is permitted in an extension brace for 21 days. Flexion is limited to 90° for 45 days.

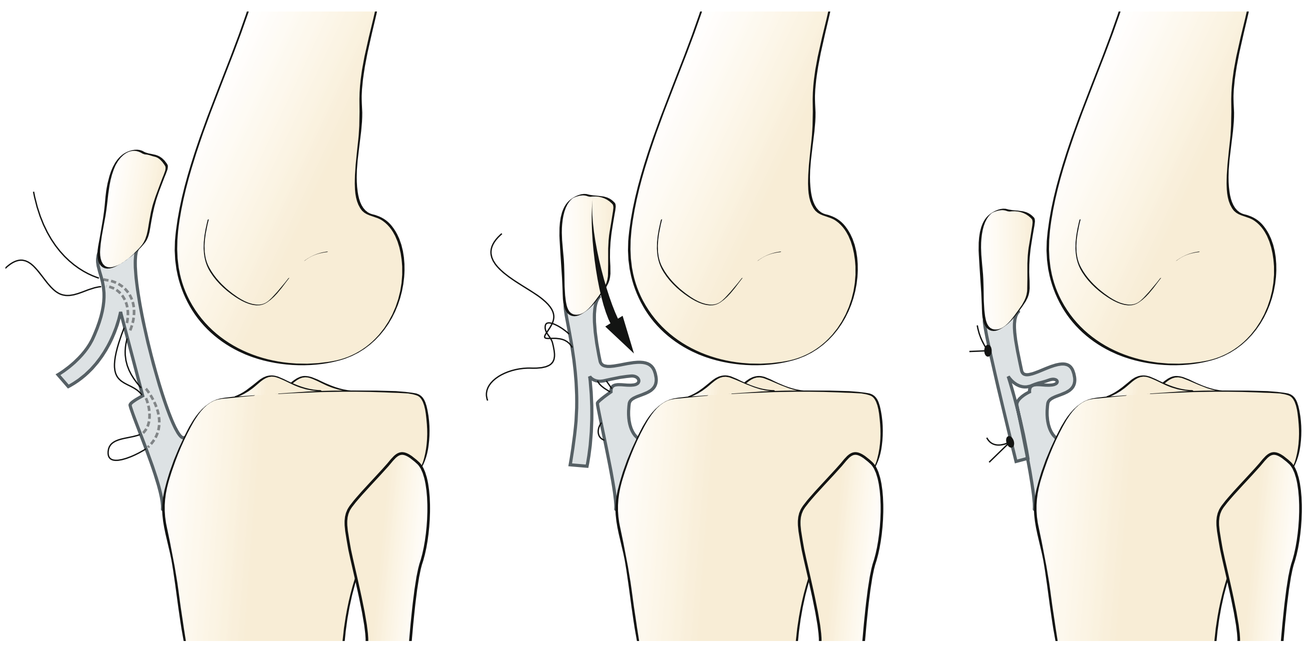


Fig. 32.4 The technique used to shorten the tendon

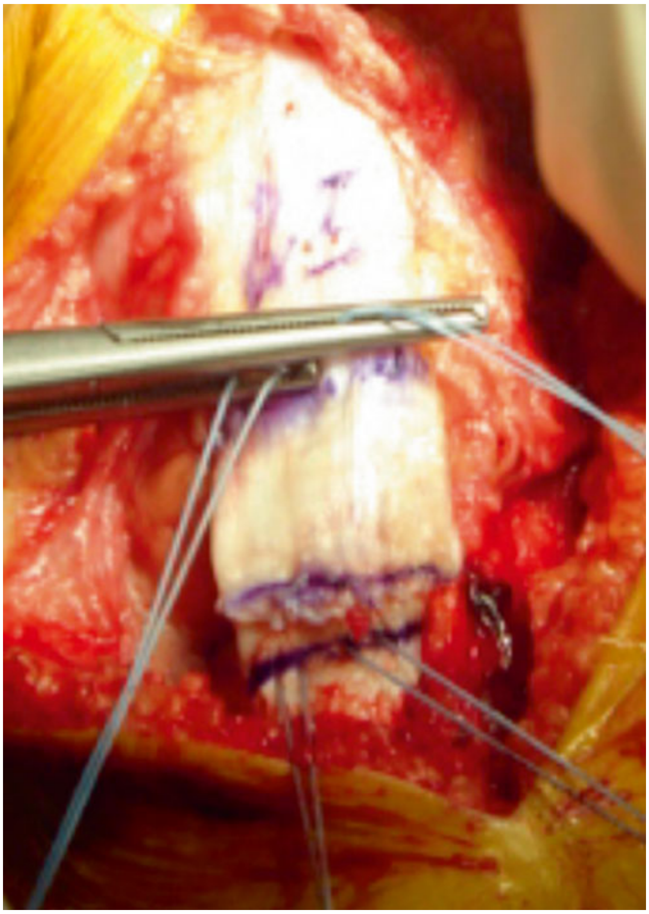


Fig. 32.5 Intraoperative shortening

Fig. 32.7 Suture fixation of the shortening

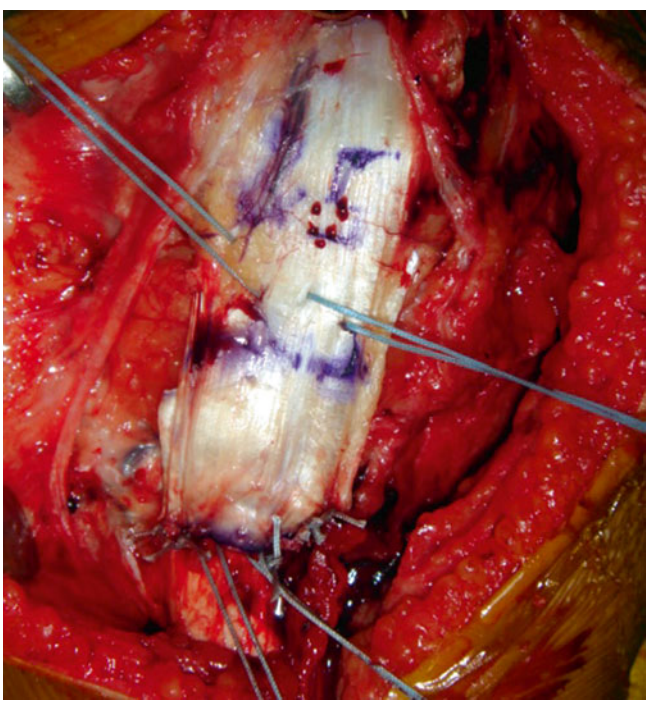


Fig. 32.6 The placement of the sutures

33 Acute Ruptures of the Quadriceps and Pateller Tendons

G. Demey and Robert A. Magnussen

After patellar fractures, rupture of the quadriceps tendon is the most common cause of a disruption of the extensor mechanism. Sixty percent of quadriceps tendon ruptures occur through the tendon and 40 % occur due to avulsion of the tendon from its insertion onto the patella. This latter injury was first described by Albert Trillat and is due to a periosteal sleeve avulsion at the quadriceps tendon insertion.

The typical history is of a knee injury associated with eccentric loading of the quadriceps tendon, such as tripping. Injury can be somewhat subtle and present late due to the ability of the retinaculum to transmit some load through the extensor mechanism. Bilateral ruptures often have predisposing factors that lead to tendon degeneration such as the use of corticosteroids, renal dialysis, or a history or treatment with fluoroquinolone antibiotics. It is a diagnosis that is often missed and must always be in the back of the clinician's mind particularly following trauma to the knee. MRI and ultrasound are useful to diagnose and determine the extent of the tear.

Indication

Surgical treatment is the rule. It is a relative surgical urgency, as a delay of more than a few days leads to quadriceps contracture and scarring. This scarring makes the repair more difficult leading to an increased incidence of stiffness and places the repair under greater stress during knee flexion.

Surgical Technique

The goal of surgery is to repair the rupture "fiber by fiber." The repair must be strong enough to allow early rehabilitation. Reinforcement with a semitendinosus or patellar tendon graft is necessary when the surgical repair is insufficient to allow 90° of knee flexion.

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
Suite 3100, 2050 Kenny road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_33, © Springer-Verlag London 2014

Patient Positioning and Setup

The patient is positioned on the operating table in the supine position. A horizontal post is positioned distally on the table to hold the knee in a 70° flexed position when the heel rests against it and about 90° when the toes are resting on it. A lateral support holds the knee in this position. The surgery is performed under a tourniquet. The rupture is easily palpated with the in knee extension. The knee is then flexed to 90°.

The technique described is a direct repair without reinforcement. A midline longitudinal incision centered on the tear and extending distally to expose the upper edge of the patella is made. If the paratenon is intact, it is split longitudinally to expose the tear and the hematoma is evacuated (Fig. 33.1a). The ends of the tear are carefully identified and mobilized by dissecting medially and/or laterally as required (Fig. 33.1b).

Once the tear has been fully exposed, we place sutures in the tendon as follows: starting in each end of the tear, number 2 FiberWire® sutures are placed in a locking whipstitch manner (Fig. 33.2). Two such sutures should be placed into both the proximal and distal stumps, resulting in four strands exiting the end of each stump (Fig. 33.3). The knee is then placed in extension and the sutures are tied across the rupture, opposing the torn ends of the tendon together (Fig. 33.4). Four sutures crossing the gap are required to provide sufficient strength. Further strength is added by reinforcing the repair with additional 0 Vicryl sutures around the repair site in an interrupted fashion.

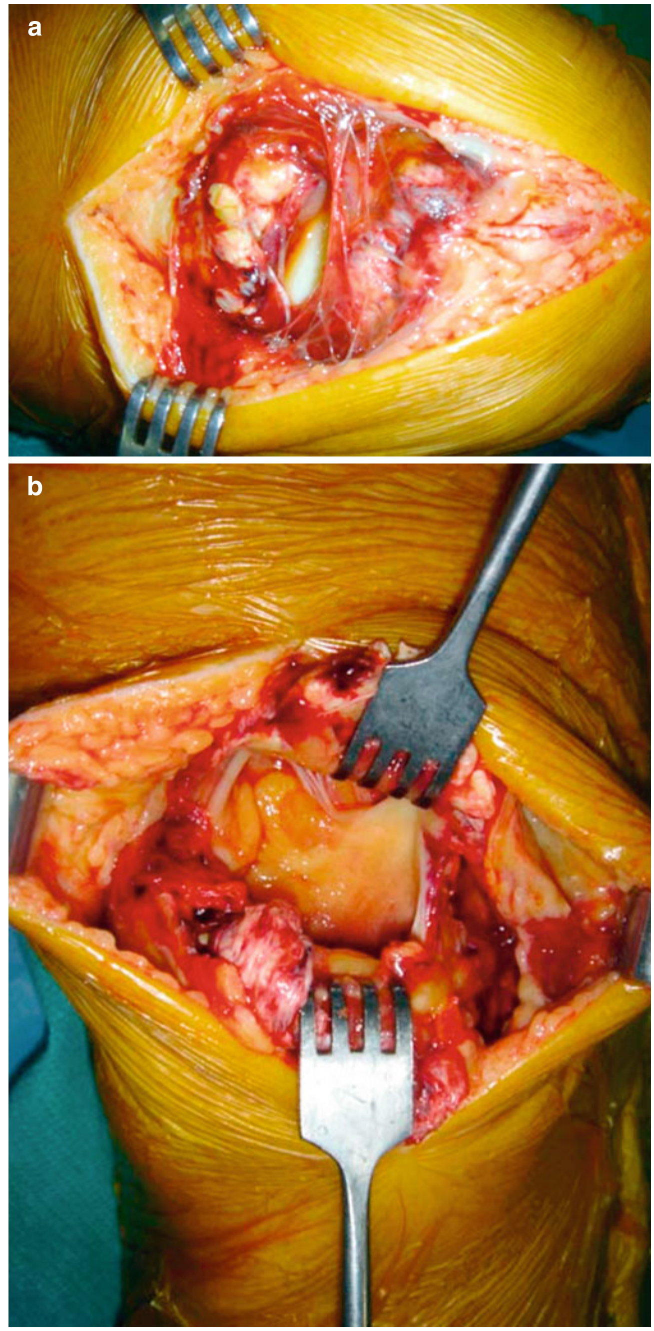


Fig. 33.1 (**a**, **b**) Exposure of the tear and evacuation of the hematoma

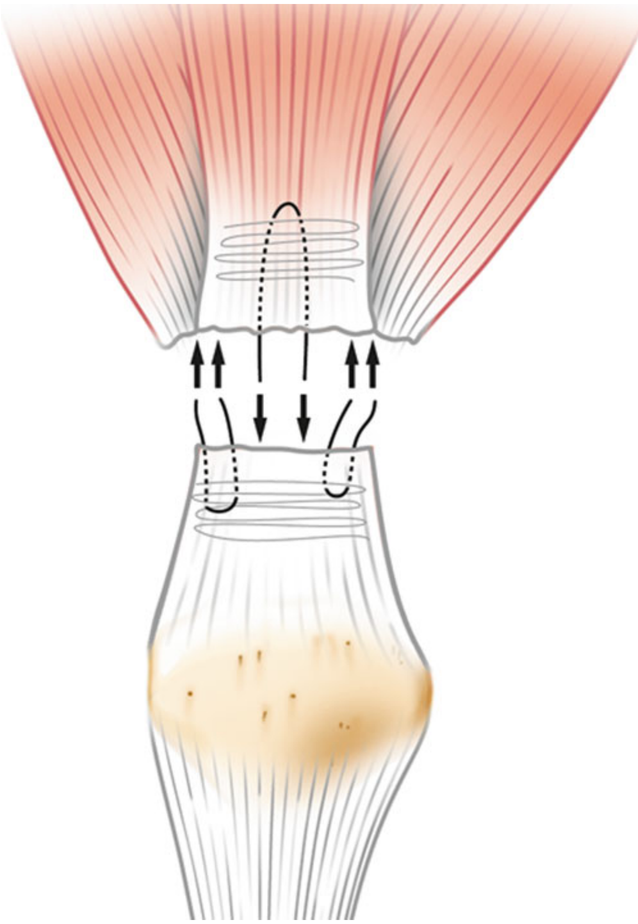


Fig. 33.2 Sutures placed in a locking whipstitch manner

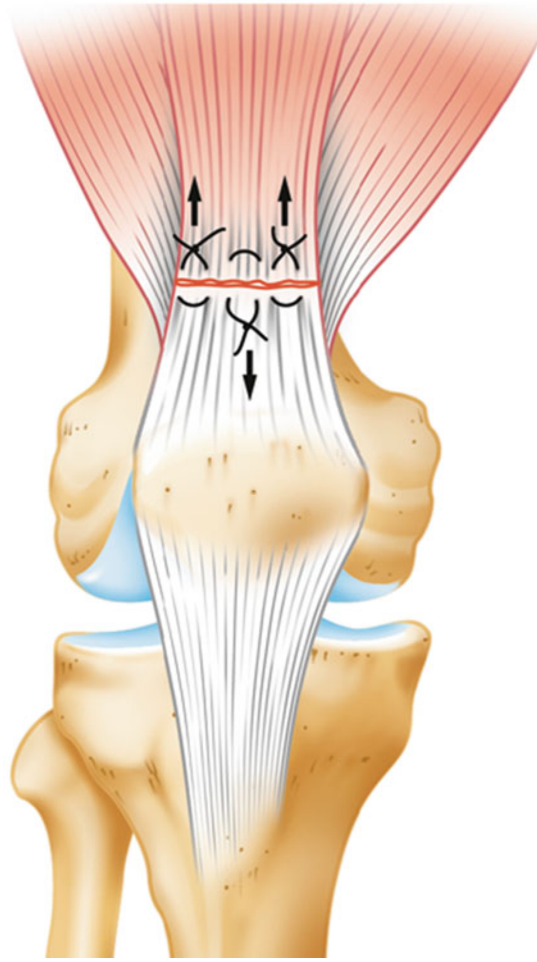


Fig. 33.3 Sutures crossing the gap

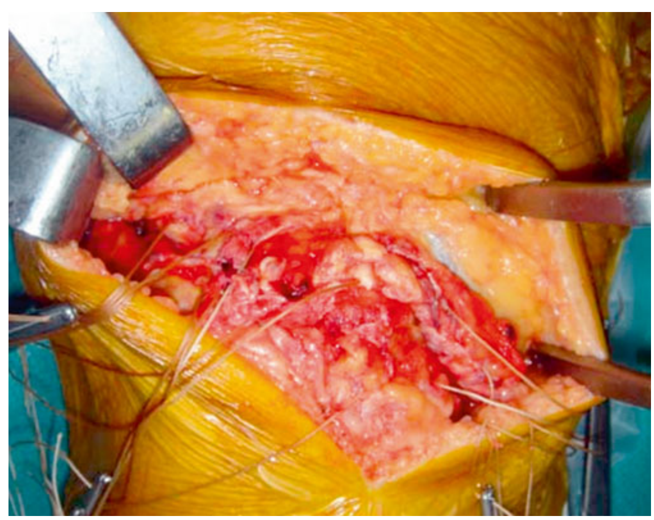


Fig. 33.4 Appearance before the sutures are tied across the rupture

Osteotendinous Tear

When the disruption occurs at the osteotendinous junction, the incision is extended distally to expose the patella (Figs. 33.5 and 33.6). Full thickness flaps are elevated to expose the extent of the tear (Fig. 33.7). The proximal pole of the patella is debrided of necrotic or frayed tissue and the quadriceps tendon is mobilized (Fig. 33.8). The periosteal sleeve is opened longitudinally for 1 cm and elevated to expose the patella (Fig. 33.9a, b). Three 2.5 mm transosseous tunnels are drilled in the proximal pole of the patella (Fig. 33.10). These are started on the upper surface of the patella 1 cm from its proximal edge and exit through the midpoint of the proximal pole, taking care not to damage the articular surface (Fig. 33.11). FiberWire® sutures are then placed through the proximal tendon stump in a whipstitch manner as described above and then passed through the transosseous tunnels and back into the tendon (Figs. 33.12 and 33.13). These sutures are tied in extension (Figs. 33.14 and 33.15). The periosteal flaps are closed with a suture passing through the medial and lateral part of the tendon. Multiple interrupted 0 Vicryl sutures are placed along the width of the tear to reinforce the repair (Fig. 33.16) and the medial and lateral retinacular defects are closed.

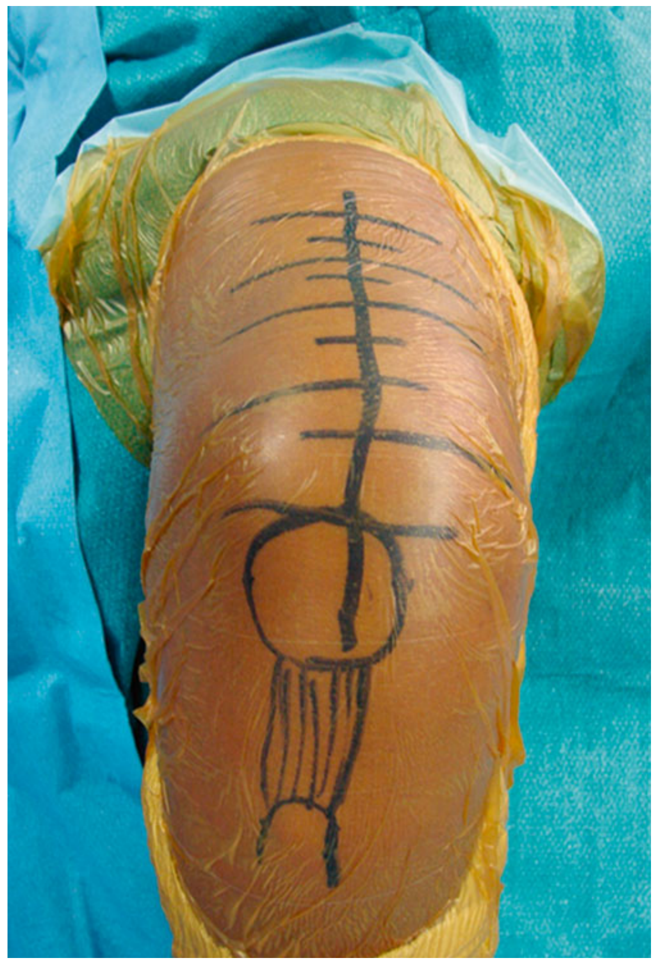


Fig. 33.5 Skin incision

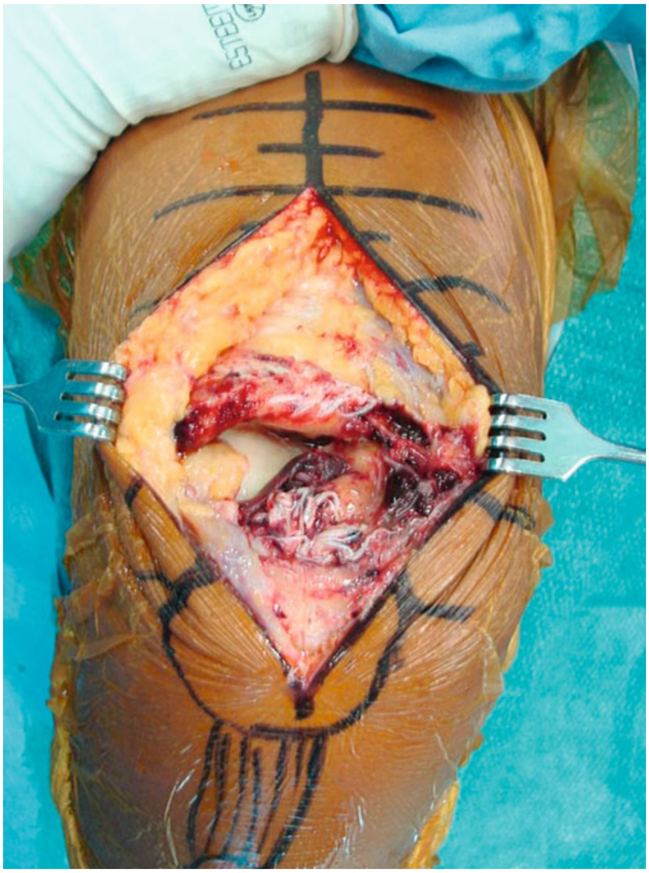


Fig. 33.6 The surgical exposure required for the repair of an osteotendinous avulsion of the quadriceps tendon

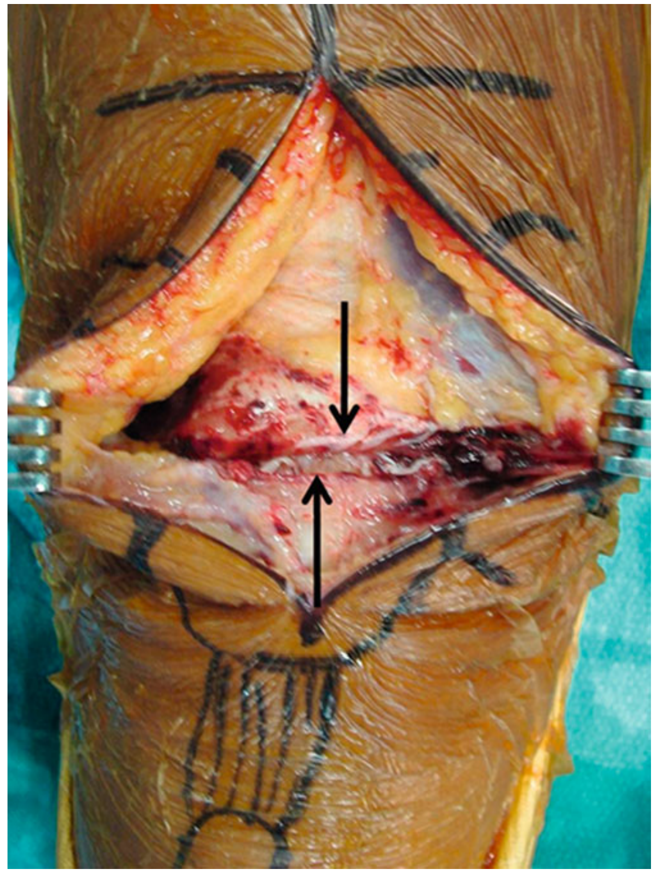


Fig. 33.7 Completed repair of the avulsion - note the tendon now reduced to the superior pole of the patella (*arrows*)

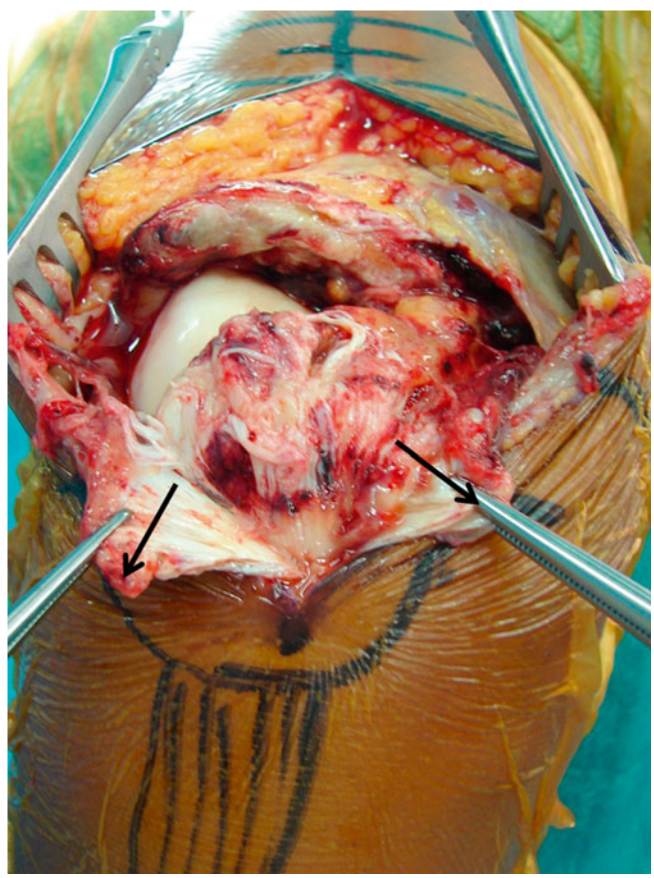


Fig. 33.8 Splitting the overlying tissue longitudinally and pulling traction distally and away from the center of the patella (*arrows*) facilitates exposure of the patella

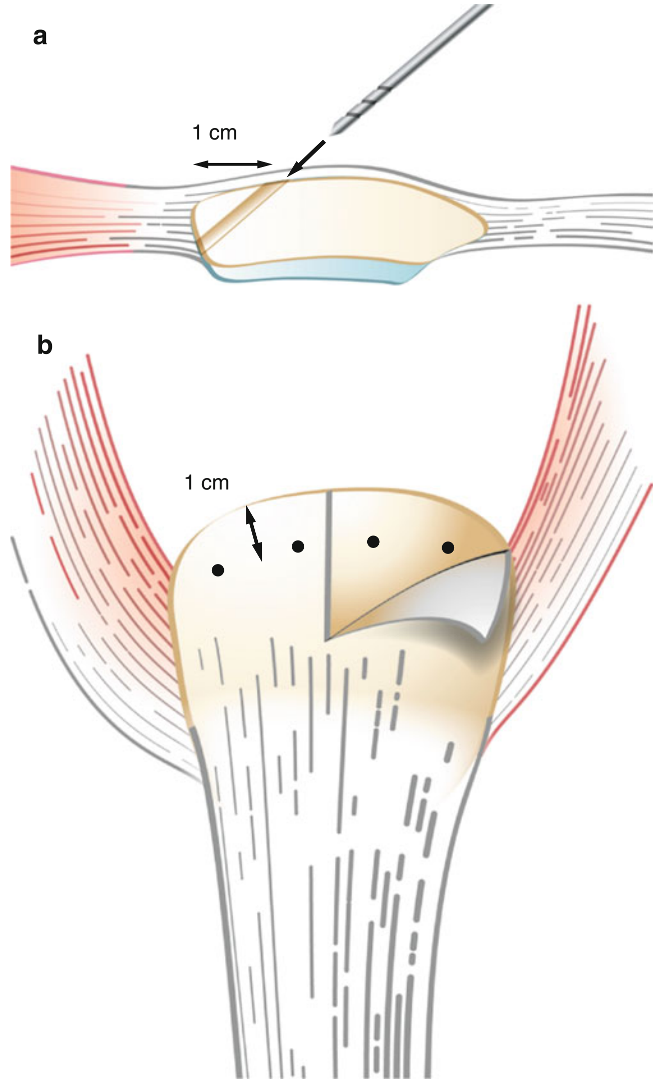
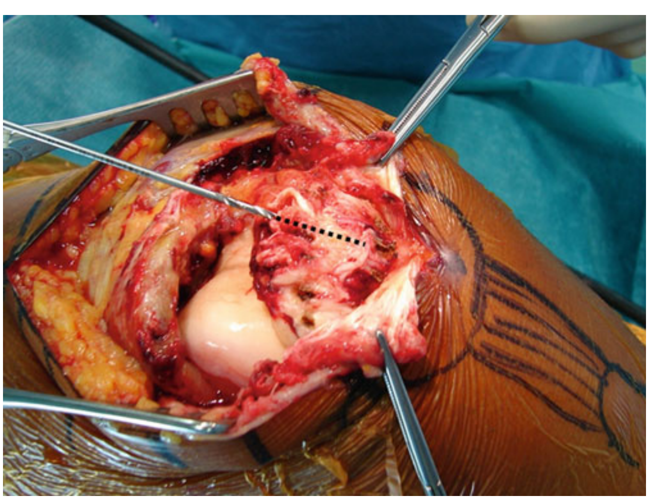
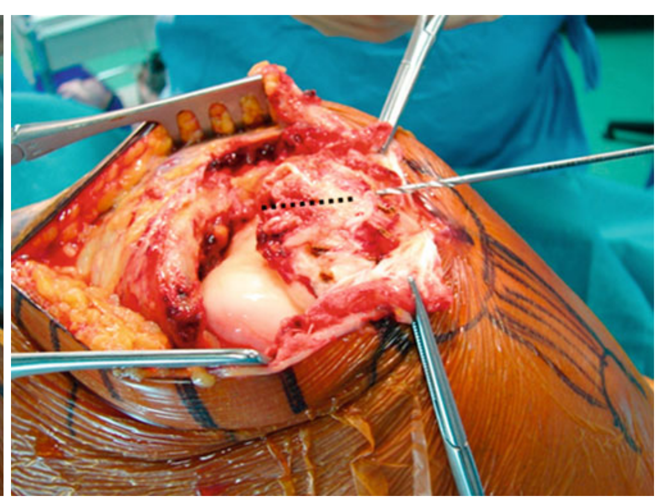


Fig. 33.9 (**a**, **b**) Direction of the transosseous patellar tunnels





Figs. 33.10 and 33.11 Creation of transosseous patellar tunnels with a 2.5 mm drill. The direction of the tunnels is marked (*dotted lines*)

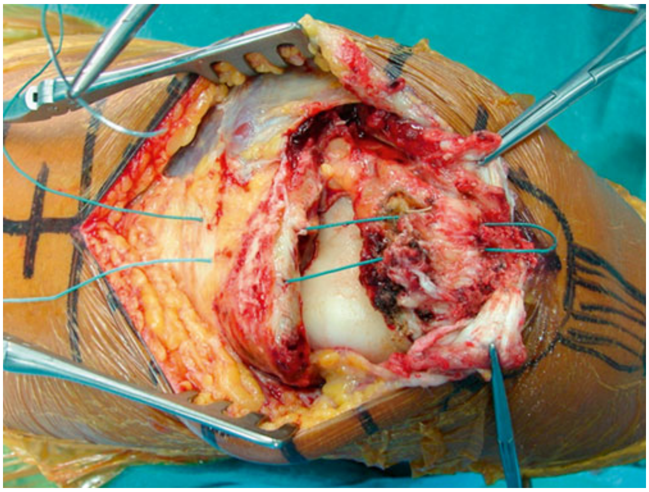


Fig. 33.12 A suture passing through a tunnel into the quadriceps tendon

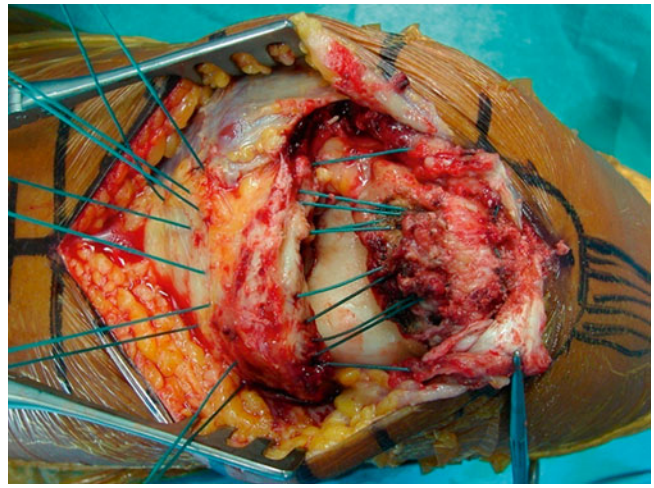
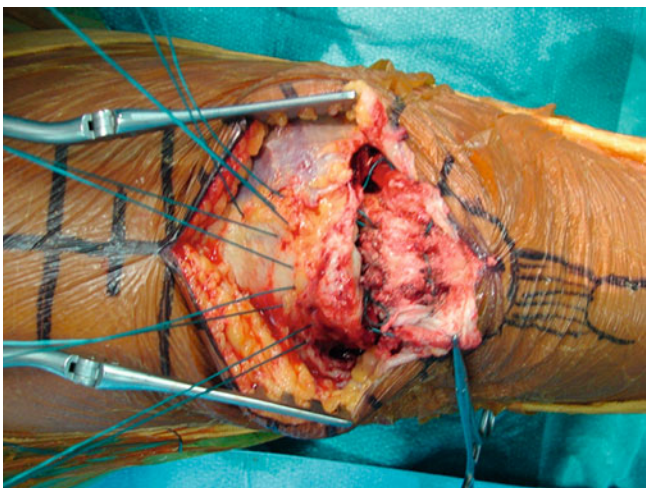
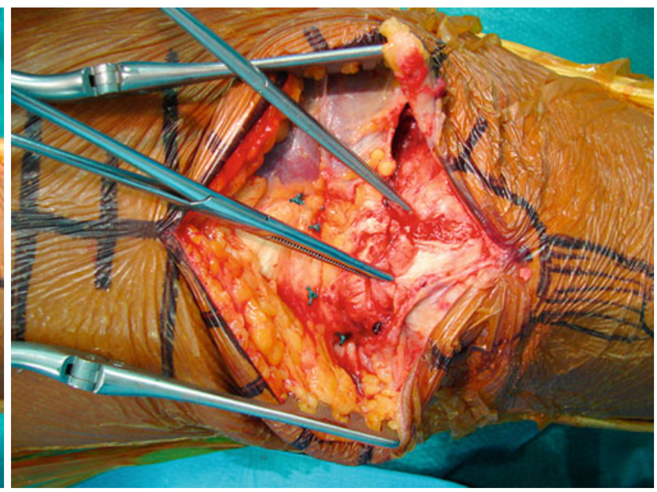


Fig. 33.13 All the sutures in place before being tied





Figs. 33.14 and 33.15 The sutures are tied in extension

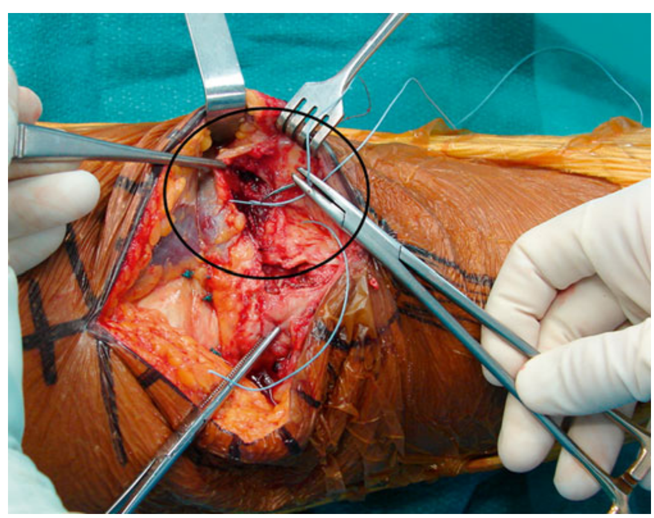


Fig. 33.16 Surgical closure of the periosteum and retinacular defects

Postoperatively

The strength of the repair is tested up to 90° of flexion (Fig. 33.17). A drain is placed and the closure is achieved at 70° of flexion. The wound is dressed with a compression bandage, which is removed after 1 h. An AP and lateral radiographs of the knee are requested and DVT prophylaxis is undertaken for 15 days. Prophylactic antibiotics are prescribed for 24 h and skin staples are removed on the 15th postoperative day.

Two removable splints are used for the first 45 days: a splint at 30° flexion for rest and an extension brace for mobilization. Physiotherapy is started early with the aim of achieving knee flexion to 90° by day 45 according to the following:

- 0–45° from D0 to D15
- 0–70° D16 to D30
- 0–90° D31 to D45

Full flexion is not allowed before 6 months. Caution is recommended in descending stairs (ramp or step by step) for 4–6 months.

Fig. 33.17 Testing the strength of the repair at 90° of flexion

Acute Repairs of the Patellar Tendon

Patellar tendon ruptures are rare. It is usually a relatively easy diagnosis to make. Patients typically present with a history of a definite knee injury and an inability to walk. Physical examination reveals a high-riding patella (Fig. 33.18) with tenderness and bruising at the inferior aspect of the patella and a palpable defect in the tendon. Occasionally, the patient can perform a straight leg raise due to an intact extensor retinaculum; however, in this situation there will be an apparent extension lag. Most commonly, the patellar tendon is avulsed from the inferior pole of the patella and radiographs reveal patella alta (Fig. 33.19). Disruptions of the middle or distal insertion of the tendon are rare.

Fig. 33.18 A high-riding patella

Fig. 33.19 Patella alta secondary to avulsion of the patellar tendon from the inferior pole of the patella

Indication

Surgical repair is the rule. Unlike an acute rupture of the quadriceps tendon, direct repair of the patellar tendon does not facilitate early mobilization; therefore, we believe that reinforcement is always required. We achieve this by using a semitendinosus graft in front of the patellar tendon. PDS tape can also be used either alone or in combination with the semitendinosus according to the quality of the repair. We do not recommend the use of a cerclage wire as this is too rigid. It can cause sagittal malalignment of the patella and always requires removal, which carries a risk of re-rupture.

Surgical Technique

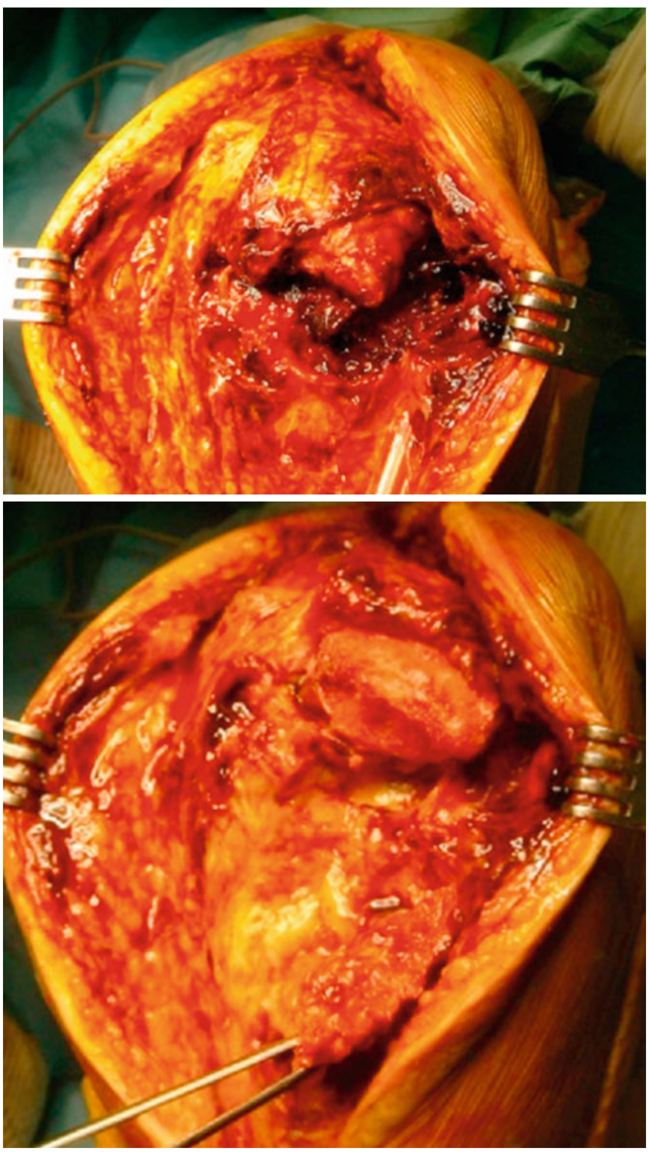
Preoperatively, radiographs of the contralateral knee should be obtained in 30° of flexion to measure patellar height with the Caton-Deschamps index. This allows an intraoperative comparison to be made with the aim of achieving an identical index to the normal knee.

The technique described below is for avulsions of the patellar tendon from the inferior pole of the patella. A longitudinal paramedian incision is made extending from distal end the of the quadriceps tendon to the tibial tuberosity. If possible, the paratenon should be identified and incised to expose the ruptured patellar tendon. The knee joint is frequently visible through the rupture and should be irrigated and inspected for damage. The ends of the frayed patellar tendon are cleaned and debrided (Figs. 33.20 and 33.21). The knee is placed in extension and the tendon ends are opposed.

Suture and Mesh Reinforcement Using PDS®

FiberWire® sutures are placed through the tendon. These sutures are tied in a semiflexed position. Multiple interrupted no.0 Vicryl sutures are placed along the width of the tear to reinforce the repair (Fig. 33.22) and the medial and lateral retinacular defects are closed.

If following this repair there is no separation of the tendon ends, the repair is reinforced by a strip of PDS® tape placed on the anterior aspect of the tendon. Biomechanically, the tape changes the forces of distraction to compression. It is folded in half and is fixed to the tibial tuberosity using an Orthomed® staple. The two strands are then sutured into a "V," onto the patellar tendon, patella, and quadriceps tendon (Fig. 33.23a, b). The suturing is done at 60° of knee flexion to prevent shortening of the patellar tendon and the occurrence of a patella baja. An intraoperative radiograph ensures the correct restoration of patellar height (Fig. 33.24).



Figs. 33.20 and 33.21 Surgical exposure of the torn patellar tendon

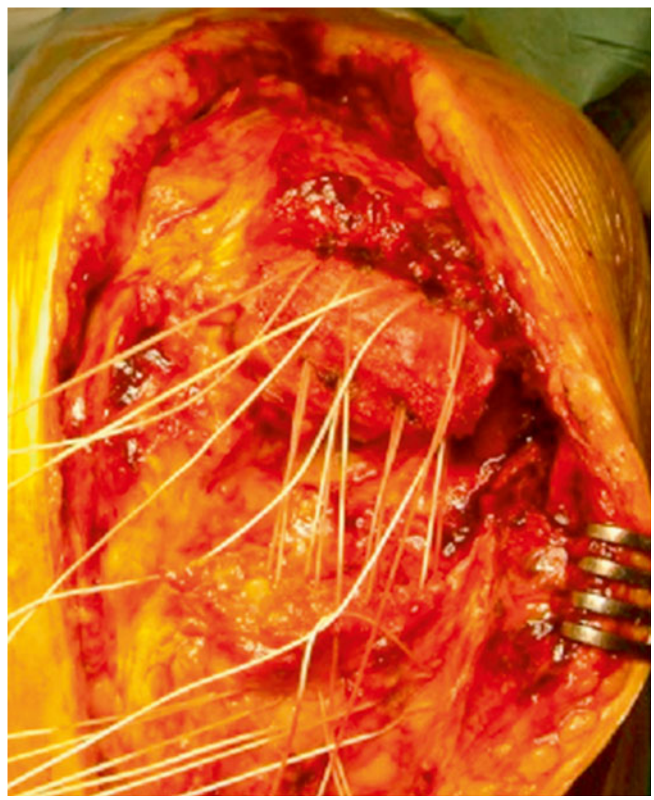


Fig. 33.22 Surgical repair of the tear with sutures

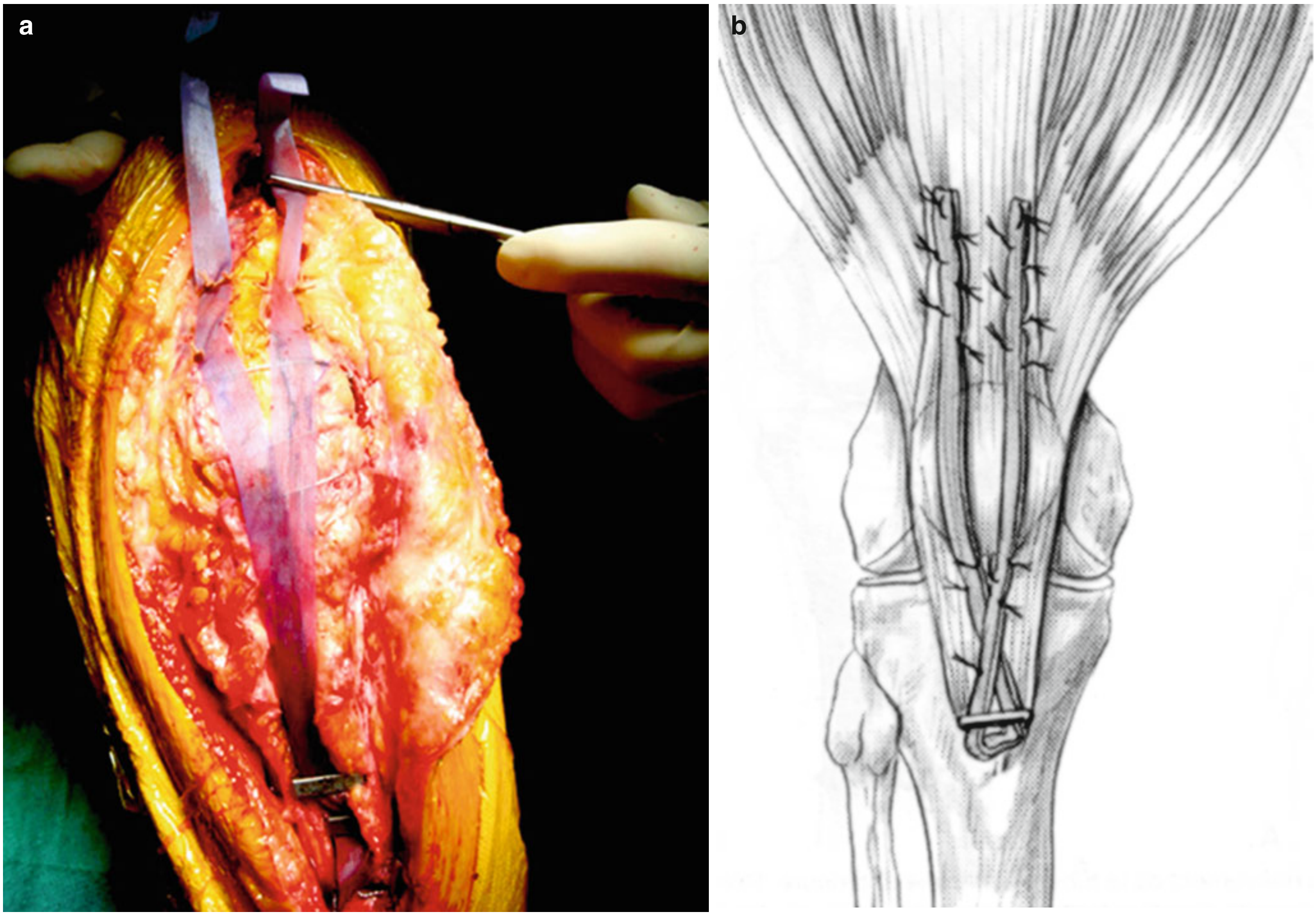


Fig. 33.23 (**a**, **b**) Reinforcement of the repair with PDS tape

Fig. 33.24 Perioperative X-ray

Suture and Reinforcement with a Tendon Graft

In the presence of separation, a semitendinosus graft is used for reinforcement. The tendon is harvested by extending the incision 2 cm distally. The pes anserinus is exposed and the tendon is stripped and prepared (Fig. 33.25). A 4.5 mm transverse tunnel is drilled in the TT (Fig. 33.26) and the distal patella (Fig. 33.27). This drill hole should not be made too high to avoid tilting the patella (Fig. 33.28). The graft is passed through the two tunnels (Fig. 33.29a, b). The knee is placed in extension and the two strands are tightened and sutured together. They are then sutured edge to edge with the patellar tendon.

To avoid a fracture an alternative technique is to pass the semitendinosus tendon in front of the patella. This transforms the forces of distraction into compression and stops the risk of tipping the patella.

If the quality of the repair is still poor following the use of the semitendinosus graft, we use a quadriceps graft to further reinforce the repair. A 25 cm by 15 mm quadriceps graft, centered on the top edge of the patella, is harvested from the middle third of the quadriceps tendon. In order not to breach the capsule, we try to only take the two most superficial layers of the quadriceps tendon. To achieve this, it is often easier to find the correct cleavage plane from the proximal horizontal edge of the quadriceps tendon graft. The quadriceps graft is not detached distally but is instead elevated with a periosteal hinge, which extends for half the length of the patella. Once the periosteal hinge has been elevated from the anterior cortex, the entire graft is flipped in continuity to cover the patellar tendon. It is then sutured at its edges into place. This secondary reinforcement is particularly indicated if the length of the semitendinosus graft is insufficient.

The postoperative management is identical to acute ruptures of the quadriceps tendon.

Fig. 33.25 Semitendinosus graft

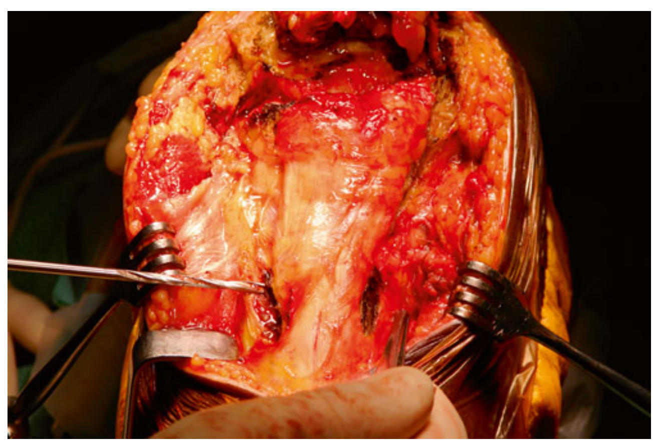


Fig. 33.26 The tibial tunnel with a 4.5 drill

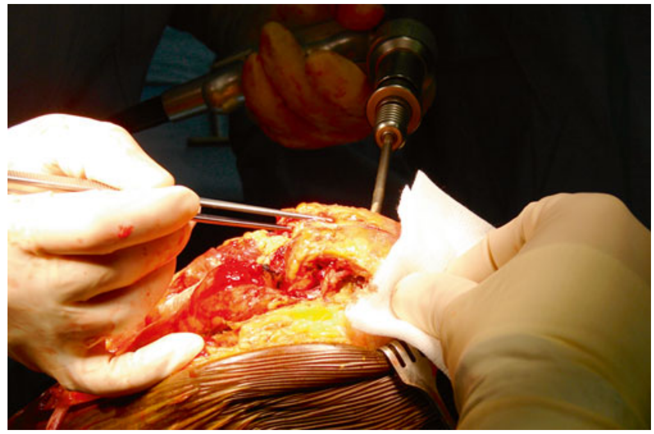


Fig. 33.27 The patellar tunnel with a 4.5 drill

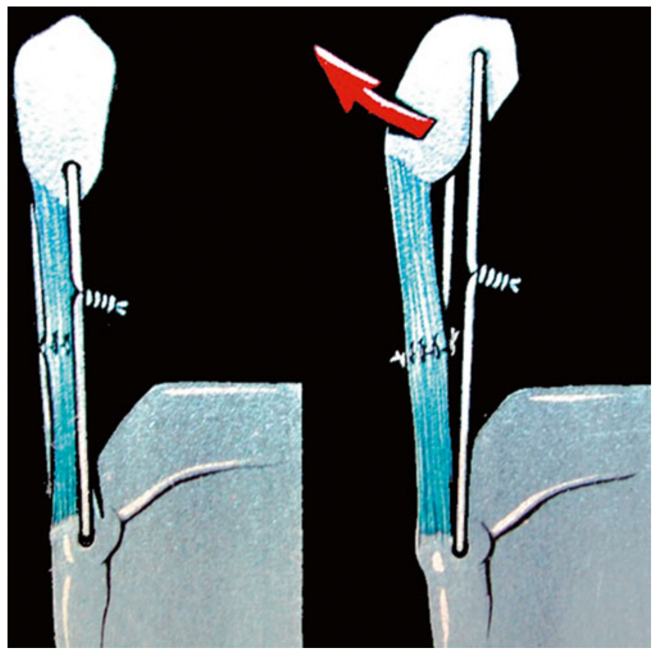


Fig. 33.28 The correct height of the patellar tunnel to prevent patellar tilting

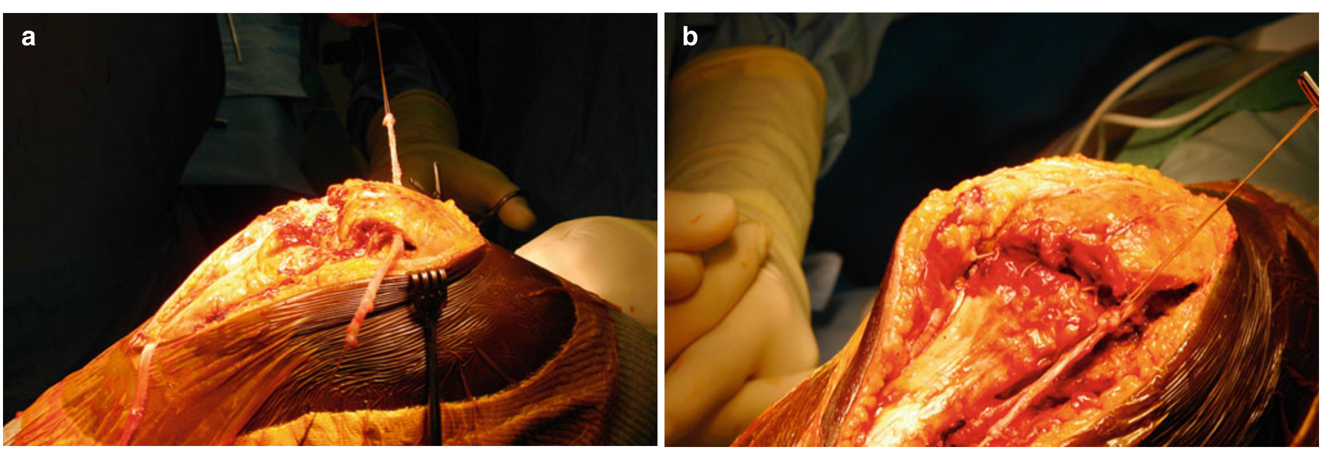


Fig. 33.29 (**a**, **b**) Reinforcement of the patellar tendon repair with a semitendinosus graft

Chronic Rupture of the Extensor Apparatus

34

G. Demey and Robert A. Magnussen

Chronic Rupture of the Quadriceps Tendon

Often, the clinical picture is very suggestive of a chronic deficiency of the extensor mechanism. Typical symptoms relate to the extensor lag, episodes of giving way, and disability with stairs and rising from a seated position. Clinical examination should focus on the degree of extensor lag, the restriction to passive extension (flexion contracture), and patellar height. In particular, patellar mobility should be assessed. If the patella cannot be mobilized proximally, it indicates that the patellar tendon is retracted.

MRI confirms the diagnosis. It also assesses the feasibility of surgery by measuring the size of the gap and by showing the degenerative change in the quadriceps muscle (Fig. 34.1). Due to fibrosis and retraction, it is a more complex surgery than that for acute repairs and requires reinforcement. If patella infera is present on comparative weight-bearing lateral radiographs at 30° of flexion, the patellar tendon is retracted. This finding indicates that it will be necessary to reinforce the repair. This technique was proposed by Pierre Chambat.

This chapter also describes the use of an extensor mechanism allograft, although this technique is more suitable for chronic ruptures of the patellar tendon.

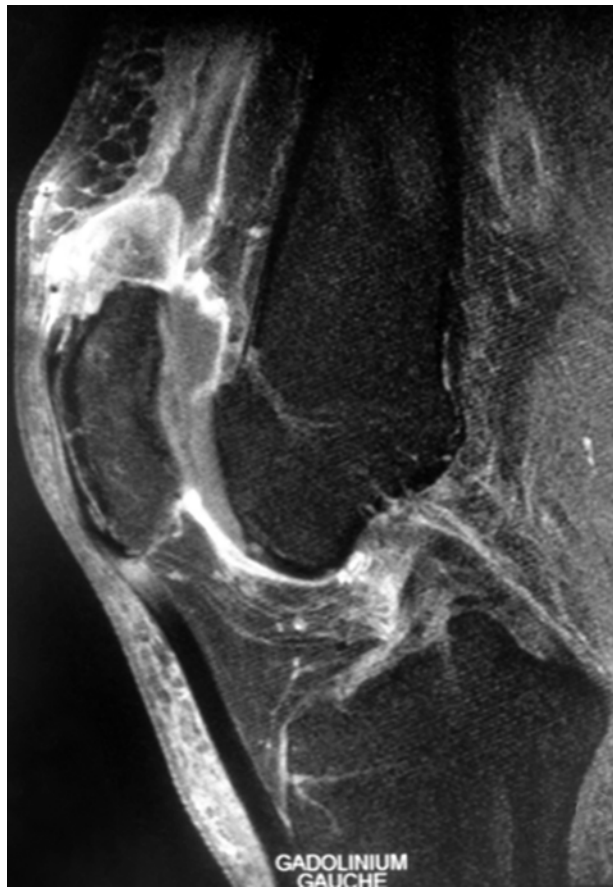


Fig. 34.1 MRI findings in a chronic tear of the quadriceps tendon

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery,
Sports Health and Performance Institute,
The Ohio State University,
Suite 3100, 2050 Kenny Road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_34, © Springer-Verlag London 2014

Suture Technique Protected by Metal Framing

Chronic quadriceps tendon ruptures occur through the tendon or secondary to an avulsion of the tendon from its patellar insertion.

Patient Positioning and Setup

The patient is positioned on the operating table in the supine position. A horizontal post is positioned distally on the table to hold the knee in a 60° flexed position. A lateral support holds the knee in this position. A tourniquet is placed at the base of the thigh but not inflated, as it can hamper the repair by preventing full mobilization of the quadriceps. In a chronic rupture with tendon retraction, it is sometimes unrealistic to seek to achieve 90° of flexion during the procedure.

Incision

A midline longitudinal incision is made beginning at the lower pole of the patella and extending 10 cm above the superior pole (Fig. 34.2).

The dissection is carried down in the midline elevating subcutaneous flaps. The upper pole of the patella and ends of the tear are exposed. The ends of the tear are carefully identified and mobilized by excising scar tissue and dissecting medially and/or laterally as required (Fig. 34.3). It is critically important to preserve as much healthy tissue as possible. It is usually not necessary to perform arthroscopic arthrolysis or to incise the retinaculum.

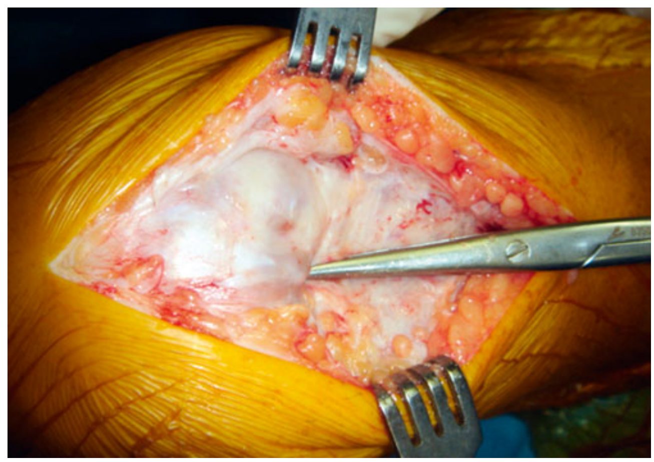


Fig. 34.2 Surgical exposure of the chronic tear

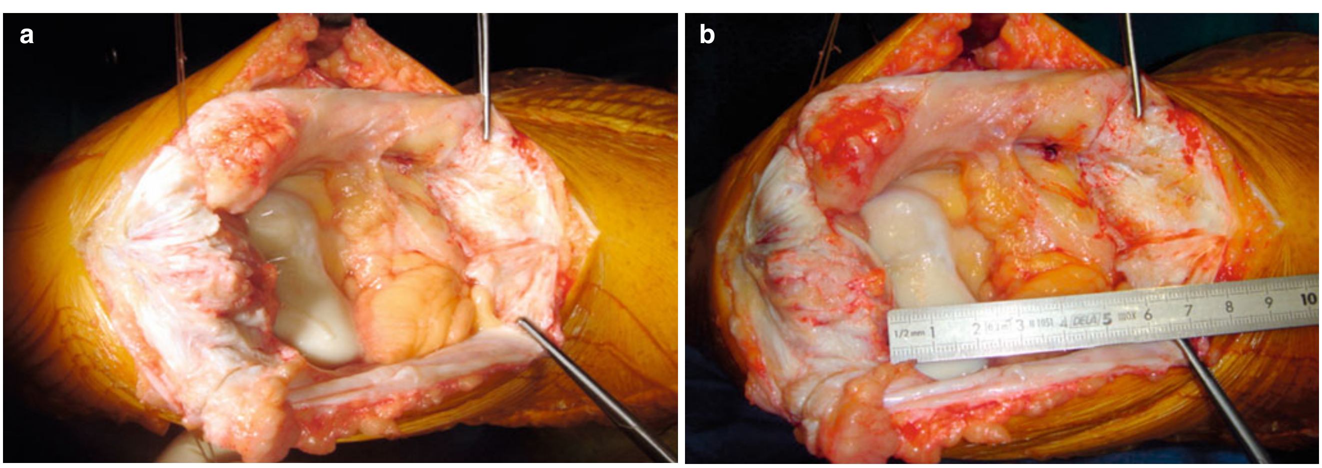


Fig. 34.3 Mobilization and debridement of the ends of the tear (**a**) and measurement of the gap (**b**)

Mobilizing the Proximal Quadriceps Stump

A 2 mm K-wire is inserted transversely into the stump of the quadriceps tendon. Contrary to popular belief, there is no "cheese-slicing effect," and the K-wire will not pull out of the tendon distally. A second trans-patellar 2 mm K-wire is placed transversally 1 cm below the proximal pole of the patella. A loop of metal wire is then placed on either side of the K-wires (this arrangement is preferred to a mounting frame or a figure of 8 with a single wire) (Fig. 34.4). By progressively tightening the wires with the knee in extension, the proximal quadriceps tendon stump is pulled to the stump at the proximal pole of the patella (Fig. 34.5).

To complete the repair, a whipstitch is placed in the two tendon stumps with FiberWire suture and the ends are tied over the tear. The repair is then reinforced with 0 Vicryl suture around the repair site as described in the previous chapter.

The strength of the repair is tested at 60° and 90° of knee flexion. Closure is achieved in layers, and a suction drain is placed subcutaneously. The skin is closed with staples (Fig. 34.6).

In cases of osteotendinous avulsion, a similar technique to that used in acute ruptures of the quadriceps tendon is used to complete the repair after placement of the wire augment as described above. The sutures are passed through the quadriceps tendon stump proximally and then through longitudinally bone tunnels in the patella and tied (see chapter 33).

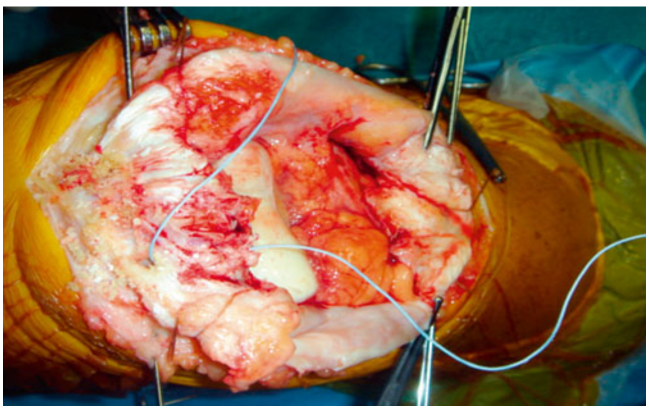


Fig. 34.4 Placement of the 2 mm K-wires and wire loops

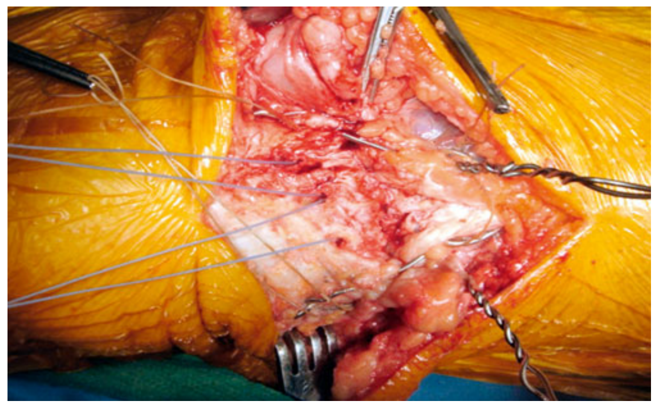


Fig. 34.5 Tightening of the wires and closure of the tear

Fig. 34.6 Postoperative x-ray

Reinforcement of the Tear Using a Patellar Tendon and Semitendinosus Graft

Reinforcement of a chronic quadriceps tendon rupture is indicated when the direct repair is at high risk of failure due to poor tissue quality. The reinforcement may be achieved with both a patellar tendon and semitendinosus graft. Dependent on the quality of the repair, a single or double reinforcement can be done.

Incision

A longitudinal paramedian incision is made extending from 10 cms above the superior pole of the patella ending on the medial side of the tibial tuberosity.

Full-thickness flaps are elevated to expose the chronic rupture. Scar tissue is excised in an economical manner to expose the upper pole of the patella and the ends of the tear (Fig. 34.7).

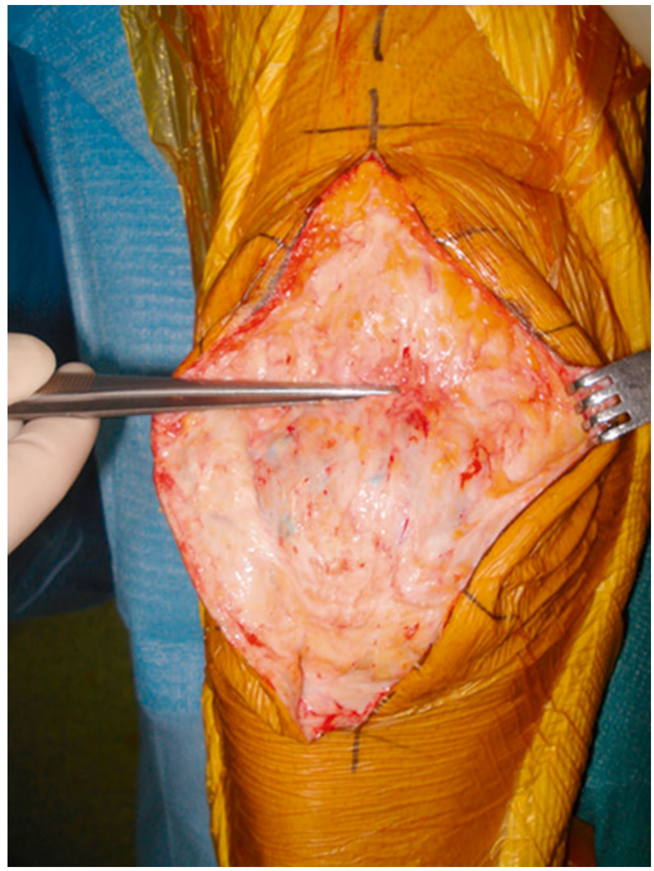


Fig. 34.7 Surgical exposure of the chronic tear

Harvesting the Semitendinosus Graft

The tendon is harvested by extending the incision 2 cm distally. The pes anserinus is exposed and the tendon is stripped and prepared (Figs. 34.8, 34.9, and 34.10). This produces a graft about 25–30 cm long (Fig. 34.11).

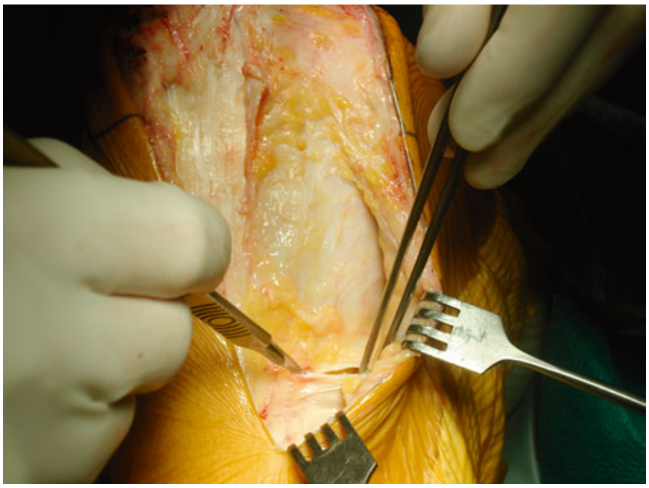


Fig. 34.8 Harvesting of the semitendinosus graft (1)

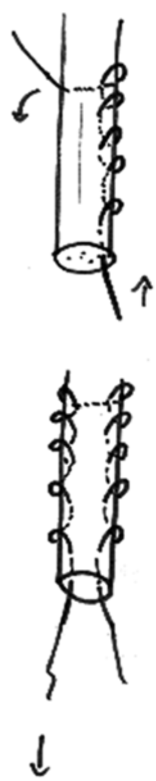


Fig. 34.9 Preparation of the tendon extremity

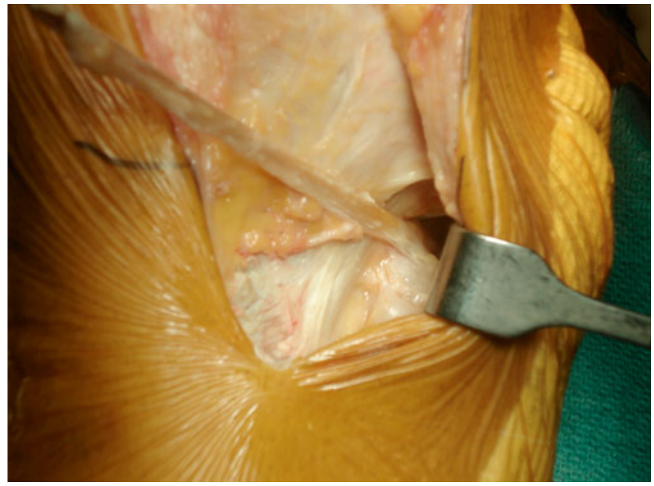


Fig. 34.10 Harvesting of the semitendinosus graft (2)

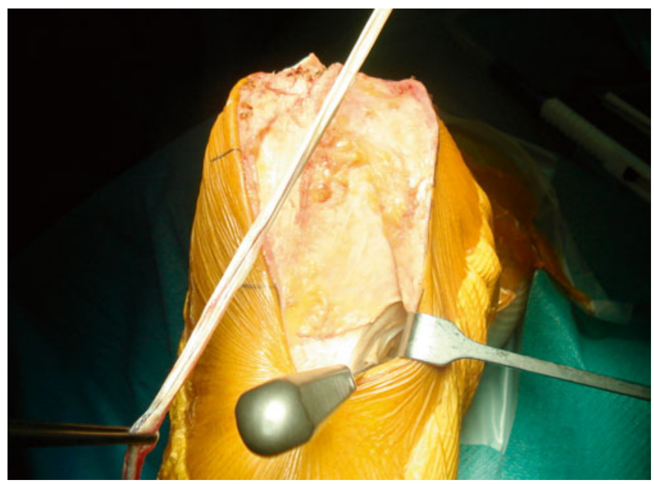


Fig. 34.11 Harvesting of the semitendinosus graft (3)

Harvesting the Patellar Tendon Graft

A 1 cm strip in the middle third of the patellar tendon is incised. Its distal insertion is mobilized with a strip of periosteum from the TT using a scalpel. This strip of tendon is then peeled from the front of the patella being careful to leave it attached to at least half the height of the patella. A compromise between getting sufficient graft length and keeping enough of its attachment to the patella must be made (Fig. 34.12a–c).

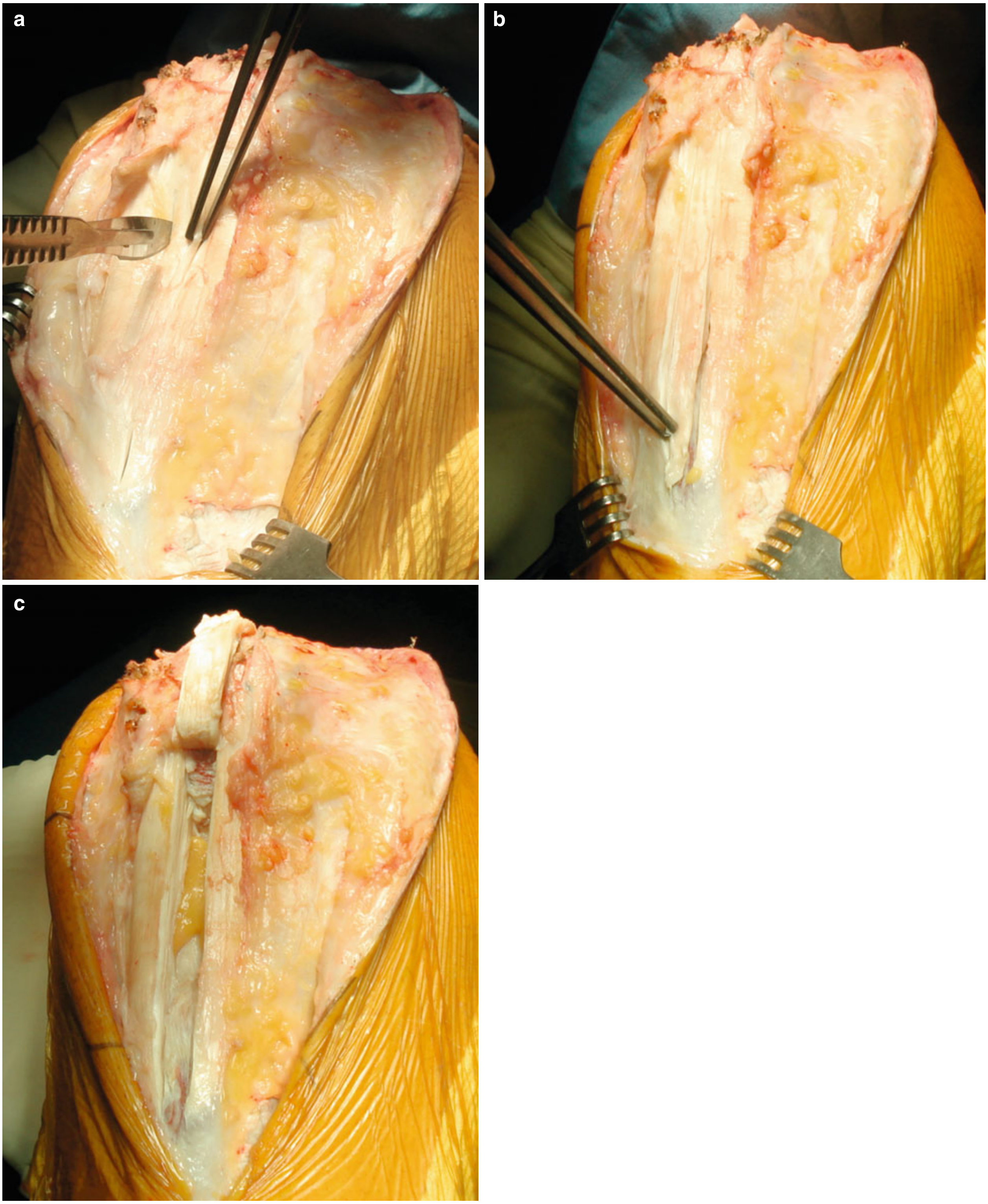


Fig. 34.12 Harvest of the patellar tendon begins by isolating the central third (**a**), detaching the tibia insertion of the central third of the tendon (**b**), and finally flipping the tendon proximally and performing subperiosteal elecation off the the pattla (**c**), while making sure that sufficient patellar attachment is maintained

Three 2.7 mm transosseous tunnels are drilled in the proximal pole of the patella. These are started on the upper surface of the patella 1 cm from its proximal edge and exit through the midpoint of the proximal pole, taking care not to damage the articular surface (Fig. 34.13).

A 4.5 mm horizontal tunnel is made through the upper one-third of the patella. Care must be taken to do this in the right direction to prevent any weakening of the patella and a possible fracture (Fig. 34.14). FiberWire® sutures are then placed through the tendon and then through the transosseous tunnels back into the tendon. These sutures are tied in extension.

The semitendinosus tendon graft is then passed through the patella using a guide pin.

Dissection is then carried out to create a tunnel in the quadriceps tendon in order to create a tunnel for the semitendinosus graft (Fig. 34.15). The graft is then pulled tight at 60° of flexion and sutured to itself with absorbable Vicryl at multiple points. The sutures are tied in extension (Fig. 34.16a, b).

Finally, the strip of patellar tendon is turned over and sutured over the front of the repair using number 2 Vicryl. The strength of the repair is tested by placing the knee in 60° of flexion. Closure is achieved in layers and a suction drain is placed subcutaneously. The skin is closed with staples. The postoperative instructions are identical to those described in acute ruptures of the quadriceps tendon.

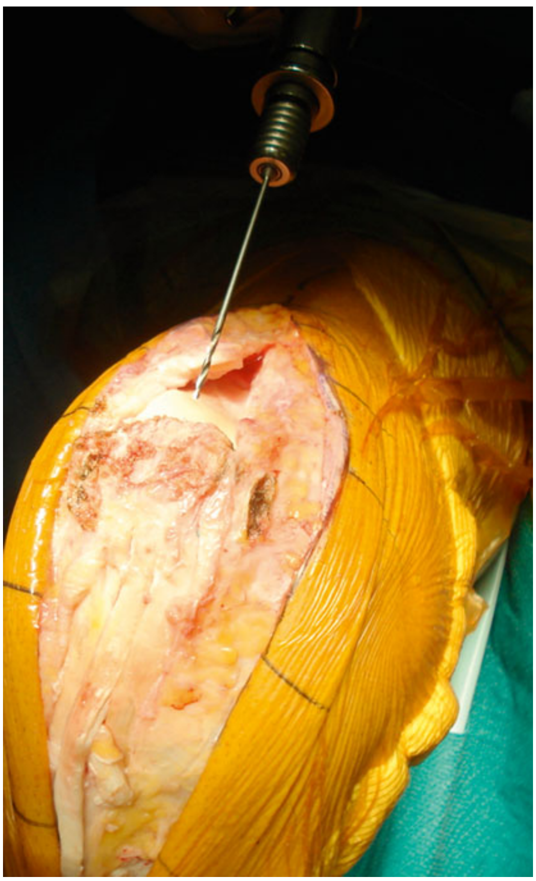


Fig. 34.13 Transosseous tunnels in the proximal pole of the patella

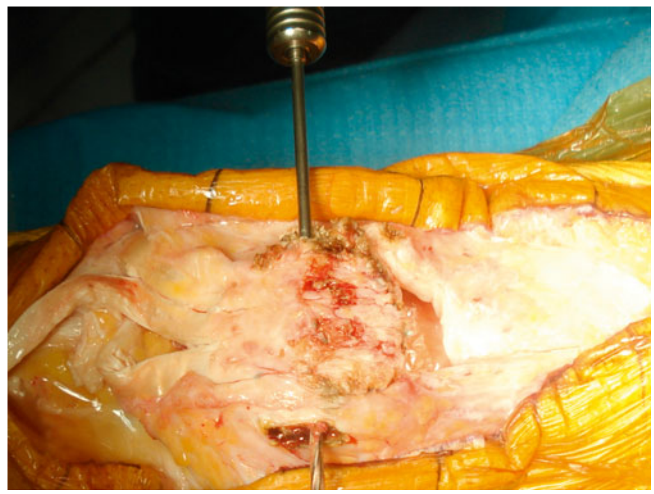


Fig. 34.14 Horizontal transosseous patellar tunnel

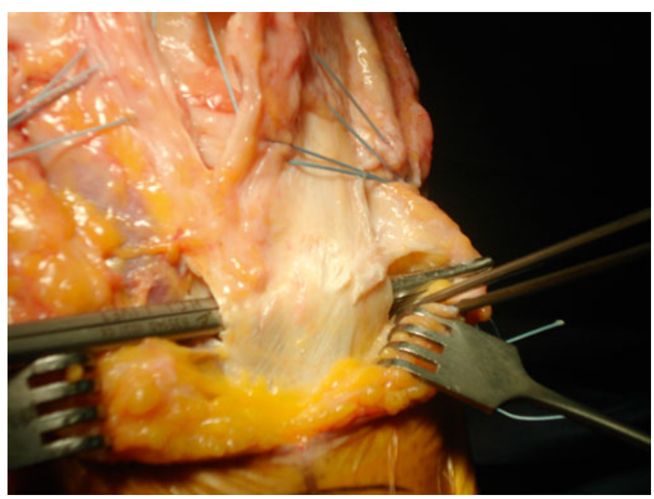


Fig. 34.15 Creating a tunnel for the semitendinosus graft within the quadriceps tendon

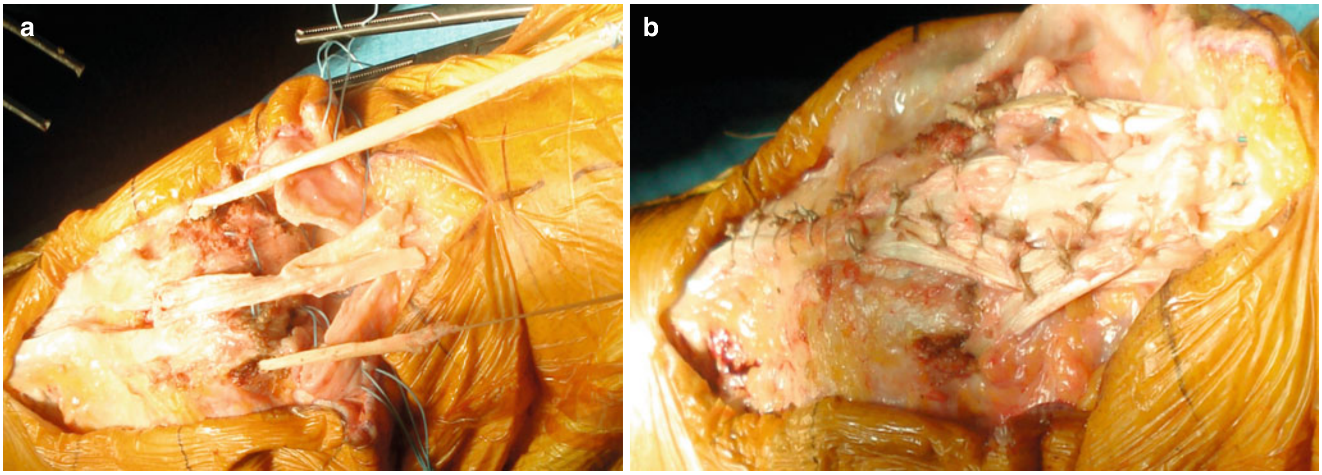


Fig. 34.16 Patellar tendon and semitendinosus grafts are placed (**a**) and tied in position (**b**)

Reconstruction of a Chronic Rupture of the Patellar Tendon

Reconstruction of chronic ruptures of the patellar tendon is difficult due to contraction of the quadriceps and hence the difficulty of restoring the correct height of the patella.

If the correct patellar height is achieved relatively easily, reinforcement of the repair can be achieved by using a strip of PDS tape or a quadriceps tendon graft (see section "Acute Ruptures of the Patellar Tendon"). In contrast, if it is difficult to lower the patella (Fig. 34.17), it is necessary to use an autologous extensor mechanism graft.

Fig. 34.17 MRI showing a chronic tear of the patellar tendon

Autologous Transplantation of the Extensor Mechanism

This technique was presented with Henri Dejour in Toronto in 1991. In revision surgery or when the quality of the patellar tendon is insufficient to achieve a satisfactory repair, we use an autograft taken at the expense of the middle third of the contralateral extensor mechanism. This is a composite graft: quadriceps tendon, patellar bone block, patellar tendon, and tibial bone block. The contralateral patellar tendon must be healthy and had no previous surgery (tibial nailing, TT transfer, harvest for ACL reconstruction, etc.). If necessary, an extensor mechanism allograft can be used, using the same surgical technique.

Harvesting the Autograft (Contralateral Knee)

Both lower limbs are placed in the operative field. A tourniquet is placed at the base of each thigh (Fig. 34.18).

Fig. 34.18 Patient setup

Incision

The incision begins 3 cm below the tibial insertion of the patellar tendon and extends 5–7 cm above the proximal pole of the patella. The paratenon is incised vertically (Fig. 34.19).

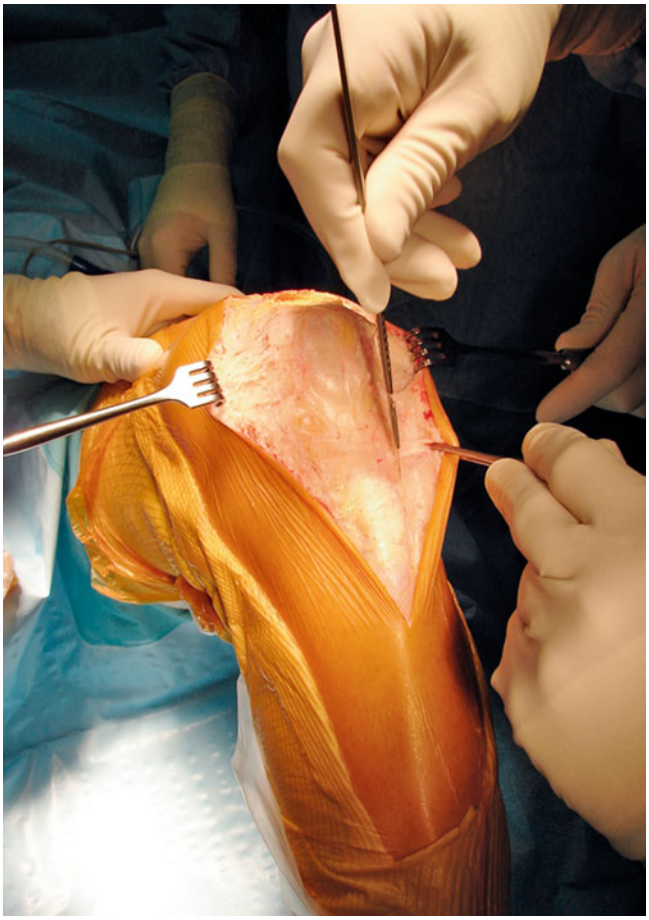


Fig. 34.19 Exposure of the extensor mechanism autograft

Delineation of the Transplant

The quadriceps tendon is exposed along its entire length, extending the exposure to reveal the most distal muscle fibers of the rectus femoris. The tendon is then incised for 5–6 cm in the line with its fibers. Only the two most superficial layers are incised to avoid entering the knee joint. The width of the graft should be 12–14 mm (Fig. 34.20a, b).

The incision extends onto the periosteum of the patella as a "dovetail," that is to say, a trapezoidal base of 14 mm proximally with a width of 10 mm distally. The harvest then continues on to the patellar tendon. The middle third is harvested at a width of 10 mm (Fig. 34.21). The tibial periosteum is then incised to mark out a 35 mm-long bone block that is 10 mm wide at its proximal portion and 12 mm at its base (Fig. 34.22). It should be noted that the bone blocks must have trapezoidal shapes in order to prevent migration of the graft.

A variant of these bone blocks can be harvested, i.e., a bone block with a narrower waist that is wider proximally and distally. This method allows the harvest of a wider patellar tendon graft while still avoiding migration of the graft and is especially useful if allograft is used.

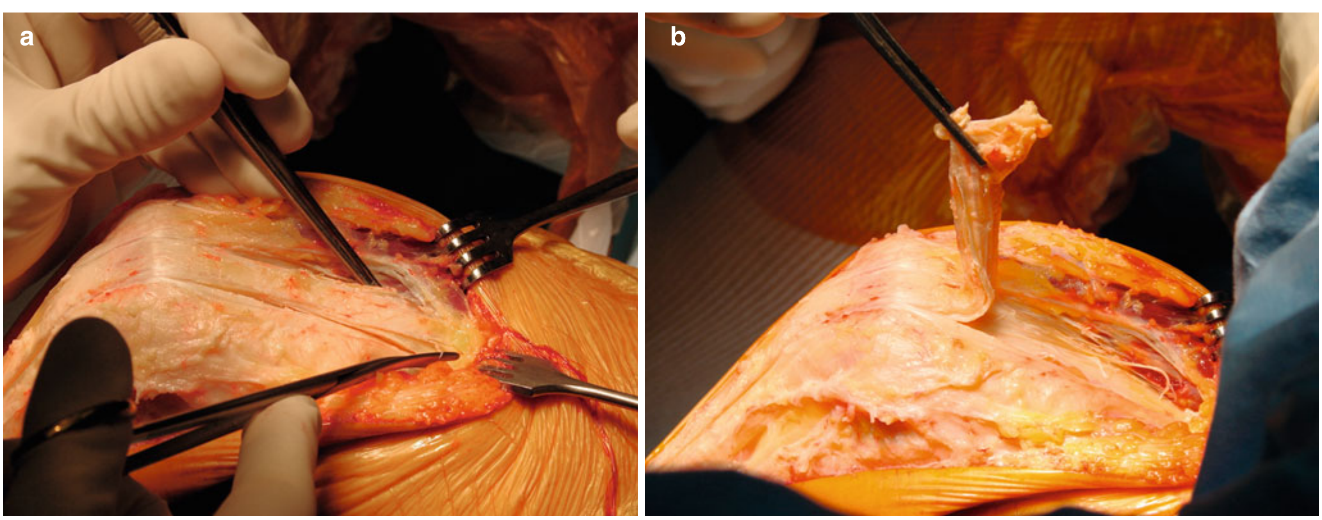


Fig. 34.20 The central third of the quadriceps tendon is identified (**a**) and detached proximally (**b**)

Fig. 34.21 Harvest of the patellar tendon

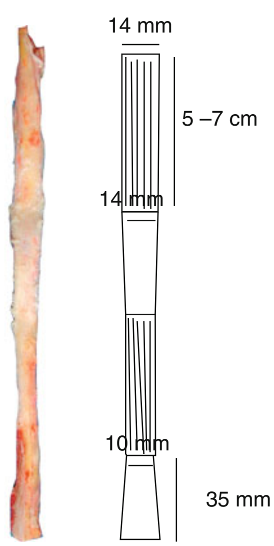


Fig. 34.22 Dimensions of the extensor mechanism autograft

Harvesting the Bone Blocks

The tibial and patellar bone blocks are harvested with an oscillating saw (Fig. 34.23a, b). At the distal end of the tibial block, the saw has to be tilted to avoid any risk of fracture. The bone block is then separated using an open gouge. The patellar tendon is then retracted upward, and it is released from the fat on its posterior surface. It must be elevated off the tip of the patella in order to assess the thickness of the bone block. A 10 mm Lambotte osteotome is then introduced parallel to the anterior cortex. This helps remove the entire bone block (Fig. 34.24). The osteotome should not be used as a lever due to risk of breaking the bone block or fracturing the patella (Figs. 34.25 and 34.26).

Fig. 34.23 Bone blocks cut with the saw from the patella (**a**) and tibia (**b**)

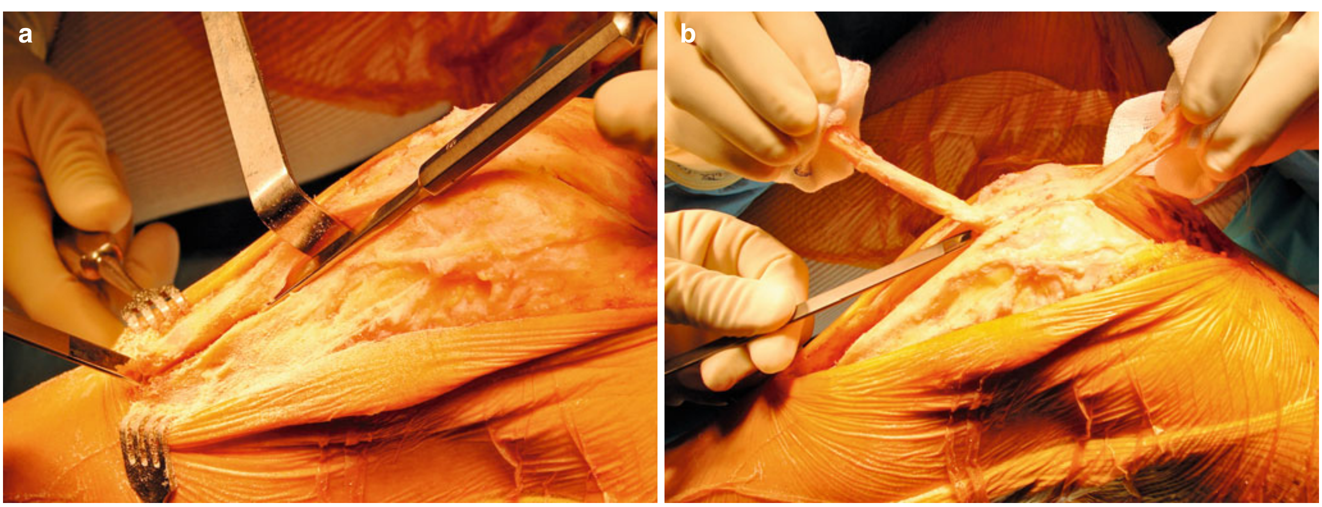


Fig. 34.24 The tibial (**a**) and patellar (**b**) bone blocks are then carefully elevated form the bony beds

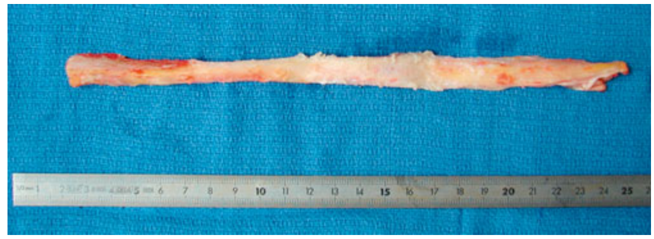


Fig. 34.25 The extensor mechanism autograft

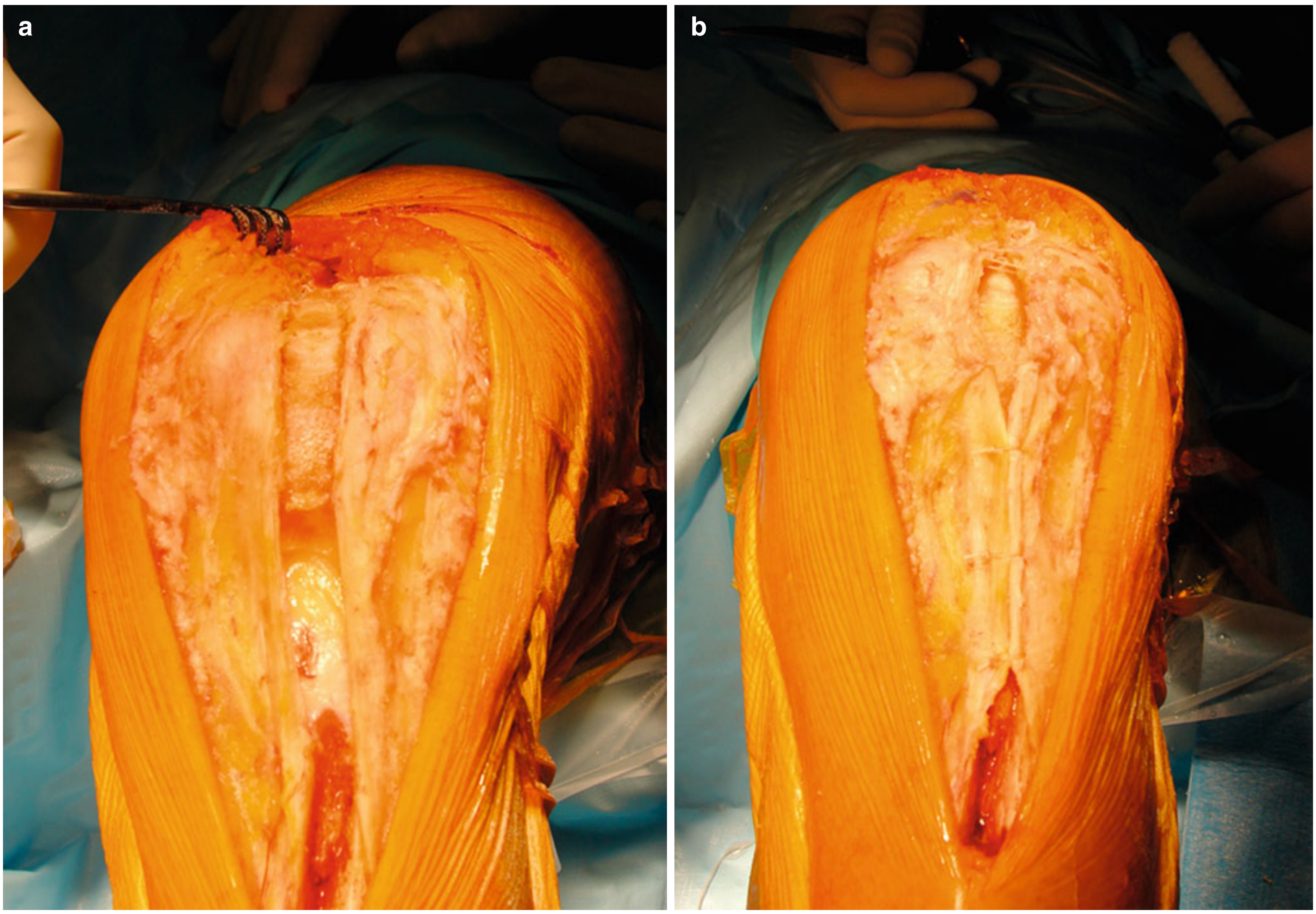


Fig. 34.26 Following autograft harvest (**a**), the quadriceps and patellar tendon and closed side to side (**b**)

Preparation of Recipient Site

Incision

A paramedian skin incision is made beginning 10 cm above the proximal pole of the patella and ending 3 cm below the distal insertion of the patellar tendon. In revision surgery, previous incisions must be taken into consideration.

Exposure

The medial and lateral edges of the patellar tendon are identified, and the scar tissue is excised to expose the two tendon stumps. The quadriceps tendon is exposed using the technique described above. The next part of the procedure involves creating a tibial and patellar bone trench to accommodate the harvested bone blocks (Fig. 34.27a, b).

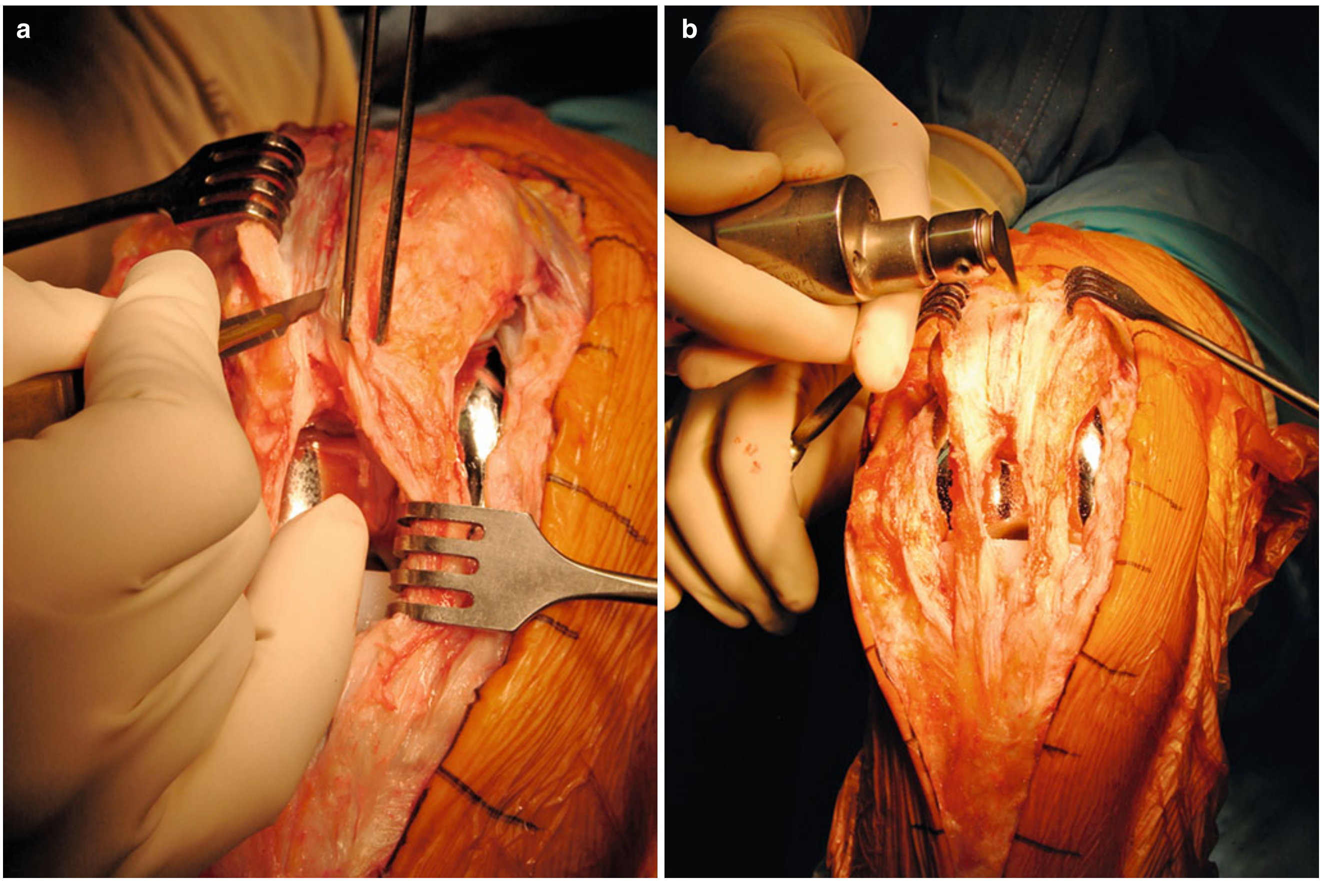


Fig. 34.27 Preparation of the recipient knee – the patellar bone trench is marked (**a**) and creasted with a saw (**b**)

Preparation of Bone Trenches

The recipient sites are marked out on the periosteum using a scalpel. The bone trenches are then cut with an oscillating saw. On the TT, the trench is 10 mm wide proximally, 12 mm distally, and 35 mm long. In order to elevate the block of bone and make the trench, a gouge is inserted vertically just above the reflected patellar tendon (Fig. 34.28a, b). On the patella, the trench is trapezoidal measuring 14 mm wide proximally and 10 mm wide at its distal end. In order to elevate the bone block and from the trench, a Lambotte osteotome is inserted parallel to the anterior cortex at the tip and at the proximal pole of the patella. The match between the transplant and recipient site is then evaluated. It is often necessary to adjust the graft using a rongeur.

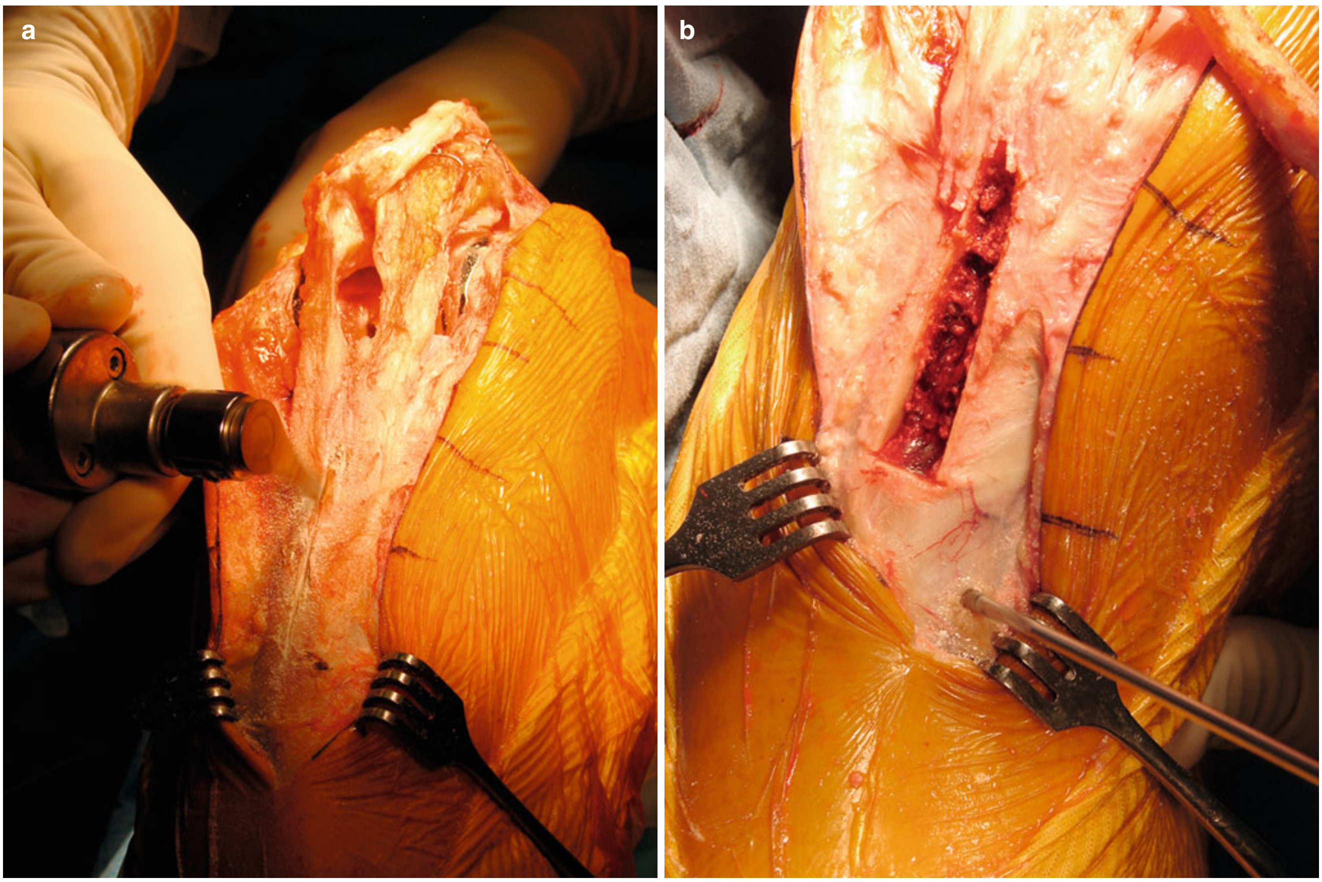


Fig. 34.28 Preparation of the recipient knee – the tibial bone trench is cut (**a**) and the bone block removed (**b**) to allow placemnt of the corresponding graft bone block

Fixation of the Graft

Patellar Fixation (Fig. 34.29a, b)

The extensor mechanism graft is initially fixed proximally. The patellar bone block is positioned in the recipient patellar trench. This should be achieved without impact in order to prevent a fracture or injury to the patellar cartilage. The dovetail of the bone block is placed proximally in the trench. The bone block is fixed with two separate metal wires, which pass transversely through the patella and bone block. The wires are tightened on one side by twisting and then cut short and buried. Proximally, an opening is made in the midline of the quadriceps tendon, and the quadriceps tendon graft is sutured into this site using a No. 2 absorbable suture.

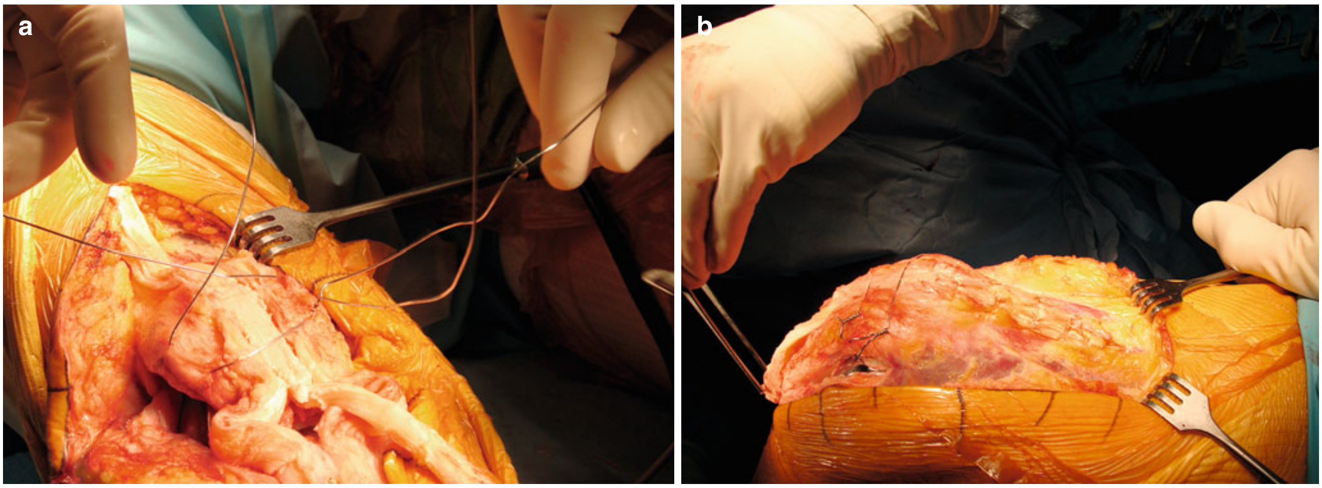


Fig. 34.29 Patellar fixation is achieved by passingtrans-osseous wires (**a**) and ties them over the graft anteriorly (**b**)

TT Fixation

A wire is passed through the tibial bone block. The tibial bone block is then positioned in the trench and impacted into the recipient site on the tibia. This restores the correct patellar height. Fixation is achieved with the wire and a screw (Hooper, Lepine®). The screw, which is placed distally, prevents proximal migration of the bone block (Fig. 34.30a, b). This fixation is supplemented by two Orthomed® staples, which can also be used to fix a strip of PDS prepared by the same technique described in the chapter "Acute ruptures of the extensor mechanism."

The inner and outer edges of the graft are sutured to the patellar tendon with a No. 2 absorbable suture (Fig. 34.31a, b). Imaging is not necessary prior to closure, as the corrected patellar height is only dependent on the length of the contralateral patellar tendon (Fig. 34.32a, b).

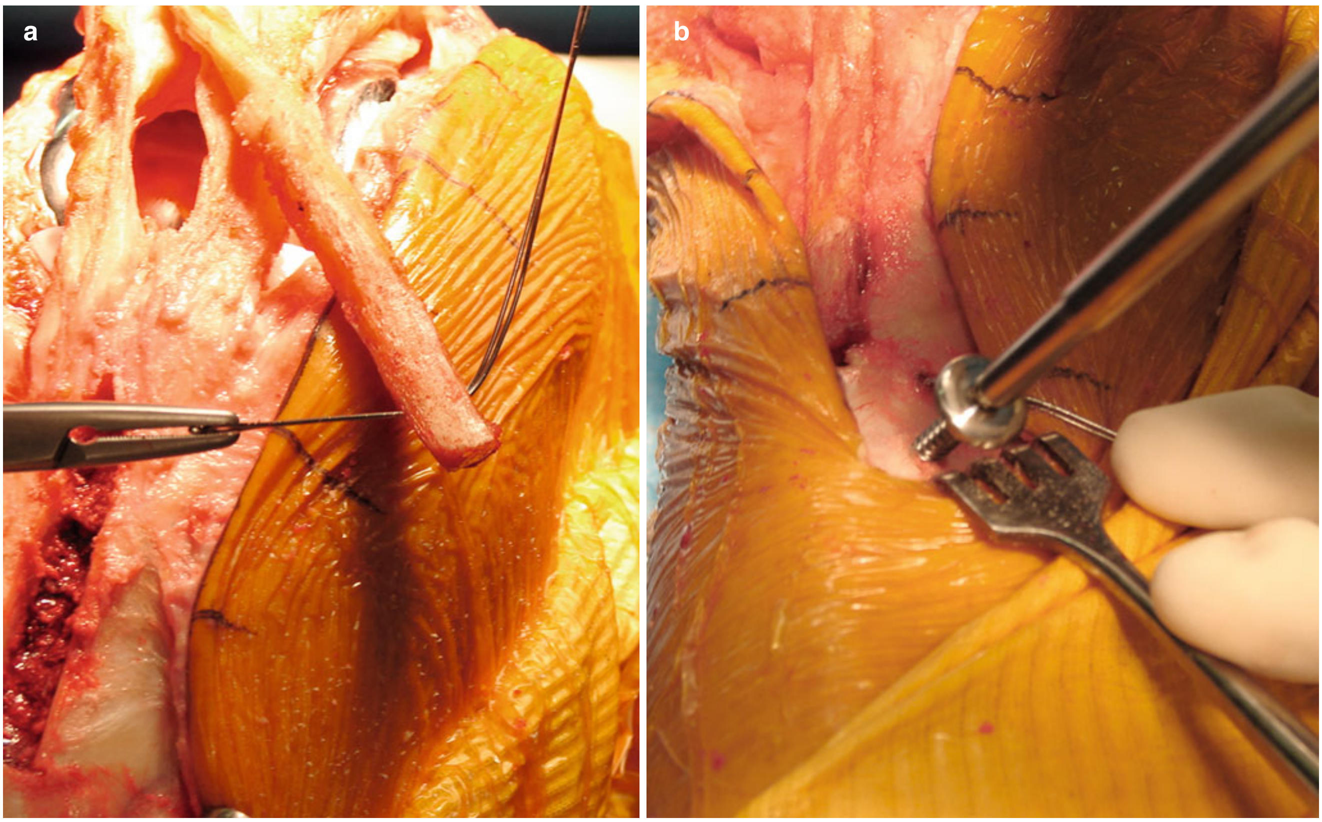


Fig. 34.30 Tibial fixation includes a trans-osseous wire (**a**) that is scured around a distal screw (**b**)

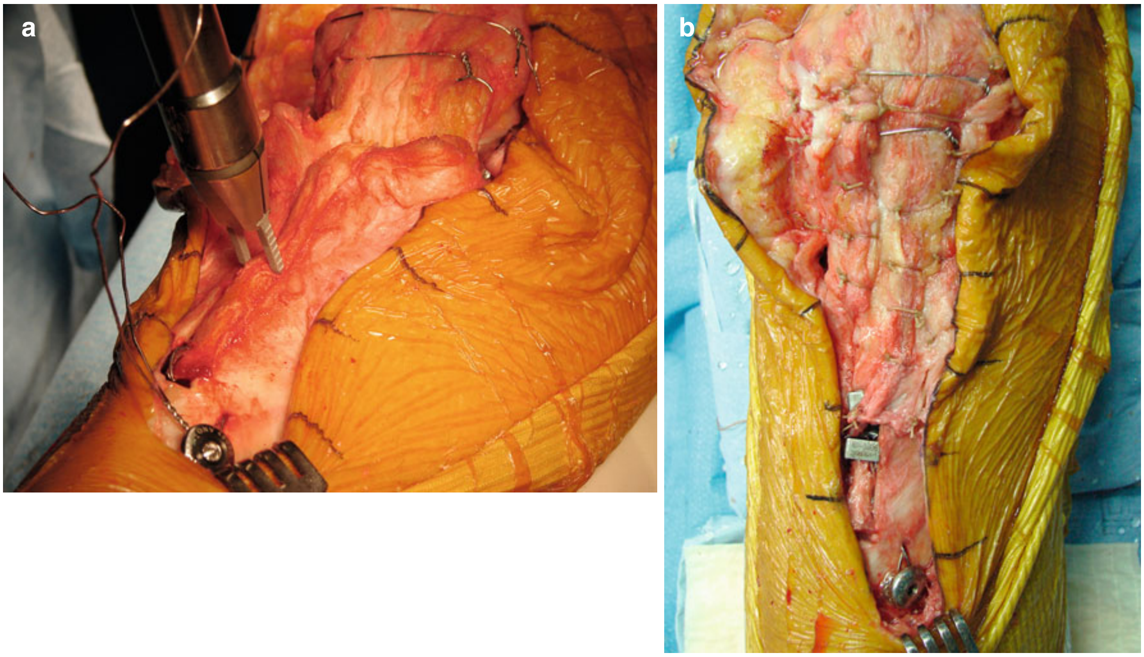


Fig. 34.31 Tibial fixation is augmented with two staples (**a**), yielding the final construct (**b**)

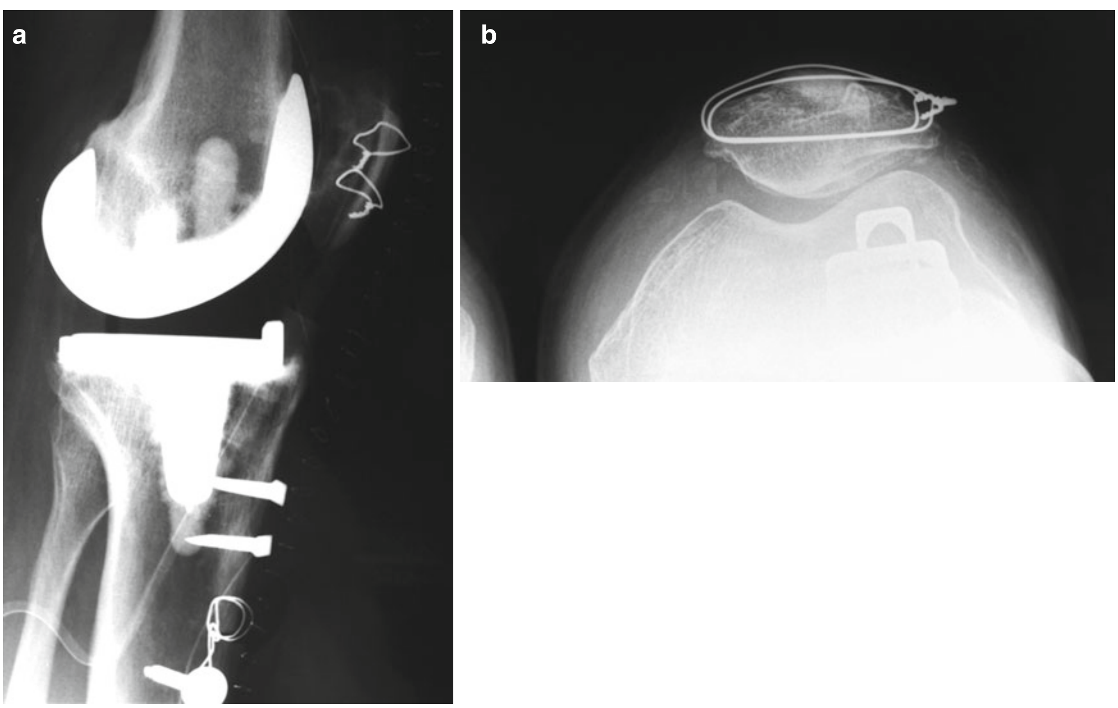


Fig. 34.32 Postoperative lateral (**a**) and axial (**b**) x-rays

Closure

Recipient Site (Fig. 34.33)

A suction drain is placed in contact with the graft. Hemostasis is achieved and closure is achieved in layers. Staples are used in the skin.

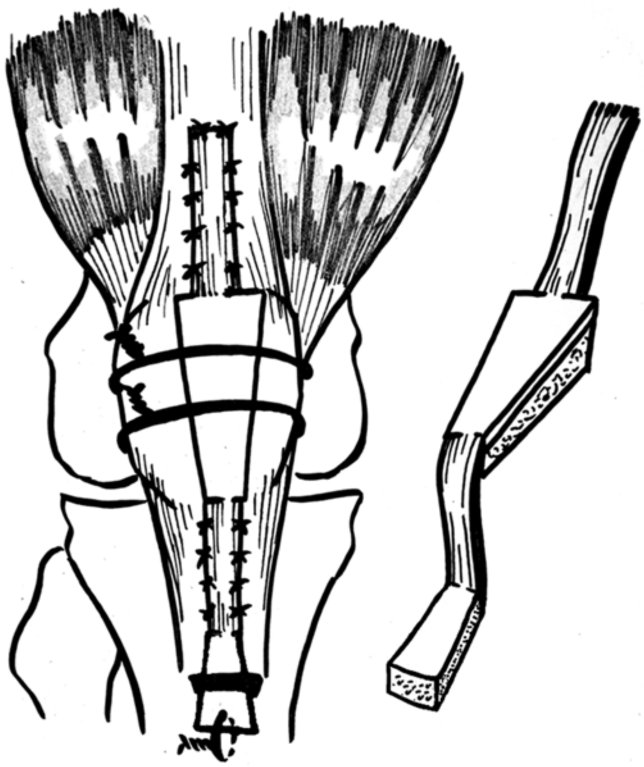


Fig. 34.33 Diagram showing the graft in situ

Donor Site

The edges of the tendons are approximated with a No. 2 absorbable suture. A suction drain is placed in the subcutaneous space, and closure is achieved in layers. We do not fill the bone defects on the patella or TT with the bone fragments taken from the recipient knee.

Postoperative

The postoperative regime is identical to the protocol described above. Prophylactic anticoagulation should be avoided unless absolutely necessary. The skin should be monitored closely due to the risk of infection or necrosis. The grafted side should be protected in complete extension for 2 months.

Allograft Transplantation of the Extensor Mechanism

There are some advantages to the use of allograft tissue for extensor mechanism reconstruction. There is no harvest site morbidity on the other extremity such as fracture, extensor mechanism rupture, or pain after harvesting. Allograft tissue is particularly useful in patients with a collagen disease or a history of injury or surgery involving the contralateral knee (contralateral TKA, fracture, or more generally osteoporosis) (Fig. 34.34). Further, the allograft can be thicker and longer than autograft and results in shorter surgical times.

On the other hand, there are a few disadvantages. Allograft is not available in every country and can be costly. While the risk of viral contamination is low (estimated to be 1/200,000), the patient must be informed of the risk of this devastating complication. Finally, poor tissue quality is sometimes seen with allografts relative to autografts.

The length of the patellar tendon and patella should be matched to the patient when allograft is used. Specific measures of these structures must be made during the preoperative radiological assessment.

The surgical technique for reconstruction with allograft is very similar to the autograft technique described above. The surgical assistant can prepare the graft while the senior surgeon prepares the surgical site.

There are a few key differences between the techniques. The allograft typically can be made larger because of the absence of morbidity at the donor site. The allograft arrives as a complete extensor mechanism with tibial tuberosity, patellar tendon, patella, and quadriceps tendon (Fig. 34.35). The patellar bone block is prepared to be wider proximally and distally with concave edges medially and laterally. This method allows for the use of wider patellar and quadriceps tendon grafts (Fig. 34.36).

The fixation technique is similar. We use a wire wrapped around a low profile screw distally with the addition of staples for tibial bone block fixation (Fig. 34.37). Metal wires are used to fix the patella (Fig. 34.38). The tendon is secured with absorbable suture and sometimes FiberWire® depending on tissue quality. One PDS tape is distally fixed by the staple and sutured throughout extensor mechanism with the knee flexed to 90°. This tape protects allograft stress during bending (Fig. 34.39). Rehabilitation is very careful (see protocol cited above). The range of motion is particularly cautious and progressive to allow time for consolidation of the bone blocks. Successive radiographs are done every 45 days to check bone block consolidation before advancing range of motion (Fig. 34.40).

Fig. 34.34 Chronic patellar tendon rupture on TKA with failure of conventional technique. An allograft is required. Another option would be a technique utilizing synthetic mesh (recently described by Hanssen and Browne)

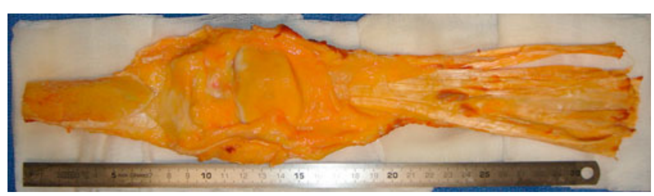


Fig. 34.35 Complete extensor mechanism

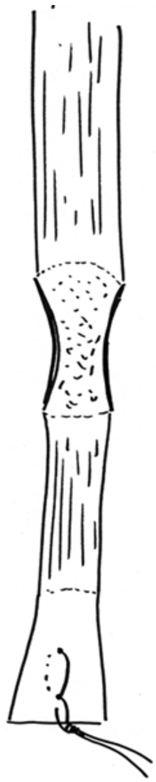


Fig. 34.36 Shape of the graft

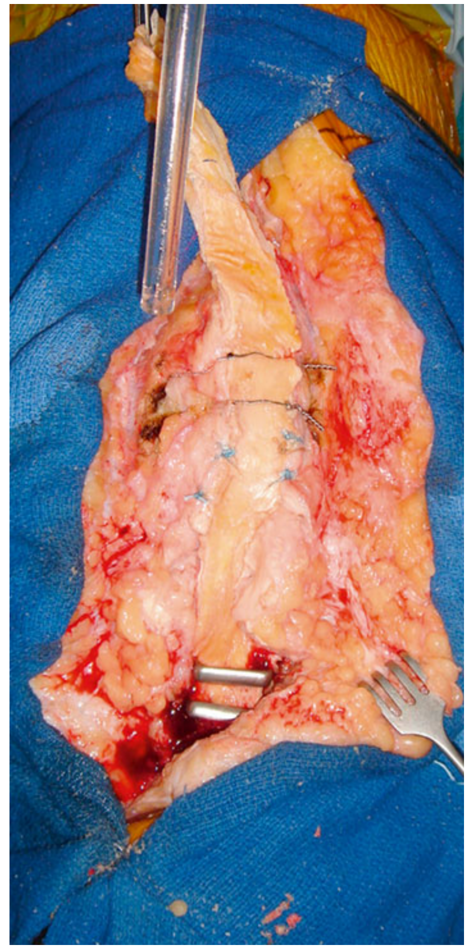


Fig. 34.38 Tibial fixation (2) using Blount staples

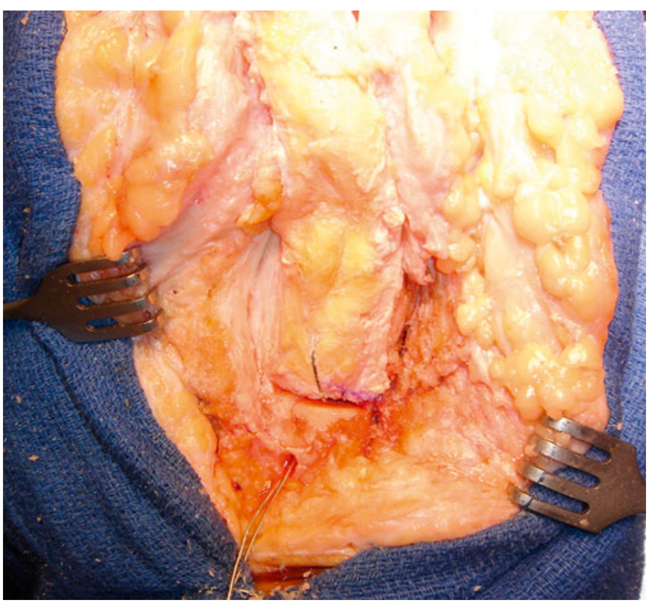


Fig. 34.37 Tibial fixation (1) using metal wire passed through the bone block and fixed using a cortical screw

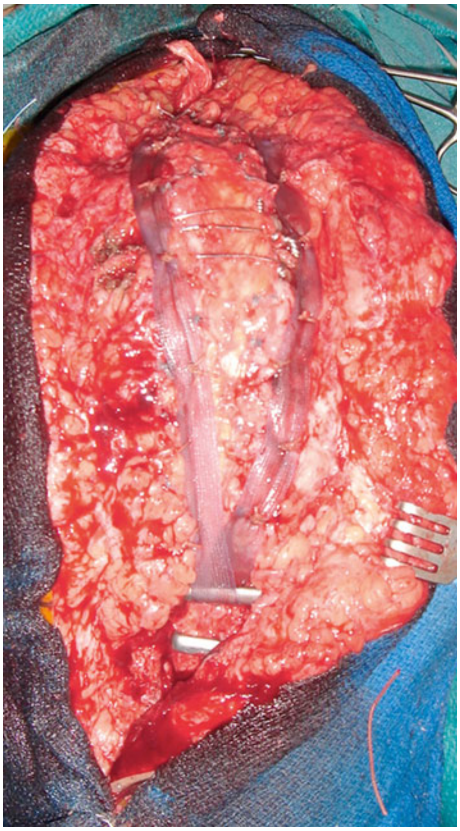


Fig. 34.39 Final aspect after fixation, suture, and reinforcement using PDS tape

Fig. 34.40 Case of chronic rupture with previous failure of suture plus augmentation. Excellent result at 6-month follow-up

35 Patellar Fractures

G. Demey and Robert A. Magnussen

The aims in the treatment of a patellar fracture are:

- To restore the continuity of the extensor mechanism
- To restore articular congruity
- To avoid at all costs a patellectomy
- To limit the devascularization of the patella
- To restore adequate stability in order to achieve early mobilization of the knee

Indication

Nonoperative management:

- Stable, congruent fracture
- Longitudinal fractures with an interfragmentary gap of less than 1 mm
- Transverse fracture without articular impaction (separation and step-off under 1 mm)
  Open reduction and internal fixation (usually indicated):
- Fractures resulting in disruption of the extensor mechanism (Fig. 35.1)
- Articular incongruity (step-off >1 mm)
- Osteochondral fractures
- Open fractures

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health
and Performance Institute, The Ohio State University,
Suite 3100, 2050 Kenny road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_35, © Springer-Verlag London 2014

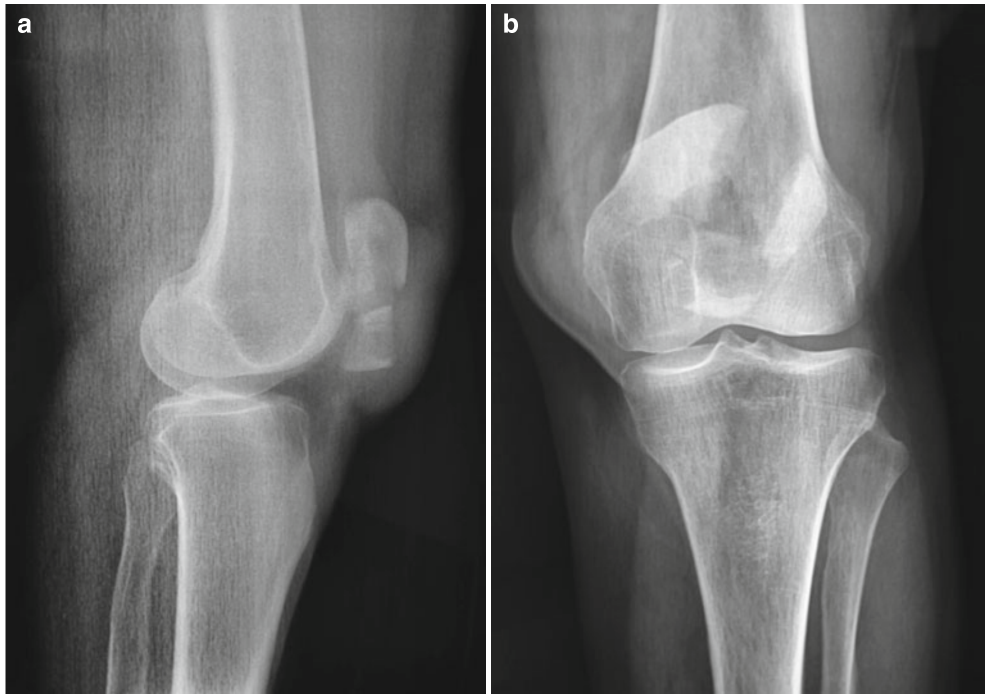


Fig. 35.1 AP (**a**) and lateral (**b**) radiogrpahs demonstrating a displaced patellar fracture

Nonoperative Management

Tense hemarthroses are painful and can damage the articular cartilage. Therefore, they should be drained. An important fact to be considered during a patient's rehabilitation is that forces applied to the patella are small in extension but increase dramatically by 6 % per degree of flexion.

Early Rehabilitation

This should be cautious and protected. Its aim is to gently mobilize the knee, fire the quadriceps, and help prevent venous thrombosis. Knee flexion is commenced after the 3rd or 4th day during the hyperanalgesic phase. Passive flexion by a CPM or physiotherapist should not exceed 45° for the first 3 weeks. After 3 weeks flexion is gradually increased to 90° by the 45th day. Mobilization is allowed in an extension brace. A second splint at 30° of flexion is used at night and prevents the occurrence of patella baja. Radiographs are repeated at D10, D21, and D45 to ensure an adequate reduction has been maintained. At day 45, fracture consolidation is usually sufficient to allow full flexion. Caution is recommended in descending stairs (ramp or step by step) for 4–6 months.

Surgical Management

Incision

A midline or paramedian longitudinal incision centered over the patella is made. Consideration should be made to incorporate open wounds (Fig. 35.2). The joint is typically visible through the fracture site. The fracture is exposed and debrided. The periosteum adjacent to the fracture is elevated to allow accurate reduction (Fig. 35.3). Pointed reduction forceps are used to maintain the reduction while fixation is achieved (Fig. 35.4). Following reduction and fixation of the fracture, the periosteal flaps and retinacular defects should be closed with sutures.

Fig. 35.3 Fracture site following exposure and debridement

Fig. 35.2 Surgical approach

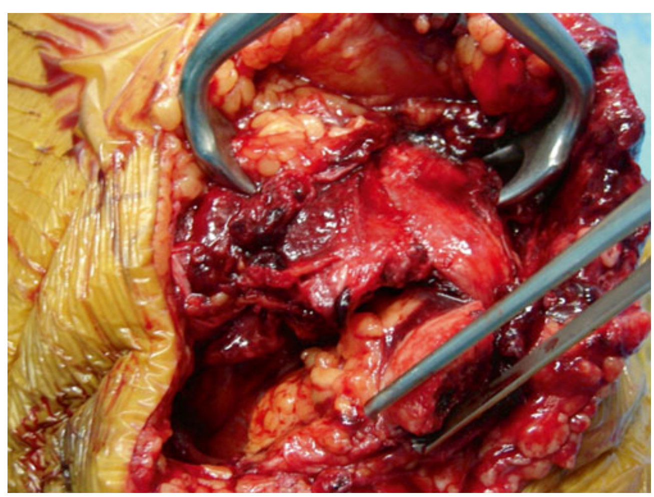


Fig. 35.4 Reduction of the fracture fragments

Method of Osteosynthesis

- Tension band wiring
  This technique is indicated when anatomical reduction is achieved (Fig. 35.5). The reduction is initially held with two vertical, parallel 1.6 mm K-wires. The cerclage wire is passed behind the K-wires and over the front of the patella in a figure of 8. This configuration turns the distractive force into a compressive force during knee flexion and prevents separation of the fracture fragments. The wire must be firmly against the upper and lower edges of the patella close to the emergence of the wires (Figs. 35.6 and 35.7).
- In comminuted fractures, a second cerclage wire around the periphery of the patella is useful in maintaining the reduction of the fragments (Fig. 35.8).
- In transverse fractures that can be anatomically reduced, osteosynthesis with screws is an alternative to using K-wires (Fig. 35.9).

Postoperative Rehabilitation

Rehabilitation is started early. The protocol is identical to that of conservative treatment.

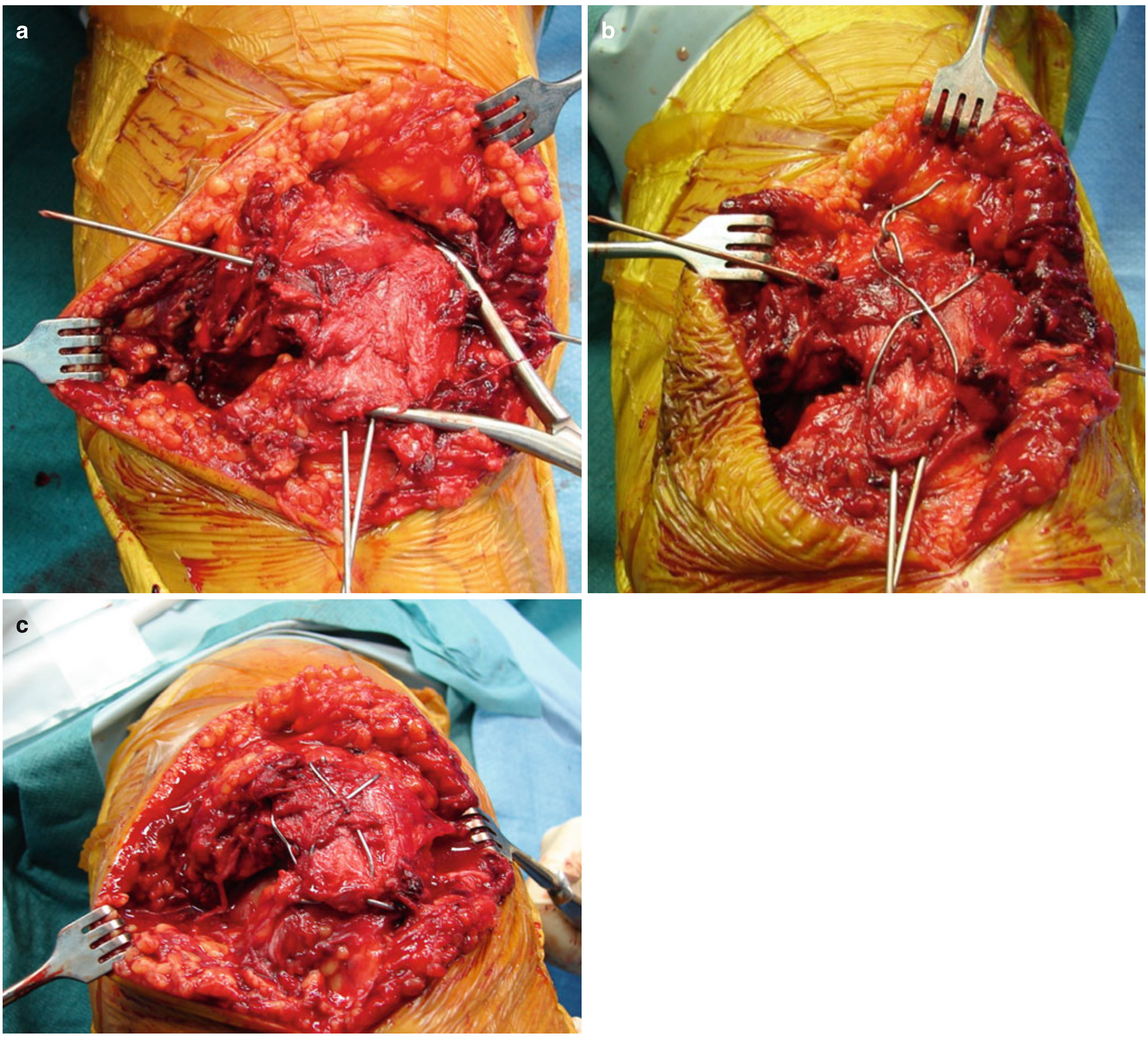


Fig. 35.5 A clamp and Kirschner wires (**a**) are used to obtain and maintain anatomical reduction of a patellar fracture. Tension band wiring fixation (**b**) completes the fixation. The final construct following trimming and bending of the Kirschner wires (**c**)

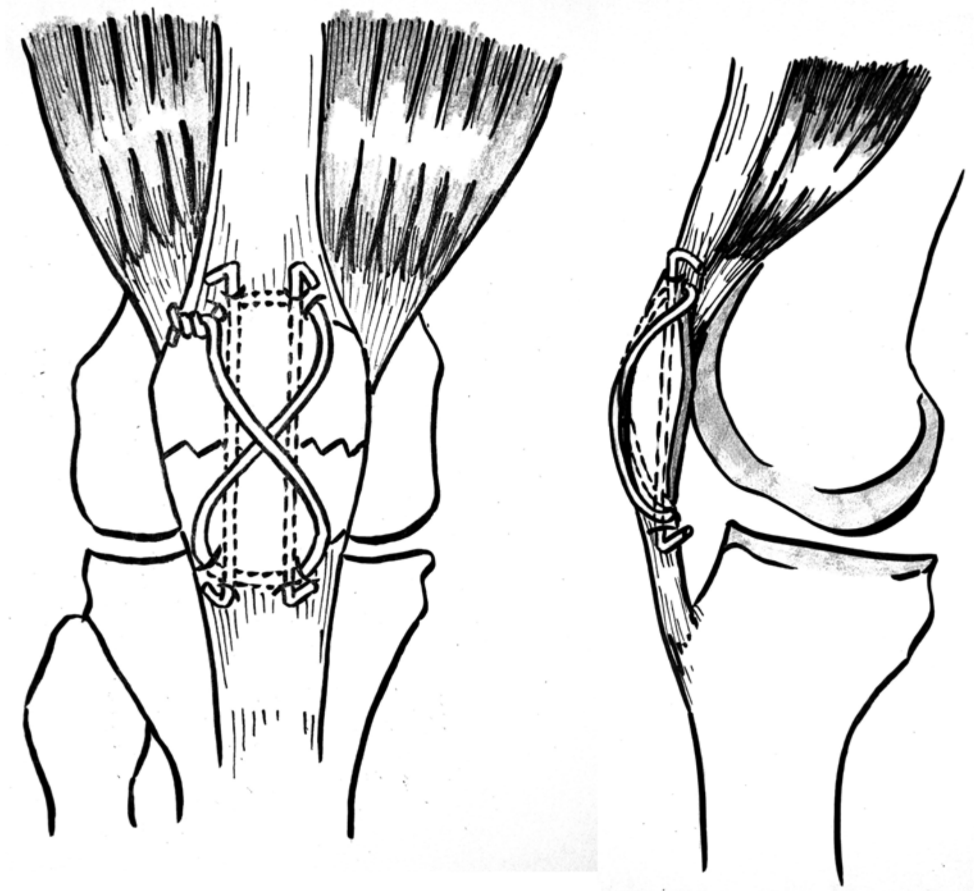


Fig. 35.6 Diagram showing the correct technique for TBW of the patella

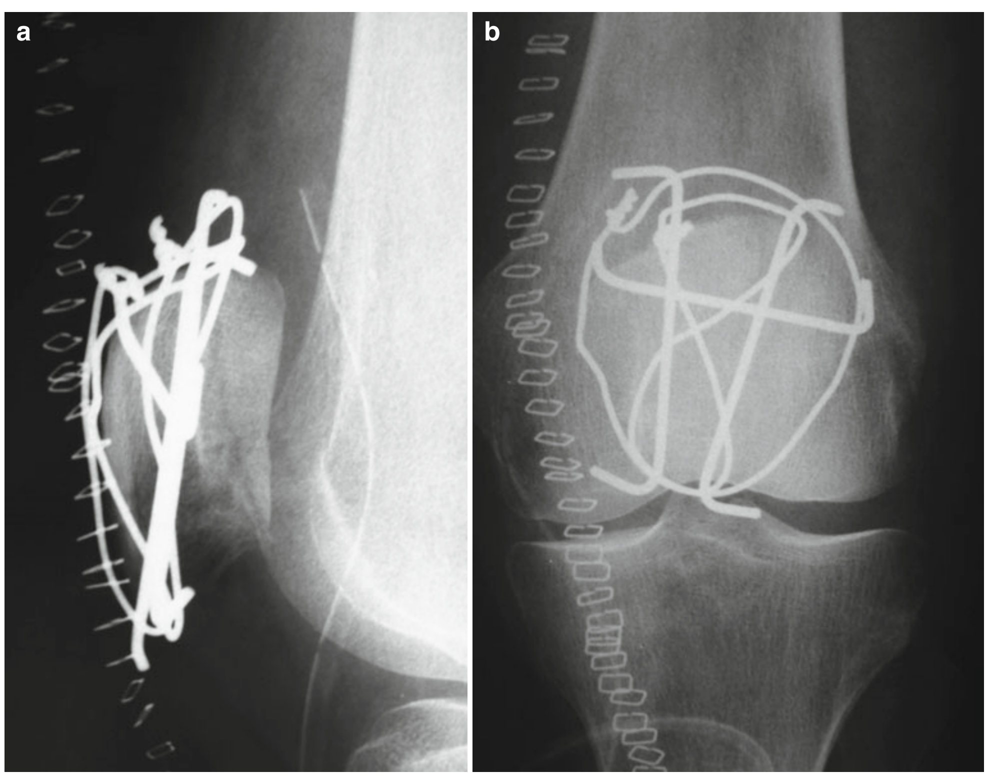


Fig. 35.7 Postoperative lateral (**a**) and AP (**b**) radiographs following tension band wiring of a patella fracture

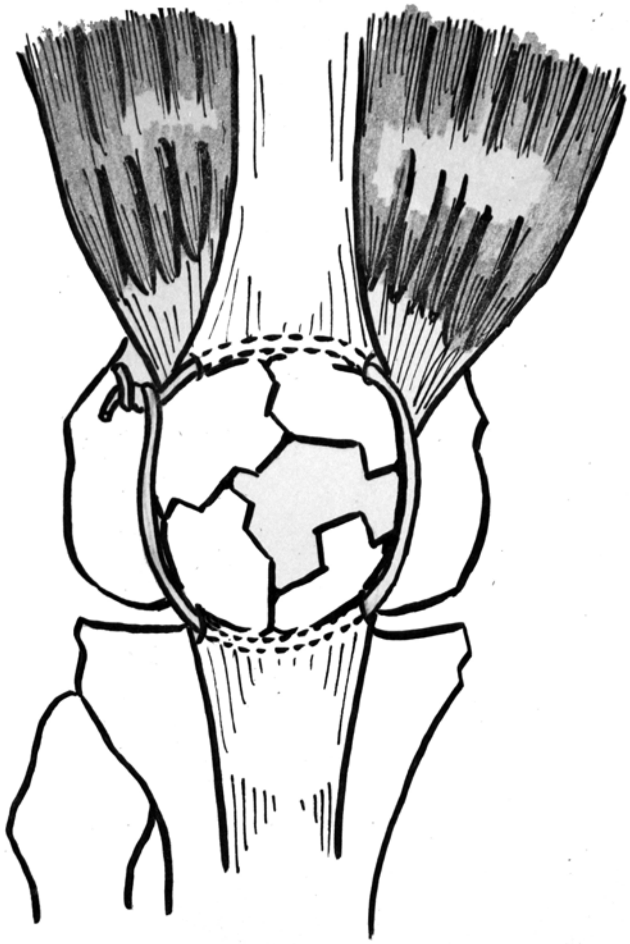


Fig. 35.8 Cerclage wiring of a patellar fracture

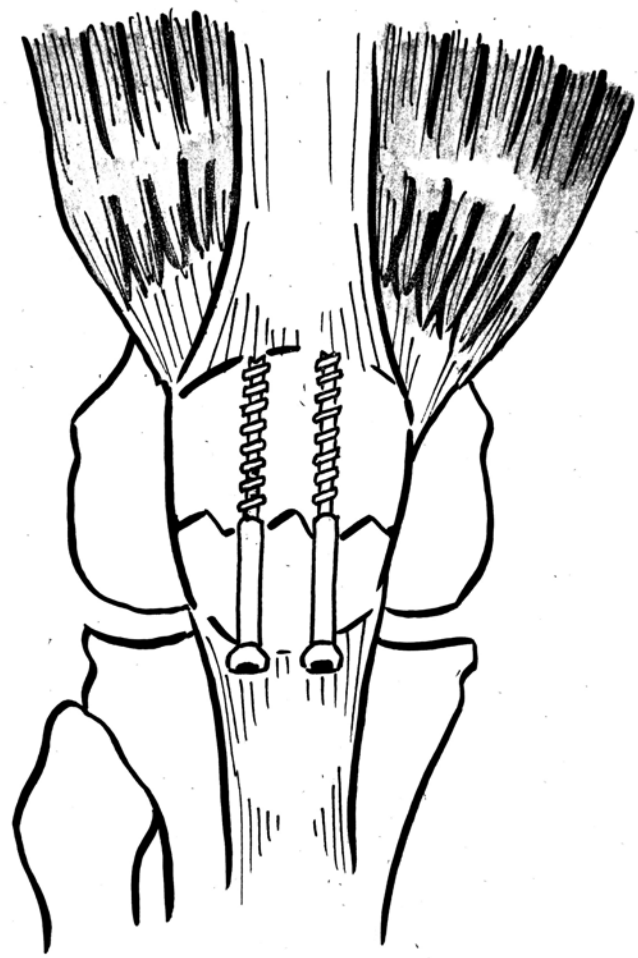


Fig. 35.9 Screw osteosynthesis of a patellar fracture

Patellectomy

Partial Patellectomy

This is rarely indicated but may be necessary when there is a significant defect in the articular cartilage due to the removal of fragments or when significant comminution prevents a satisfactory reduction. In partial patellectomies involving the upper pole of the patella, the quadriceps tendon should be reattached via transosseous tunnels. This technique is similar to that used in the repair of a distal quadriceps tendon rupture.

When the partial patellectomy involves the lower pole of the patella, the patellar tendon should be reattached to the distal patellar fragment on its posterior aspect via transosseous tunnels in order to avoid sagittal tilting of the patella. This repair (Fig. 35.10) must be reinforced with a strip of PDS® or a semitendinosus graft rather than a cerclage wire.

In comminuted fractures, an attempt should be made to preserve the distal end of the patella which is then fixed to the remaining proximal fragment. The fixation is achieved by using a transosseous wire that passes through the distal fragment into the proximal fragment. This is tightened and buried at the proximal edge of the patella, thus compressing the fragments together.

In longitudinal fractures, simple excision of small fragments is usually sufficient. When the vertical resection involves more than half of the patella, a total patellectomy should be considered. In this circumstance, joint incongruity results in disordered patellofemoral kinetics and pain.

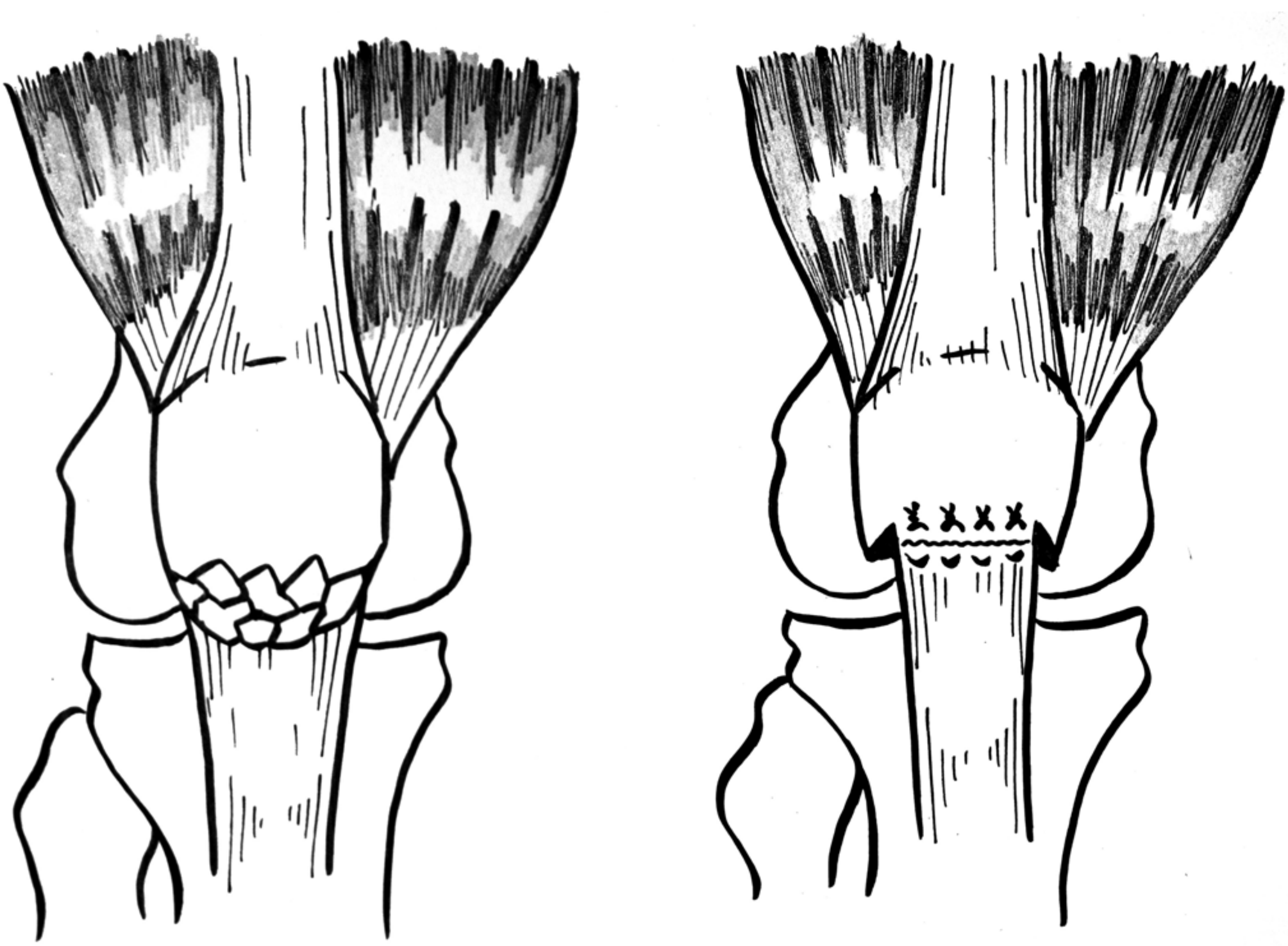


Fig. 35.10 Partial patellectomy of the distal pole of the patella

Total Patellectomy

A total patellectomy can be debilitating and should be considered only as a last resort (Fig. 35.11). It should always remain rare. When it is necessary, care should be taken when excising the bony fragments, to maintain the continuity of the extensor mechanism. To achieve this, we use a medial parapatellar arthrotomy and evert the patella laterally. The extensor mechanism is then restored by closure of the remaining soft tissue. Some surgeons, like Trillat, feel that the extra-articular tip of the patella should be retained.

Following the patellectomy, if the remaining soft tissue is insufficient to restore the continuity of the extensor mechanism, a flap of the quadriceps in the form of an inverted V can be turned down to fill the defect. The goal in all patellectomies is to moderately shorten the extensor mechanism, thus allowing limited flexion (90° to obtain 60 appears sufficient). This is because the repair tends to lengthen gradually over time, improving flexion. One must also ensure correct centering of the extensor mechanism over the trochlea in order to maximize the efficiency of the remaining extensor mechanism.

Fig. 35.11 The mutilating effect of a total patellectomy of the right knee

36 Surgical Management of the Stiff Knee

P. Archbold and R. Debarge

Introduction

Stiffness of the knee or, more precisely, limited range of motion of the knee is an ill-defined term. The reason is that it is both a functional description and clinical sign that can evolve over time. Absolute numbers therefore have a limited value. Stiffness of the knee can be defined by certain variables:

- Evolution over time
- Tolerance (there is a difference between a total knee arthroplasty and ligament surgery)
- Etiology (ACL surgery, intra-articular fractures, etc.)

The precise range of motion must be clearly recorded in the patient's clinical notes with the same care, for example, that is taken to document the body temperature and arterial blood pressure during the pre- and postoperative period. These values should be transferred to the physiotherapist once the patient leaves the hospital. During surgery it is important to document the range of motion prior to the anesthetic induction and also at the end of the surgical procedure.

The clinical history should be analyzed carefully, in particular the circumstances of the initial accident, the previous surgical interventions, and the different rehabilitation programs undertaken. The range of motion must be documented during each of these steps, in order to make it possible to document the evolution of the stiffness. Some threshold values are known: 90° of flexion is required for stair-climbing, and 120° is needed to comfortably perform the activities of daily living. Three measurements can quantify the range of knee motion: the first is the hyperextension, the second is the extension deficit, and the third is the maximal flexion. For example, a range of motion documented as 5/0/120 represents 5° of hyperextension, 0° of extension deficit, and 120° of flexion. The clinical examination should always be comparative; therefore the values for the contralateral knee have to be documented as well. A clinical examination in the prone position is important in order (Fig. 36.1) to evaluate an extension deficit (cyclops of the ACL). Normal function of the medial and lateral gutters and the supra-patellar pouch are necessary to have a normal range of motion, in particular for flexion. Stiffness of the knee can be classified using different criteria.

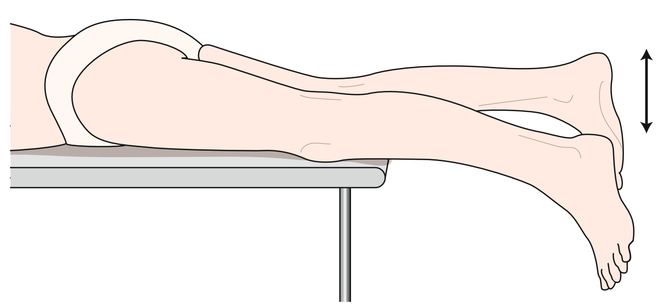


Fig. 36.1 Clinical examination in the prone position to evaluate an extension deficit

P. Archbold, MD (✉)
The Ulster Independent Clinic,
245 Stranmillis road, Belfast BT95JH, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

R. Debarge, MD
Clinique Jean Causse,
Traverse de Béziers, Colombiers 34440, France
e-mail: r_debarge@hotmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_36, © Springer-Verlag London 2014

Etiological Classification

- Reflex sympathetic dystrophy (complex regional pain syndrome): usually conservative therapy is initiated.
- Posttraumatic (femoral fracture, patella fracture, tibial plateau fracture, grade III sprain of the medial collateral ligament, ACL rupture with cyclops lesion).

Albert Trillat illustrated that adhesions between the medial collateral ligament and the medial femoral condyle could limit the motion of the medial capsular structures (Fig. 36.2a, b). These adhesions cause a functional shortening of the medial collateral ligament; the center of the rotation moves from the medial condyle to a point close to the tibiofemoral joint line. These adhesions limit flexion to approximately 60°.

- Postoperative (ACL reconstruction, total knee arthroplasty, synovectomy)
- Postinfectious (septic arthritis of the knee)
- Certain muscular diseases

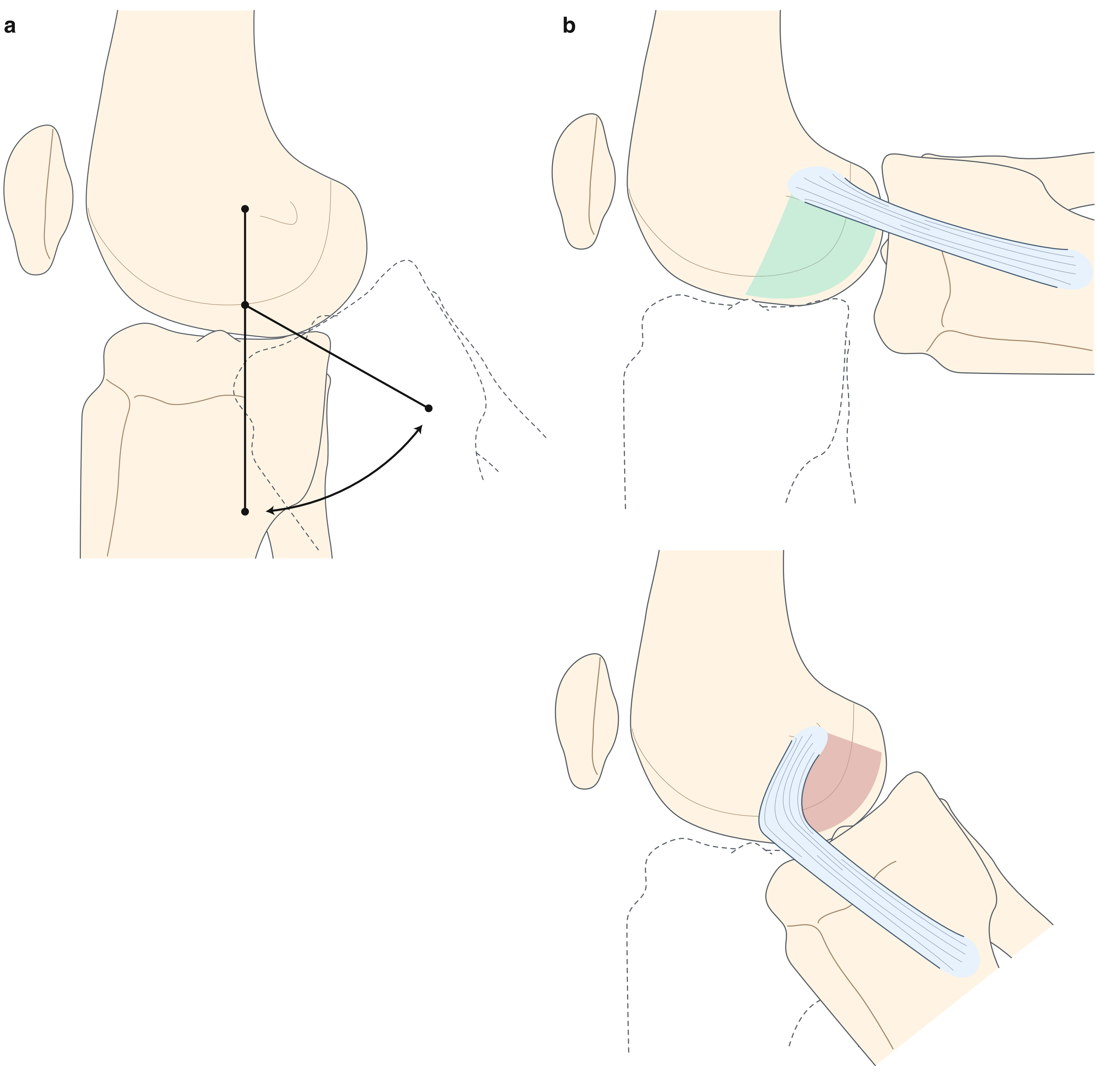


Fig. 36.2 (**a**, **b**) Albert Trillat's drawing: stiffness and MCL lesion. Adhesions limit flexion to approximately 60°

Stiffness According to the Type of Limitation (Excluding the Specific Considerations for Knee Arthroplasty)

Flexion Limitation

In the case of limitation of flexion, it is necessary to release the adhesions in the supra-patellar pouch and the condylar gutters. Sometimes retraction of the quadriceps and extensor mechanism necessitates an additional release according to Judet.

Limitation of Extension (Fixed Flexion Deformity)

A fixed flexion deformity (FFD) results in a reduction of the contact area of the cartilage, which can lead to pain and arthritis. It is very important to address a fixed flexion deformity in the hip or the contralateral knee since these can result in fixed flexion deformity of the index knee. Because of the limited extension, it is important to think about an obstacle situated in front of the intercondylar notch (e.g., a free body or a dislocated bucket handle tear of the meniscus).

Other reasons could be a recent rupture of the ACL (mop tear) or a cyclops syndrome secondary to an ACL reconstruction. Finally, a reconstructed ACL can also cause a fixed flexion deformity: most frequently secondary to malpositioning of the femoral or tibial tunnels. Capsular or ligamentous scarring is a less frequent cause but can sometimes necessitate a posterior capsulotomy or even resection of the reconstructed anterior cruciate ligament to overcome the deformity.

Mixed Limitation (Flexion and Extension)

Iatrogenic Limitation Associated with Tibial External Rotation

This type of stiffness is essentially observed after a Lemaire extra-articular anterolateral plasty fixed in external rotation, which has been described in detail by H. Jaeger.

Classification of Stiffness According to Anatomy (Fig. 36.3a, b)

Articular Stiffness

Capsular or intracapsular.

Intracapsular stiffness can be addressed by arthroscopy.

Extra-articular Stiffness

Requires open surgery.

In the case of limitation of flexion and extension, multiple anatomical structures are involved. The common denominator remains capsular retraction. Shortening of the posterior knee capsule secondary to a fixed flexion deformity (because of an obstacle in front of the intercondylar notch) can perpetuate the deformity. Posterior osteophyte causing a flexion deformity cannot be addressed arthroscopically.

Stiffness of the Knee According to the Degree of Limitation

A clear difference needs to be made between a fixed flexion deformity observed in the athletic population and a limitation in flexion after a total knee arthroplasty.

The following surgical options are available:

- Manipulation under anesthesia (MUA)
- Arthroscopic arthrolysis
- Open arthrolysis with an arthrotomy (anterior and posterior)
- Arthrolysis according to Judet (not in this chapter)

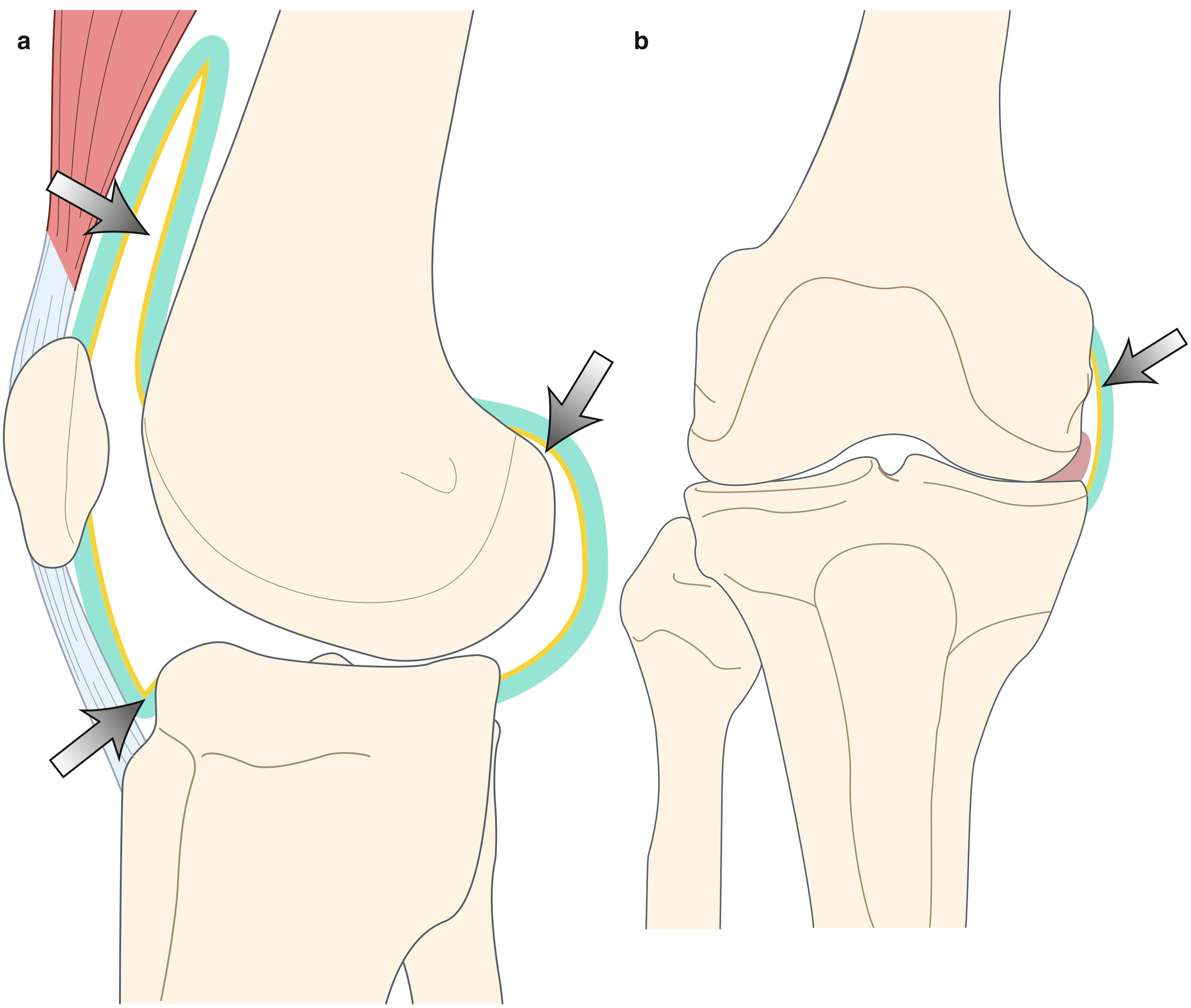


Fig. 36.3 (**a**, **b**) Intracapsular stiffness (supra-patellar pouch, condylar gutters, anterior compartment)

Manipulation Under Anesthesia

Indications and Risks

This aim of this intervention is to overcome intra-articular adhesions. Sometimes, these adhesions are present between the articular surfaces. However, one must be aware that during a forceful manipulation a fracture or damage to the articular surface of the joint can occur.

Therefore:

- Manipulation under anesthesia should be performed after healing of the skin incision.
- In the case of a non-prosthetic knee (after trauma or ligament injury), the MUA should be performed with extreme caution and should be performed at an early stage (less than 30 days from surgery).
- Arthroscopic arthrolysis is indicated and preferable within 45 days of the initial surgery that caused the stiffness. During the arthroscopy, the synovial and cartilaginous adhesions can be cut, avoiding a forceful MUA.
- In the case of a total knee prosthesis, MUA can be done up to the 90th day after surgery. Risk for injury to cartilage is limited (except in cases where the patella is not resurfaced or in case of a unicompartmental knee prosthesis).

Manipulation Under Anesthesia Technique

Prior to the manipulation, the full clinical history of the patient and the most recent radiographs should be available. The status of the skin and in particular the skin incision should be examined to avoid complications (Fig. 36.4a, b). Once the patient is under anesthesia, the initial range of motion is documented. The mobilization starts gently by progressively exerting manual pressure with both hands on the tibial tubercle. The hip should be flexed. Commonly, the adhesions are easily overcome. Sometimes, small cracks can be heard.

If the abovementioned details are respected, everything should go according to plan. At the end of the procedure, the range of motion is documented. Spontaneous flexion should also be documented. Spontaneous flexion is defined as the maximal flexion obtained by gravity with the hip in flexion. This spontaneous flexion is most commonly the flexion obtained at the end of the rehabilitation period. In the case of a limitation in flexion, the patient is positioned with a specially designed flexion cushion in the postanesthesia care unit (Fig. 36.5). If a “delayed” MUA is performed, the surgeon has to be aware of the risks (diaphyseal fractures, rupture of the extensor mechanism). Most importantly, the manipulation has to be done progressively without excessive force. In case of an MUA on a non-prosthetic knee, the more important, but frequently unrecognized, complication is damage to the articular cartilage.

Fig. 36.4 (**a**, **b**) Case of serious complication after MUA: patellar tendon avulsion associated with wound dehiscence

Fig. 36.5 Flexion cushion

Arthroscopic Arthrolysis

Indications

This type of surgery is indicated in cases of stiffness secondary to an intracapsular cause, most commonly following ligamentous surgery.

Several surgical procedures can be done:

- Section of the synovial adhesions
- Removal of intra-articular loose bodies
- Meniscectomy for a dislocated bucked handle tear
- Treatment of ligamentous lesions (cyclops, mop tear)
- Treatment of the stiffness after prosthetic knee surgery

Surgical Technique

The classic portals are used: anterolateral and anteromedial but also superomedial and superolateral. Different surgical procedures are available depending on the cause of the stiffness:

- Release of the adhesions in the supra-patellar pouch and condylar gutters

  A specifically designed knife blade is used for this procedure (Figs. 36.6, 36.7, and 36.8).

  It is very easy to handle and it does not necessitate a skin incision. The procedure can be easily performed under visual control. Only those adhesions that are under tension will be cut, thus limiting blood loss.

- Removal of foreign bodies (cyclops, anterior osteophyte, osteochondral fragment).
- Meniscectomy for a displaced bucked handle tear.
- Stiffness after total knee prosthesis is detailed in another chapter.

  Introduced by W. Clancy, we have also observed that scarring of the anterior inter-meniscal ligament can be a cause of an extension deficit. Due to retraction, both the medial and lateral meniscus are pulled anteriorly and can impinge with the femoral condyle. It is possible to transect this anterior inter-meniscal ligament under arthroscopy. This procedure can be useful in a chronic fixed flexion deformity (several months).

Fig. 36.6 Specifically designed knife blade

Fig. 36.7 Adhesions in the supra-patellar pouch

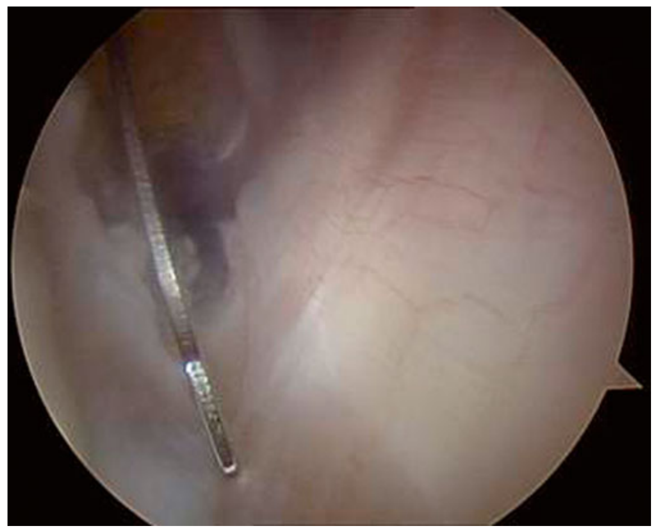


Fig. 36.8 Release of the adhesions in the medial condylar gutter

Open Arthrolysis

We will not detail the surgical approaches (cf chapter on synovectomies).

Anterior Arthrolysis

Two skin incisions can be used: anteromedial and superolateral. Both skin incisions allow an anteromedial arthrotomy and a superolateral arthrotomy.

Posterior Arthrolysis

Posteromedial and posterolateral arthrotomies are performed behind the respective collateral ligaments. In some rare cases, a posteromedial arthrolysis alone can suffice (after open medial meniscus suture or retraction of the posteromedial capsule). In all other cases, a posterior arthrolysis should be performed using both approaches. Through the posteromedial and posterolateral arthrotomies, one can easily release the posteromedial and posterolateral capsule from the posterior femoral condyles with a 15 blade knife. This release has to be a total release, meaning that "light should be observed between the incisions." Full extension is generally obtained. Sometimes full extension however is somewhat elastic in the final degrees of extension. In this situation we prefer the application of an extension brace postoperatively rather than transection of the capsule or a transection of the hamstrings. This brace should be applied for at least five nights and should be combined with a strict rehabilitation protocol.

Remarks

Posterior arthrolysis is being performed less frequently.

Anterior arthrolysis is more frequently performed under arthroscopy.

Release According to Judet

This release is beyond the aim of this chapter and is detailed in another chapter. The release of the extensor apparatus according to Judet has become a very rare surgical intervention since the introduction of arthroscopy and the decrease in road traffic accidents. Nevertheless, a release of the quadriceps muscle according to Judet is indicated in very severe cases of stiffness.

The surgical procedure is composed of two essential steps:

- The first is the arthrolysis.
- The second is release of the quadriceps muscle.

This intervention is very demanding and the risk for fractures because of devascularization is real. An isolated transection of the vastus medialis has also been reported in the literature recently to address this important problem.

Stiffness and the ACL

Although the treatment is similar, one must make a distinction between two diagnostically different situations:

(a) Recent rupture of the ACL with a mop tear (positioning of the distal end of the ruptured ACL inside the intercondylar notch). Arthroscopic resection should result in full extension (Fig. 36.9). A reconstruction can be indicated during the same surgical procedure.

(b) Cyclops syndrome after reconstruction of the ACL, which is a fibrous soft tissue reaction in front of the reconstructed ACL. Arthroscopic resection usually results in full extension (Fig. 36.10). In general we combine this procedure with a notchplasty. The notchplasty can be done with curved osteotome or a burr.

If extension still cannot be obtained, a complete sectioning or removal of the ACL reconstruction should be considered. This decision is of course easier to make if the femoral and tibial tunnels are malpositioned. Not uncommonly, an osteophyte can be observed in front of the tibial tunnel. This osteophyte can be easily removed. We commonly combined this procedure with a notch plasty to create a sufficiently large clearance for the graft.

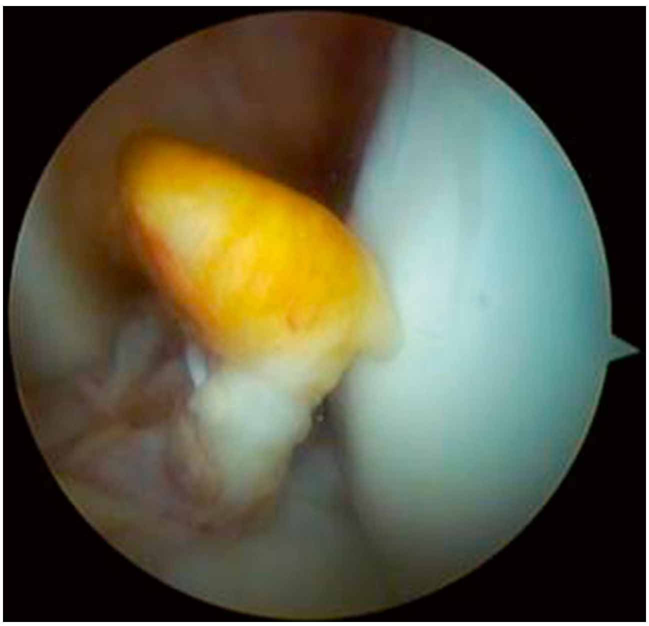


Fig. 36.9 Recent rupture of the ACL with a mop tear

Fig. 36.10 Resection of a fibrous soft tissue reaction in front of the reconstructed ACL (cyclops syndrome)

Stiffness After Total Knee Arthroplasty

General Information

Stiffness after a total knee arthroplasty is not an uncommon phenomenon (10–15 %). It is important to determine the origin of the stiffness, its extent, and its impact on function in order to institute the appropriate treatment. Stiffness after a total knee arthroplasty can be defined as a flexion less than 90° or an extension deficit greater than 10° irrespective of the type of knee prosthesis.

Four surgical procedures are available:

- Manipulation under anesthesia
- Arthroscopic arthrolysis (attention should be paid not to damage to the prosthetic surfaces)
- Open arthrolysis
- Revision of the prosthesis

Our therapeutic approach:

- Well-positioned implant

Between days 15 and 90	Manipulation under anesthesia
Between days 90 and 180	Arthroscopic arthrolysis
After day 180	Open arthrolysis

- Malpositioned implant

  Revision surgery is indicated in cases in which the posterior cruciate ligament is retained. Sectioning of the posterior cruciate ligament can be an option (the polyethylene should be changed to an ultracongruent polyethylene). In some of these cases, the prosthetic design has to be changed to a posterior cruciate substituting design. The surgeon should follow up his patients in the early postoperative period to observe the progression in the range of motion. If he is confronted with a stiff knee within 3 months post surgery, he can consider an MUA after the elimination of potential complications such as complex regional pain syndrome or infection.

Arthroscopic Arthrolysis (Fig. 36.11a–c)

Stiff total knee arthroplasties can be treated arthroscopically by sectioning the adhesions in the supra-patellar pouch, the condylar gutters, and the space in front of the knee. The articulating surfaces of the total knee arthroplasty should not be damaged. In some cases, it could be necessary to perform a medial and lateral patellar retinaculum release to obtain a better flexion.

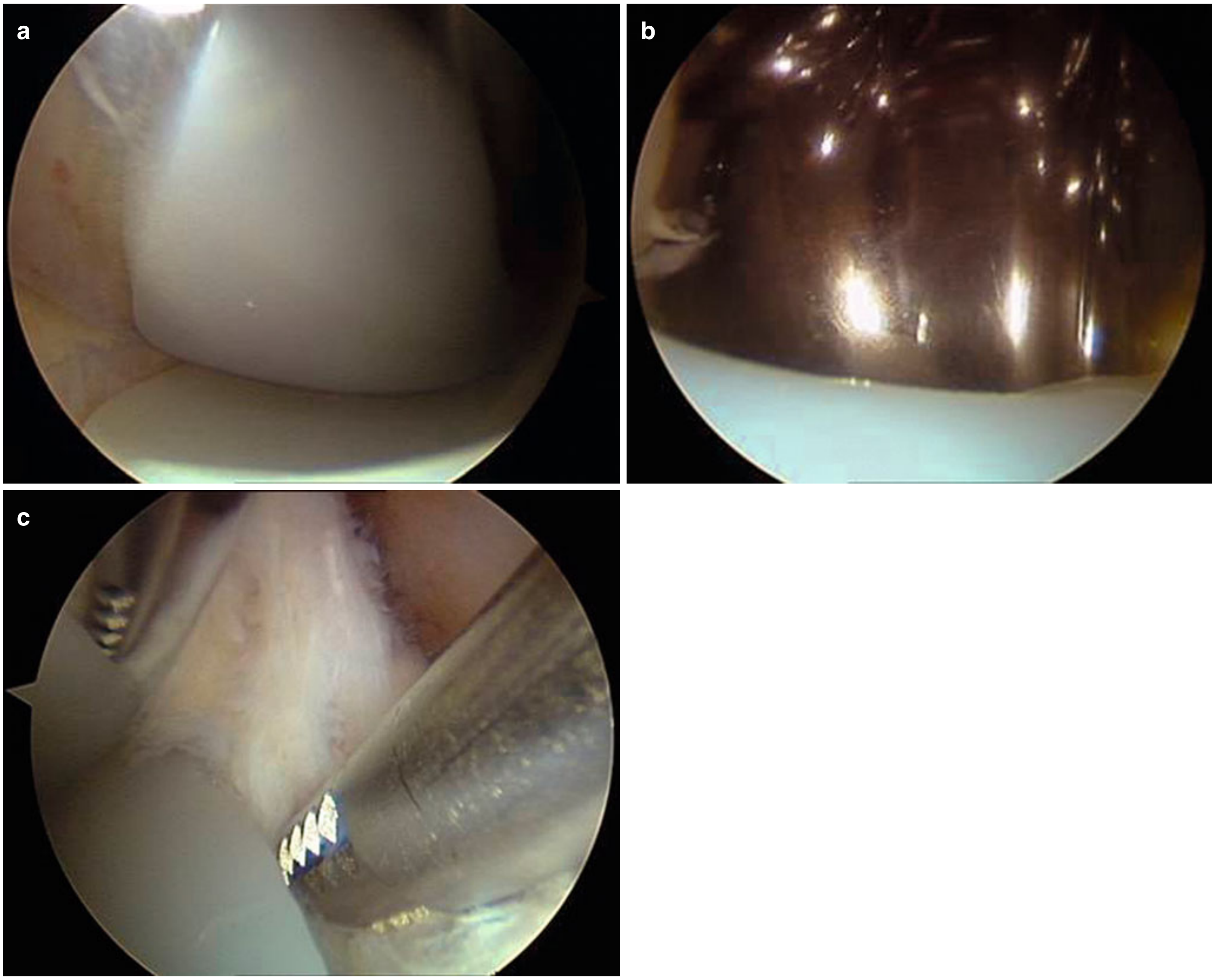


Fig. 36.11 (**a**–**c**) Arthroscopic arthrolysis on TKA

Adjuvant Treatments and Postoperative Guidelines

Full weight bearing is allowed with a brace in full extension (for 3–5 days).

Low molecular weight heparins are not prescribed. However, strong pain medication and muscle relaxants are indicated.

Flexion Deficit

At the end of the mobilization, a specifically designed cushion at 90° is applied to the knee for the first postoperative night and continued every 6 h thereafter (Fig. 36.5).

Fig. 36.12 Continuous passive motion

Continuous passive motion (Fig. 36.12) is started on the second or third postoperative day.

Extension Deficit

Routinely a brace in extension is applied to the knee before the end of the anesthesia. This brace should be worn initially until the next morning and should be continued during the night for another five to ten nights depending on the progression and the result that was obtained during surgery.

Lengthening of the Patellar Tendon

37

G. Demey and P. Archbold

Patella Infera

Patella infera with a Caton-Deschamps (C-D) index of 0.6–0.8 is not uncommon. If symptomatic, a proximal transfer of the tibial tubercle (TT) can be considered.

Patella infera (C-D index <0.6) occurs following surgery or trauma secondary to reflex sympathetic dystrophy (complex regional pain syndrome). It presents with pain out of proportion to the initial injury. An early diagnosis is critical to obtaining an outcome, and its occurrence should be suspected in patients who are slow to rehabilitate, who have reduced mobility of the patella, and whose quadriceps fire late. Patients typically complain of a burning prepatellar pain, a "vice"-like sensation, or subpatellar tightness. Descending stairs, prolonged sitting, and rising to stand increase the pain. Flexion is also limited. Osteopenia of the patella is seen on radiographs (Fig. 37.1), and patella infera occurs secondary to contracture of the patellar tendon/retinaculum and quadriceps hypotonia. The axial view may reveal the classical "sunset" (Fig. 37.2). If diagnosed early, it can be treated by bracing the knee in 30° of flexion to put the patellar tendon under tension and rehabilitation with active quadriceps contractions.

Once a significant infera has occurred (index <0.6), it can be treated by lengthening the patellar tendon or by proximalization of the TT. Preoperatively the patellar height and tendon length can be accurately assessed from radiographs by measuring the C-D index. This information can also be obtained from magnetic resonance imaging (MRI). Tibial tubercle transfer is an easier procedure, but is less logical than lengthening the tendon itself if the tendon is short. TT transfer is generally insufficient to treat severe patella infera (C-D index <0.6).

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

P. Archbold, MD
The Ulster Independent Clinic,
245 Stranmillis road, Belfast BT95JH, Northern Ireland, UK
e-mail: poolerarchbold@aol.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_37, © Springer-Verlag London 2014

Fig. 37.1 Lateral radiograph of the knee showing patella infera

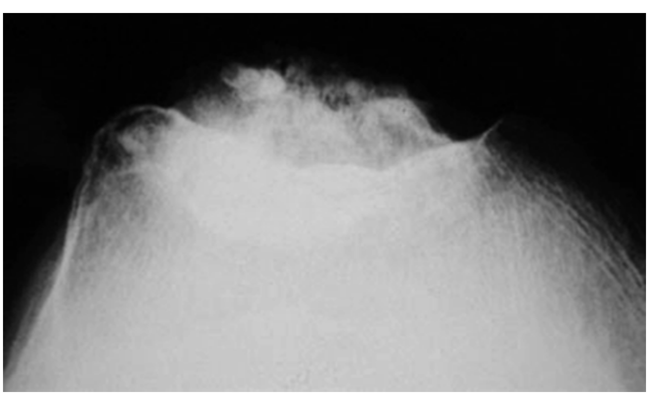


Fig. 37.2 Classical "sunset" sign on the axial radiograph

Surgical Technique for Lengthening the Patellar Tendon

This technique is based on the principle of the sliding flap first described by H. Dejour.

Incision

A midline longitudinal incision is made taking into consideration any previous incisions.

Patellar Tendon Lengthening

Expose the patellar tendon throughout its width and length and incise the tendon vertically from the tip of the patella to the tibial tubercle in the midline. The incision is continued over the patella and onto the quadriceps tendon for a distance of 2 cm (Fig. 37.3). The patellar tendon is released medially and laterally, and the fat pad (fat pad) is excised from the posterior aspect of the tendon.

The medial flap remains in continuity with the patella. It is mobilized by releasing the medial half of the patellar tendon from the TT with a 2 cm periosteal flap (Fig. 37.4). The incision medially is continued along the medial border of patellar tendon up to the patella, completely mobilizing the flap.

The lateral flap is the lateral half of the patellar tendon. The flap is left attached distally and elevated from the patella with a periosteal flap and a full-thickness strip of the quadriceps tendon. The vertical incision in the middle of the patellar tendon is extended over the patellar and onto the quadriceps tendon for 2 cm. Two centimeters above the top edge of the patella, the lateral aspect of the quadriceps tendon and the vastus lateralis are incised transversely. The lateral flap is then raised by elevating the full-thickness strip of patellar periosteum and quadriceps tendon off the patella and mobilizing the lateral strip of the patellar tendon. It is left attached on the tibial tuberosity (Fig. 37.5a, b). The elevation of the lateral flap completes the release of the patella from TT (Fig. 37.6).

An intraoperative radiograph ensures the correct restoration of patellar height (true lateral at 30° of flexion), and the medial and lateral flaps are sutured edge to edge along their entire length (Fig. 37.7). The lateral flap is fixed on the lateral part of the proximal pole of the patella, and the medial flap is fixed to the TT with two suture anchors (Fig. 37.8a, b).

The sliding flap is reinforced by a strip of PDS® (Fig. 37.9a, b). It is folded in half and fixed to the tibial tuberosity using an Orthomed® staple. The two strands are then sutured into a "V," onto the patellar tendon, patella, and quadriceps tendon. The suturing is done at 60° of knee flexion to prevent shortening of the patellar tendon and the reoccurrence of a patella infera.

The closure often requires several small vertical incisions in the medial capsule close to the medial collateral ligament in order to lengthen the medial retinaculum.

The lateral retinaculum is left open.

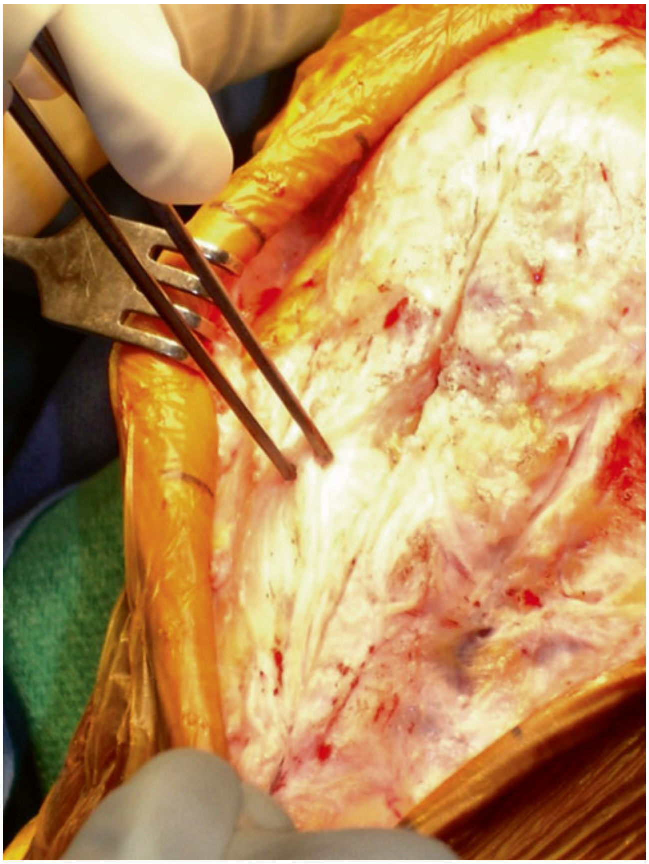


Fig. 37.3 Incising the patellar tendon

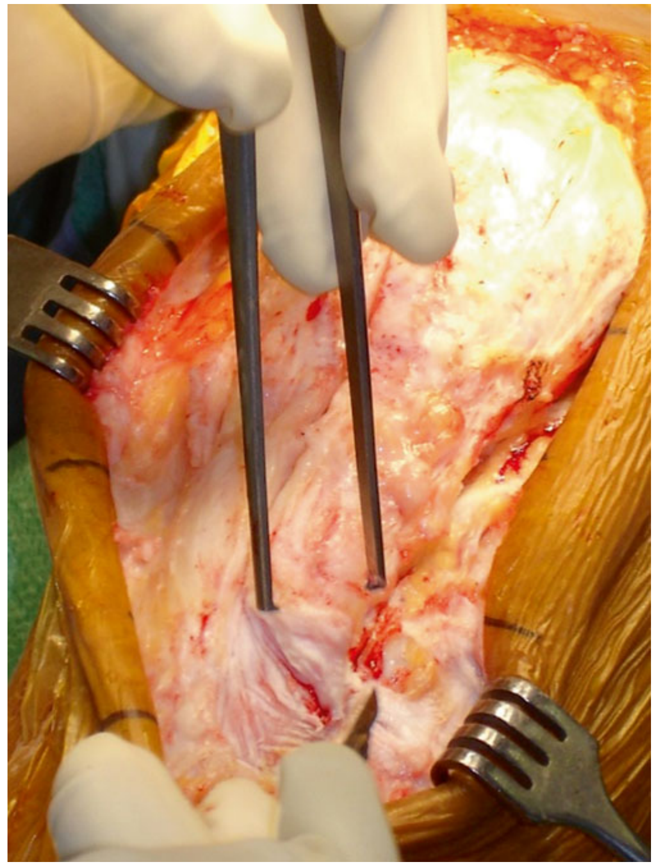


Fig. 37.4 Mobilizing the medial flap – medial half of the patellar tendon

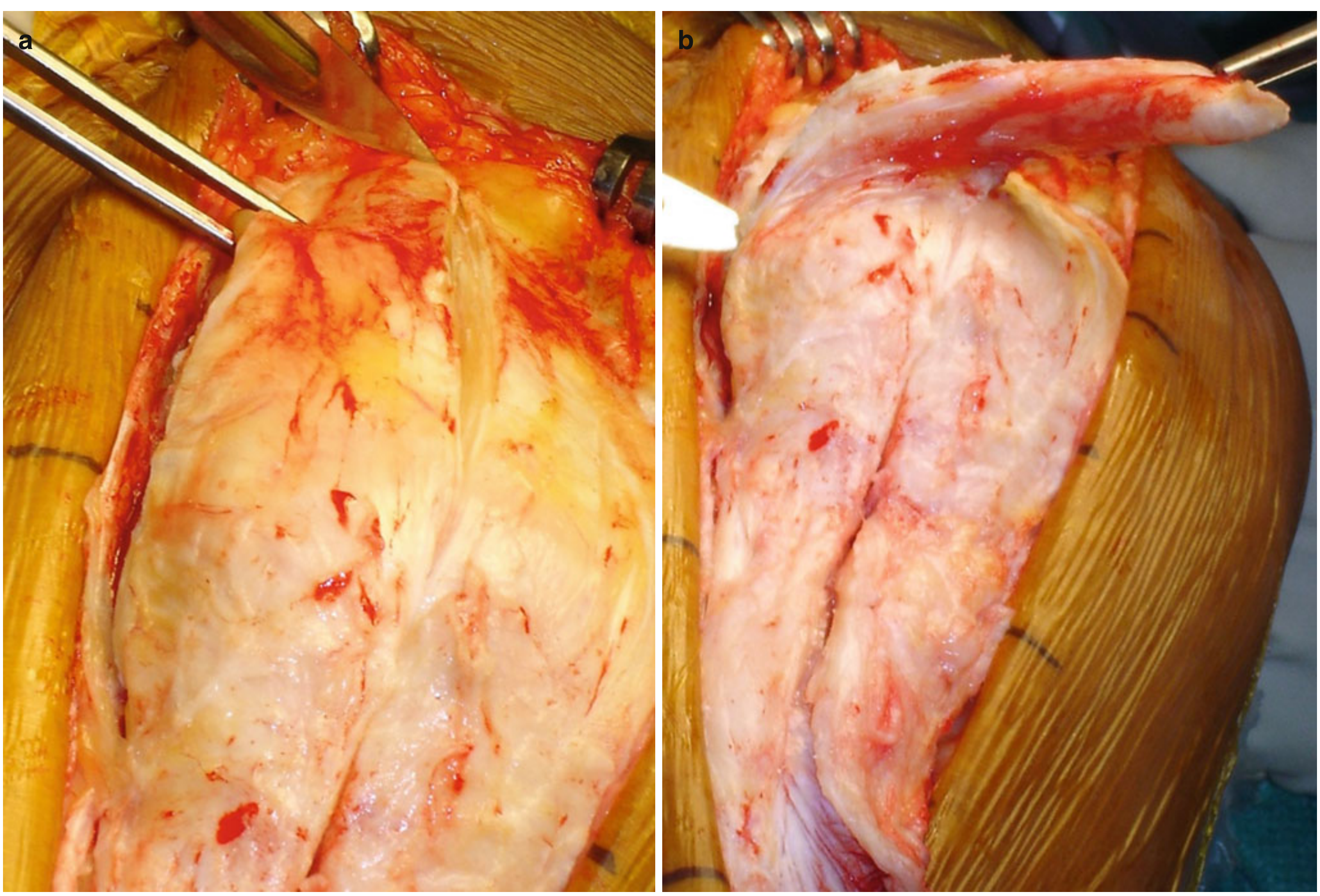


Fig. 37.5 (**a**, **b**) Mobilization of the lateral flap

Fig. 37.6 Release of the patella

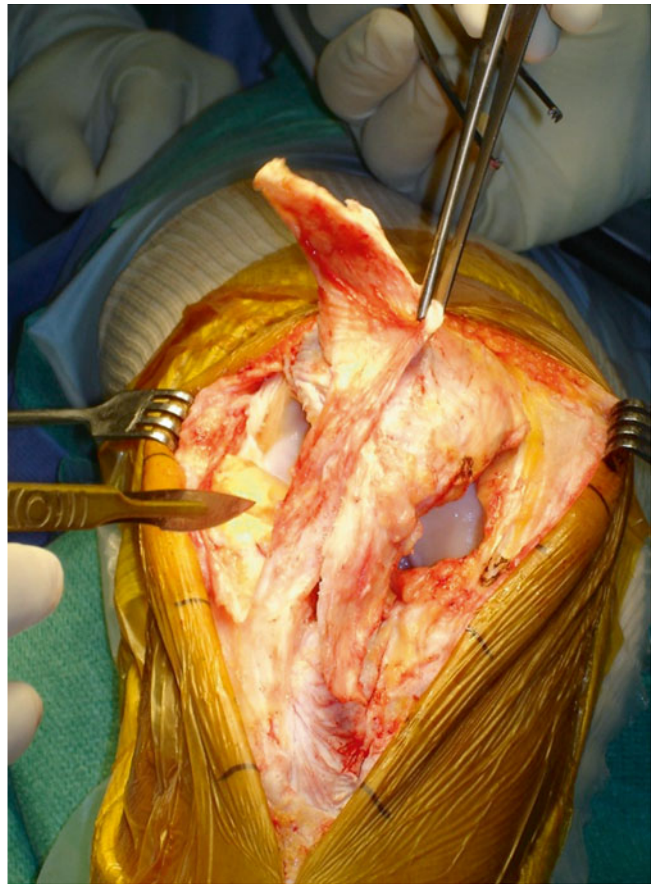


Fig. 37.7 Suture of the medial and the lateral flaps edge to edge

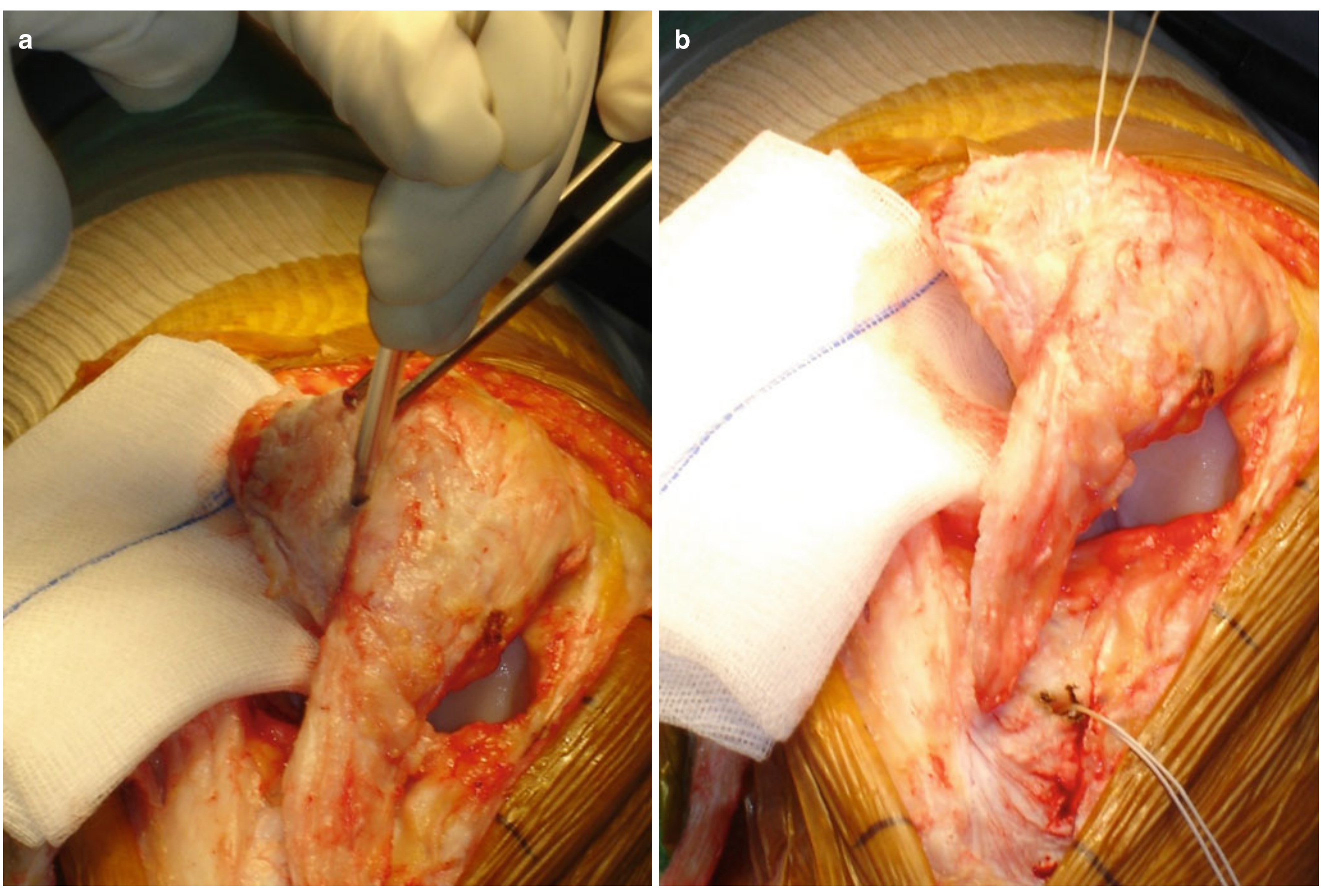


Fig. 37.8 (**a**, **b**) Suture anchors are used to fix the flaps to the patella and ATT respectively

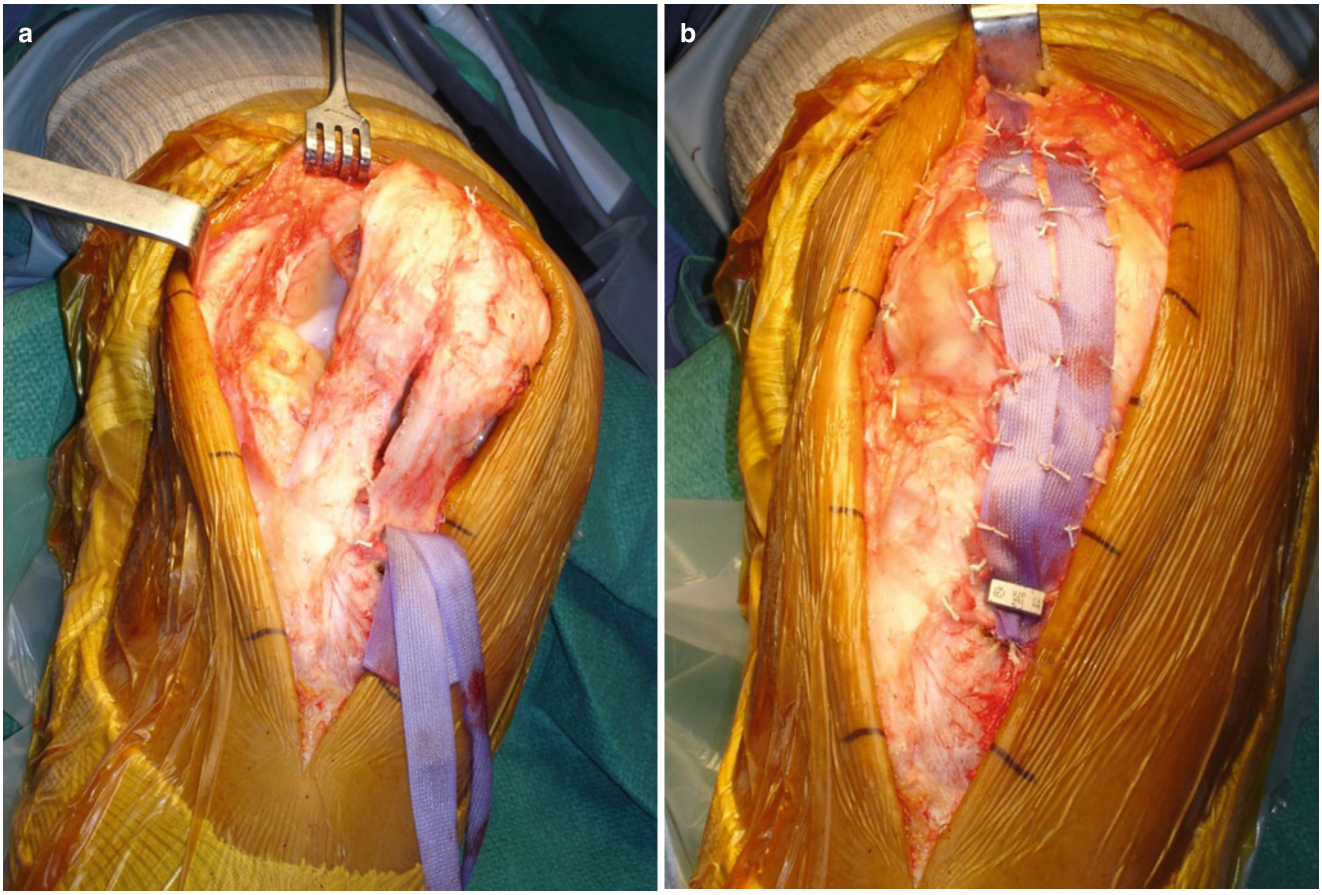


Fig. 37.9 (**a**, **b**) Reinforcement of the sliding flap with PDS tape

Postoperative

Radiographs should be obtained (Fig. 37.10). There is no specific physiotherapy protocol for lengthening of the patellar tendon. We recommend a protocol identical to that for acute ruptures of the patellar tendon. The only difference being that the knee should be immobilized in 60° of flexion to keep the lengthened patellar tendon in slight tension. Therefore in the immediate postoperative period, the knee is immobilized on a cushion at 60° of flexion (Fig. 37.11).

Fig. 37.10 Postoperative x-ray

Fig. 37.11 Postoperative immobilization at 60° of flexion

Patella Infera Following TKA

Following TKA it is still unknown why patella infera causes pain. In cases that require surgery, we do not recommend a simple sliding flap due to the significant risk of rupture. Instead we perform a technique involving an extensor mechanism reconstruction as described previously.

38 Stiffness of the Knee: Release According to Judet

H. Hobbs, J. Bruderer, and G. Demey

We do not aim to accurately reproduce the technique that was originally and precisely described by Robert and Jean Judet, but rather to describe the procedure that we perform when confronted with severe and permanent stiffness of the knee. This is often secondary to a fracture of the distal femur.

Stiffness of the knee can be defined as a limitation of the range of motion of the knee. The absence of spontaneous resolution is characteristic. An absolute value of the range of motion should not be considered without looking at the whole context.

Similarly, the procedure described below is not a "one size fits all" operation. We find that the different parts of the procedure need to be performed in different patients depending on the etiology of the stiffness being treated. For example, in cases of stiffness after a fracture, only a localized release of subsequent scarring under the quadriceps may be indicated where in cases of chronic dislocation of the patella and shortening of the entire extensor mechanism, a more complete elevation of the musculature is needed. Similarly, physical examination can inform this decision. Cases in which the degree of knee flexion obtained does not depend on hip flexion or extension will likely not benefit from a rectus femoris tenotomy.

H. Hobbs, MD (✉)
Sports Science Institute,
Boundary Road, Newlands Cape Town, South Africa
e-mail: haydhobbs@gmail.com

J. Bruderer, MD
Mühlegasse 18, Frick 5070, Switzerland
e-mail: james.bruderer@ksbh.ch

G. Demey, MD
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

Several factors should be investigated:

- The range of motion and the patient's activity level. Climbing stairs requires a minimum of 90° of flexion (the initial goal when performing a total knee arthroplasty). One hundred twenty degrees is usually sufficient for most everyday activities of daily living.
- The evolution of the stiffness over time.
- The etiology (ligament surgery, periprosthetic or articular fracture, etc.).
- The anatomical structures involved.
- The influence of hip position on the degree of knee flexion that can be obtained.

All these elements will determine what management is needed:

- Conservative treatment
- Mobilization under general anesthesia
- Arthroscopic arthrolysis
- Open arthrolysis via an arthrotomy (anterior and posterior)
- Arthrolysis and release according to Judet
- Arthrolysis and release according to Lobenhöffer

The release of the extensor mechanism, according to Judet, is for stiffness of an extra-articular origin and is fortunately an intervention that is less frequently performed today due to the introduction of stronger fixation and more aggressive rehabilitation protocols following femur fractures. Nevertheless, it must be discussed and is indicated in cases of severe stiffness, especially those associated with sequelae of fractures of the femur or with short extensor mechanism (permanent dislocation of the patella). The release according to Lobenhöffer is an alternative in cases of stiffness related to fracture or following TKA.

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_38, © Springer-Verlag London 2014

The Release of Quadriceps

Indication

The main indication is severe stiffness resulting in loss of flexion. This stiffness is often posttraumatic (following fixation of fractures of diaphyseal or distal femur fractures).

Two mechanisms contribute to the stiffness:

- Intra-articular: it may be capsular or intracapsular.
- Extra-articular: adherence due to a previous external fixator, adherence of the quadriceps to the femur and fascia, muscle shortening due to scarring, or adherence to the skin.

In light of this, the operative technique has two fundamental components:

- The arthrolysis
- The quadriceps release

A second indication is when there is a permanent dislocation of the patella, which is always associated with a short extensor mechanism. The release according to Judet lengthens the extensor mechanism and allows rotation of the quadriceps muscle to realign the patella.

Risks

This procedure is a technically demanding and painful intervention. Prolonged postoperative rehabilitation is required. Patients should be warned of this.

We must ensure that there is proper consolidation of the femur following fracture fixation and that there is no infectious process present. In cases of infection, we recommend waiting for a period of at least 1 year once the infection has been cleared.

Any retained hardware in the lower metaphysis may be removed at the same time as the release. If there is an intramedullary nail present, it is usually left in situ to prevent femur fracture following treatment.

Finally, we must pay special attention to the condition of the skin and soft tissues prior to embarking on such a release.

Technique

The patient is placed in a supine position. A side post and a distal post keep the knee at 60° of flexion (in practice this is typically the maximum flexion possible). The procedure is performed without a tourniquet. The leg and hip are free draped from the iliac crest down (Fig. 38.1a, b).

Incision

The release of the extensor mechanism is performed using several steps. At each stage, the effectiveness of the procedure is verified. If the flexion is inadequate, it continues on. The objective is to achieve knee flexion with gravity from 100° to 120° with the hip flexed.

Two surgical approaches are needed. They take into account the previous approaches used. The aim is to achieve an intra-articular arthrolysis via arthroscopy or an arthrotomy and an extra-articular release via a lateral (and sometimes also medial) approach to the quadriceps.

The technique begins with a medial incision from the medial tibial plateau to the medial edge of the patella, extending 3 cm above the patella to follow the margin of the vastus medialis. The incision is approximately 10 cm long.

The lateral approach extends from Gerdy's tubercle proximally to the greater trochanter in the line of the fascia lata.

An anterior approach to the hip, in line with the anterior superior iliac spine, dissecting between the sartorius and tensor fascia lata is conducted if a section of the direct head of the rectus femoris tendon is needed. It is sectioned under direct vision.

Arthrolysis

The arthrolysis is done before the external procedure. We release the supra-patellar pouch and both the medial and lateral condylar gutters. The condylar recesses are released with a knife following the anatomical insertions until normal condyle is visible (after A. Trillat). The ligamentum mucosa and fat pad are resected. Adhesions of the patella in the trochlea are released with a scalpel. Lastly, a lateral release of the patella is done.

This procedure alone may sometimes yield flexion between 100° and 120°; if not, then the quadriceps release is continued.

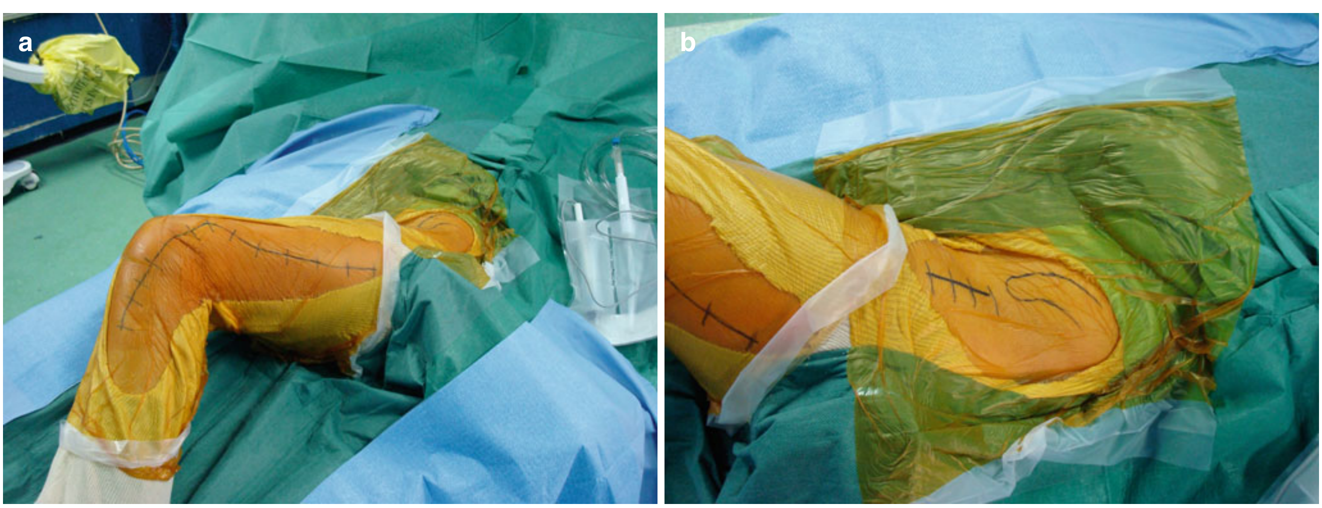


Fig. 38.1 (**a**, **b**) Patient setup. Two incisions are needed for this procedure

Quadriceps Release

The aim is to achieve a release of adhesions between the fascia lata and skin remaining as close as possible to the fascia lata. Adhesions between the fascia lata and quadriceps are also released gradually by blunt dissection using a blunt periosteal elevator. Incise the anterior edge of the fascia lata along its entire length at the junction with the fascia of the vastus lateralis (possible transverse section of the fascia lata initially recommended). The vastus lateralis and intermediate are released from their aponeurosis and linea aspera by using a knife and not the blunt periosteal elevator (Fig. 38.2). This release necessitates a careful dissection and hemostasis of the perforating vessels. The vastus lateralis and intermediate are released from the femoral diaphysis remaining extraperiosteal. The main tendon of the vastus lateralis is then sectioned and released from the subtrochanteric ridge and the anterior greater trochanter. With two Homan spreaders, the vastus lateralis and intermedius are separated. The vastus medialis is then freed off the femur. At this stage, if stiffness persists, one must look for a contracture at the distal end of the vastus medialis, a contracture of the fascia lata, or an extremely tight rectus femoris tendon.

In the presence of a large medial contracture, the initial route is by attempting to stretch the medial structures proximally, respecting the skin bridge.

If there is a contracture of the fascia lata, a “Z”-plasty of the tensor fascia lata is required.

In the event of a retraction of the rectus femoris tendon, a section is performed under direct vision to avoid trauma to the femoral nerve (Fig. 38.3a, b). The knee may then be mobilized and the amount of flexion visualized.

After surgery, it is verified that the flexion obtained is at least 100°, with the hip flexed. The flexion obtained at the end of the operation is the maximum flexion that will be obtained at the end of the rehabilitation with physiotherapy (Fig. 38.4). Spontaneous flexion of the knee with gravity (leg hanging) is the final flexion that is most often obtained.

After careful hemostasis, closure is performed at 90° knee flexion. Four suction drains are placed, two subfascial and two intra-articular. The patellar retinaculum is left open. The skin is closed carefully. If necessary, undermining of the skin and the subcutaneous tissue is done to reduce the tension on the skin sutures.

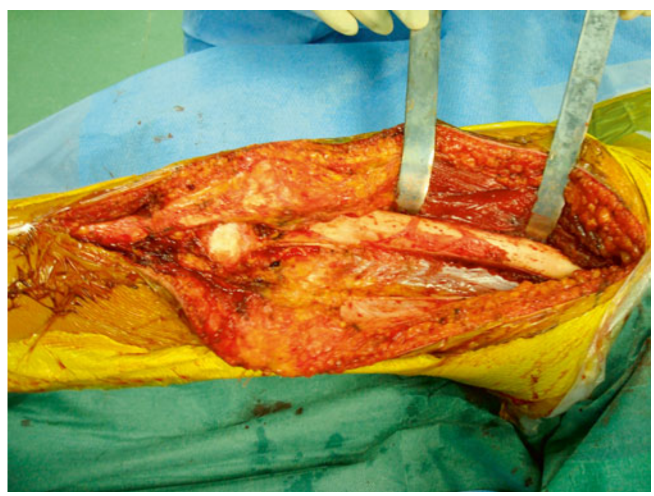


Fig. 38.2 Vastus lateralis and intermediate are released

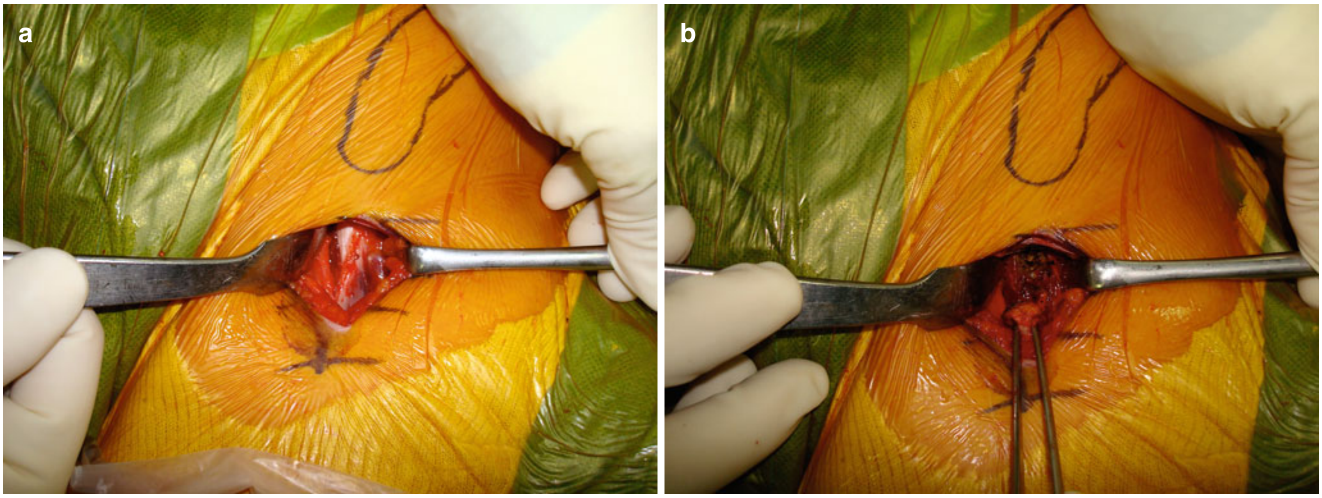


Fig. 38.3 (**a**, **b**) Rectus femoris tendon section

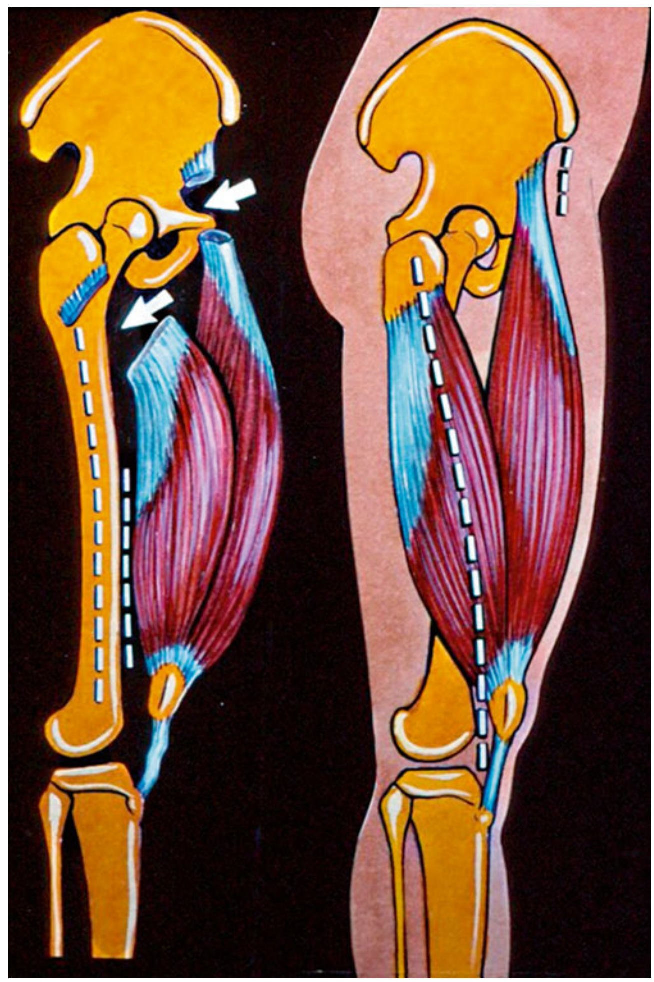


Fig. 38.4 Judet procedure

Postoperative Care

The knee is placed on a pillow at 90° of flexion before leaving the operating room. The position of the knee is alternated between flexion and extension every 6 h. Analgesia should be sufficient to allow optimal rehabilitation. Epidural anesthesia, femoral and sciatic blocks, and morphine PCA pump are all very important in the early postoperative period. Skin necrosis is a major potential complication in the early postoperative period due to numerous incisions. Prepatellar hematoma formation can worsen this risk and is avoided by the avoidance of anticoagulation. Mechanical DVT prophylaxis is initiated, and ultrasound surveillance is used to detect any DVTs.

Rehabilitation

Rehabilitation begins the same day of the surgery. The knee is kept flexed on a pillow at 90° and taken through flexion and extension exercises several times a day in order to prevent a recurrence of the flexion contracture. The pillow is kept for 7 days and nights.

We use CPM 24 h a day for 3 weeks. During the first 3 weeks, passive mobilization with stretching is used. After the third week, active movement with contraction of the quadriceps is begun.

Full weight bearing with crutches is allowed immediately postoperatively as long as the quadriceps can actively lock the knee in full extension. Crutches are used for 2 months postoperatively because devascularization of the femur caused by the surgery weakens the femur, leading to a fracture risk. Contact sports are prohibited for 1 year.

The rehabilitation is long and lasts several months, and one can expect the flexion to continue to improve for months after the surgery.

Lobenhöffer Algorithm

An alternative to the release according to Judet is to follow the algorithm of P. Lobenhöffer. It also differentiates intra-articular from extra-articular stiffness. Treatment of the intra-articular pathology is performed by arthrotomy or arthroscopic arthrolysis. The treatment of the extra-articular pathology is via a resection of the vastus intermedius in cases of fibrosis or if the patella is low, a lengthening of the patellar tendon or proximal transfer of the tibial tubercle.

Resection of the Vastus Intermedius According to Thompson

If the stiffness is caused by fibrosis of the vastus intermedius, the patella cannot move down during flexion of the knee, and this finding is not altered by hip position. This fibrosis is visualized on MRI. The Judet release would be ineffective in such a case.

An intra-articular arthrolysis is initially done. The patellar retinaculum is then released starting anteromedially. A long lateral incision is then made to release the vastus lateralis and rectus femoris. Under the latter, we find the fibrosed vastus intermedius. The fibrosed muscle is resected from the insertion of the muscle into the patella to the origin of the muscle.

Closure is done in flexion. The vastus lateralis and vastus medialis are sutured anteriorly to the rectus femoris in maximal flexion. The patellar retinaculum is closed, being aware that you may need to release it again if necessary, so as not to close the wound under any tension. At least two suction drains are placed in situ.

We have less experience with this procedure these days, but believe that it does have a place in stiffness of the knee caused by extra-articular pathology. We have found it particularly useful in addressing significant stiffness due to soft tissue contracture at least 1 year following TKA.

Postoperative Complications

39

G. Demey and Robert A. Magnussen

In the postoperative period, the guidance from the surgeons, anesthesiologists, physiotherapists, and general physicians should have one common aim: to obtain the best possible result for the patient.

We would therefore like to discuss some of our postoperative protocols. We would like to stress that these protocols are open for discussion.

Thromboprophylaxis

Although the use of anticoagulants is widespread, its use is "pushed" more by the industry itself than by scientific data. We believe that the risk benefit for thromboprophylaxis is less clear for knee surgery than it is for hip surgery.

A postoperative hematoma is a considerable complication both for the patient and for the surgeon. A hematoma can result in pain (complex regional pain syndrome), necrosis, infection, and stiffness of the knee joint. The efficacy of thromboprophylaxis should not only be measured with biological tests but should also be evaluated clinically.

In France, it is common practice to prescribe low-dose anticoagulants for a limited postoperative period. In our own experience, we have noted that the prescription period is getting shorter as our experience with them increases. For example, we prescribe 0.3 ml of Fraxiparine for 1 month after a total knee arthroplasty or an osteotomy (although 15 days could suffice) and 15 days for ligament surgery and unicompartmental arthroplasty. In the situation of a clinically significant hematoma, we do not hesitate to interrupt the treatment for a couple of days while we carefully review the situation. Because of the risk for skin necrosis, we also reduce postoperative exercises when a clinically significant hematoma occurs.

It is important to remember that thromboprophylaxis is not only medical. Other preventive measures should be undertaken: elevation of the feet, mobilization of the ankle, early weight bearing, and encouragement of ambulation.

If venous thrombosis is suspected, a venous ultrasound examination is performed. The ultrasound provides valuable information on the extent of the thrombosis. If the venous thrombosis is situated at the level of the calf, we do not recommend complete anticoagulation. Postoperative venous thrombosis should not be treated the same as a spontaneous venous thrombosis since the etiology (mechanical, tourniquet, dislocation of the tibia, anesthesia) is not the same as for spontaneous thrombosis (hypercoagulation syndrome, cancer, etc.). The treatment should be adapted and should not cause more harm than the pathology itself. It is not uncommon to see a recurrent thrombosis due to a hematoma in the popliteal fossa secondary to the anticoagulation therapy for the initial thrombosis. Although the risk of embolism exists, superficial venous thrombosis seldom results in fatal embolism and severe complications. Therefore, we recommend 0.3 ml twice a day of Fraxiparine, independent of the weight of the patient for a period of 1 month, and a repeat ultrasound. Compression socks are prescribed, physiotherapy is continued, and the patient is advised to remain ambulatory. If the symptoms of venous thrombosis persist after a couple of days, a repeat ultrasound is performed to rule out extension of the thrombus. The cardiovascular risk is of major importance, and the prescription of anticoagulant medication has to take this risk into account. The patient is informed of the increased risk of a hematoma, and the postoperative rehabilitation and medications are modified.

Although a proximal venous thrombosis, i.e., femoral or popliteal, is a rare event (less than 1 %), this condition is potentially lethal. The patient should be fully anticoagulated, and postoperative rehab should be interrupted until full anticoagulation is achieved. The length of therapy is prolonged.

G. Demey, MD (✉)
Lyon Ortho Clinic, Clinique de la Sauvegarde,
29B avenue des Sources, Lyon 69009, France
e-mail: demeyguillaume@gmail.com

R.A. Magnussen, MD, MPH
Department of Orthopaedic Surgery, Sports Health and
Performance Institute, The Ohio State University,
Suite 3100, 2050 Kenny road, Columbus, OH 43221, USA
e-mail: robert.magnussen@gmail.com

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4_39, © Springer-Verlag London 2014

Pulmonary Embolism

Although the diagnosis of a pulmonary embolism (PE) is frequently made, the distinction between an embolic event due to a deep venous thrombosis and a fat embolism should be made. This is of critical importance as the latter results in unnecessary anticoagulation with its potential complications. If a PE is suspected in the postoperative period, a V/Q scan or spiral CT should be acquired urgently. Frequently, microembolisms will be visualized in the peripheral perfusion of the lung. An ultrasound of the lower limb should be performed. If this study is negative, the diagnosis of fat embolism should be made. If the study is positive, a proximal deep venous thrombosis is the more likely cause of the embolism. All investigations should be considered in combination when making the final decision on the therapeutic approach. The aim of this paragraph is to remind us of the frequency of fat embolism after TKR which is frequently misinterpreted as being a deep venous thrombosis.

Postoperative Pain

Anesthesiology has made remarkable progress in pain management. Pain management, however, is not the sole domain of the anesthesiologist.

In the case of postoperative pain resistant to classic analgesia including morphine, the surgeon should always exclude:

- A hemarthrosis: aspiration, slowing down rehabilitation, cryotherapy, and interruption of anticoagulant therapy are potentially useful treatment strategies.
- Excessively tight dressings.

  But more importantly:
- Vascular complication
- Compartment syndrome
- Skin necrosis
- Infection

Infection

Infection should always be excluded in the early or late postoperative period and should not go unrecognized. The treatment of an infection includes a multidisciplinary approach. This does not mean that the infectious disease physician should be the sole treating physician of the patient. The surgeon has to decide whether to perform an arthrotomy (which we prefer above an arthroscopy) with or without removal of the hardware (osteosynthesis or prosthesis) and exchange of antibiotic spacer. In our experience, immobilization plays as an important role in the treatment of infection.

Skin Problems

The skin incisions and the wounds should be inspected regularly to observe and prevent skin problems. Certain predisposing conditions are well known: multiple incisions and diabetes.

In these situations, surveillance has to be performed more frequently, vasodilators can be used, and flexion should be limited to 60° or 70° or maybe even stopped. Cryotherapy should be limited. In case of skin necrosis, the wound should be covered; skin flap surgery and gastrocnemius flap surgery to cover the wound can be done at an early stage. Consultation with our plastic surgery colleagues is critical.

Besides the more serious complications, unsightly scars and skin pigmentation problems should not be discarded as unimportant. In certain patients, a skin problem can sometimes be considered a real complication (large scar, colored scar, keloid). More frequently observed in a young girl after surgery for episodic dislocation of the patella, these problems sometimes necessitate referral to a plastic surgeon. Skin pigmentation is often observed as a consequence of a hemarthrosis or infiltration of the soft tissues with blood. This problem catches the attention of the patient although the surgeon generally has a tendency to neglect it.

Index

P. Neyret, G. Demey (eds.), *Surgery of the Knee*,
DOI 10.1007/978-1-4471-5631-4, © Springer-Verlag London 2014