P.F.C.®
Σ
SIGMA
KNEE SYSTEM

PRIMARY CRUCIATE-RETAINING AND CRUCIATE-SUBSTITUTING PROCEDURES

DePuy
a Johnson&Johnson company
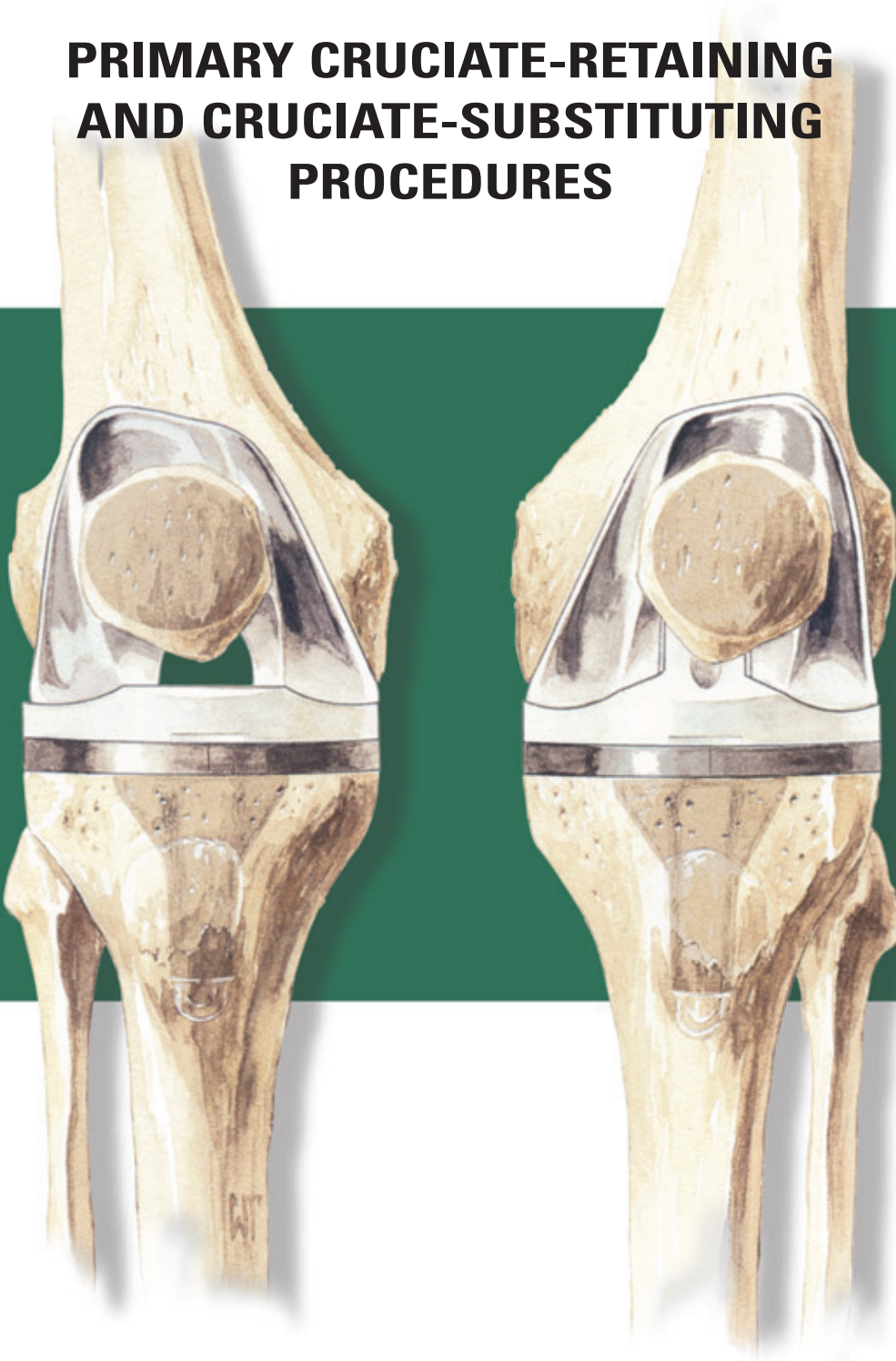
CRUCIATE-RETAINING PROSTHESIS DESIGNED BY

Richard D. Scott, MD

Associate Clinical Professor
of Orthopaedic Surgery
Harvard Medical School

Orthopaedic Surgeon
Brigham and Women's Hospital
and New England Baptist Hospital
Boston, Mass.

Thomas S. Thornhill, MD

Associate Clinical Professor
of Orthopaedic Surgery
Harvard Medical School

Orthopaedic Surgeon
Brigham and Women's Hospital
Boston, Mass.

CRUCIATE-SUBSTITUTING PROSTHESIS DESIGNED BY

Chitranjan S. Ranawat, MD

Clinical Professor of Orthopaedic Surgery
Cornell University Medical Center

Orthopaedic Surgeon
Lenox Hill Hospital
New York, N.Y.

SPECIALIST® INSTRUMENTS DESIGNED IN CONSULTION WITH JOHNSON AND JOHNSON PROFESSIONAL AND

William Petty, MD
Peter F. Gearen, MD
Gary J. Miller, PhD

Department of Orthopaedics
University of Florida College of Medicine
Gainesville, Fla.

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INTRODUCTION

Total knee replacement is performed on a range of patients, of all ages, with various pathologies and anatomical anomalies. As no single athroplastic approach is appropriate for every knee, the surgeon must be prepared, as the situation indicates, to preserve or substitute for the posterior cruciate ligament (PCL). PCL sacrifice is indicated in patients with severe deformity, pronounced flexion contracture and in the greater number of revision cases. Most primary and some relatively uncomplicated revision cases are suitable for cruciate-sparing procedures. Where the ligament is to be preserved, it is essential that its balance in flexion and extension be confirmed.

The P.F.C.® Total Knee System was designed as a comprehensive approach allowing intraoperative transition from posterior cruciate retention to ligament substitution or supplementation and providing greater restraint in cases of revision surgery. It was designed to meet the most demanding clinical and institutional requirements. It has been in clinical use since 1984 and has demonstrated a high degree of efficacy in 10-12 year studies.* The P.F.C. Sigma Total Knee Replacement (TKR) system represents the summation of clinical experience with the original P.F.C. Modular TKR system. The condyles of the femoral component have been further rounded mediolaterally to maximize contact area, thereby decreasing the stress within the polyethylene inserts. All P.F.C. Sigma femoral components incorporate the same sagittal configuration as the original P.F.C. cruciate-retaining components. The same instrumentation and protocol that has been used with the P.F.C. system since 1984 is retained. All P.F.C. Sigma femoral components share the same deep conforming patellar groove to articulate with a domed patellar implant, which has been clinically successful in the P.F.C. Modular cruciate sacrificing components. P.F.C. Sigma femoral components are asymmetrical and can be up and down-sized by one to address patient size anomalies. The system also provides intraoperative flexibility through the use of supplemental modules, conserving inventory in the process and rendering it amenable to a range of cases from the simple primary to the complex revisional. With each patient, porous or nonporous components may be selected as the intraoperative situation dictates. A single integrated set of instruments was designed to assure fully accurate bone resection and to accommodate all contingencies.

The single major difference in the design of the two prostheses is the incorporation of an intercondylar post in the PCL-substituting tibial insert and its corresponding receptacle in the femoral component to compensate for the stabilizing restraint of the PCL.

*Schai, P.A., Thornhill, T.S. and Scott, R.D. "Total Knee Arthroplasty with the P.F.C. System: Results at a minimum of Ten Years and Survivorship Analysis." *The Journal of Bone and Joint Surgery* September 1998: 850-858.

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CRITERIA FOR SUCCESSFUL TKR

APPROPRIATE SIZING OF COMPONENTS

This is attained through critical approximation of the A/P dimension of the femoral component to the lateral femoral profile. Undersizing will create looseness in flexion and possible notching of the femoral cortex. Oversizing will create tightness in flexion and increased excursion of the quadriceps mechanism.

ACCURATE COMPONENT ALIGNMENT

This is assured by resection of the distal femur in the appropriate degree of valgus as determined by preoperative evaluation, and resection of the proximal tibia at 90 degrees to its longitudinal axis.

SOFT-TISSUE BALANCE

This is realized through careful sequential release of medical constraining elements in varus deformity and lateral structures in valgus.

ACCURATE PATELLAR TRACKING

This is effected through accurate positioning of the femoral and tibial components, precise resurfacing of the patella, careful trial evaluation and, where indicated, lateral retinacular release.

DEPENDABLE CEMENT FIXATION

This is achieved through controlled technique that ensures the establishment of comprehensive bone/cement/prosthesis interlock.

BALANCING THE KNEE

The appropriate level of prosthetic constraint is determined through preoperative evaluation subject to intraoperative confirmation. Where soft-tissue constraint is identified, the system is designed to effectively address it.

PRIMARY CRUCIATE-RETAINING TKR

employs a posteriorly-lipped insert, designed for situations where the PCL is functionally intact. Where there is tightness in the PCL, a posterior cruciate recession is indicated (see Appendix I).

PRIMARY CRUCIATE-SUPPLEMENTING TKR

uses a curved insert with improved contact area to supplement the PCL where the ligament has sufficient functional laxity to accommodate the greater conformity.

PRIMARY CRUCIATE-SUBSTITUTING TKR
incorporates a central polyethylene eminence in the tibial insert to perform the function of an absent PCL. The corresponding femoral component uses A/P cuts and chamfers identical to those of the PCL-retaining component, allowing ready transition without revision of the prepared implantation site.

REVISION TKR
The geometry of the tibial insert allows for substitution of the PCL and/or MCL in revisional and in complex primary situations. The selection of modular tibial and femoral stems and wedges will accommodate virtually any revisional consideration. The system offers three levels of constraint to meet the varied requirements of revision cases: stabilized, stabilized plus or TC3.

PREOPERATIVE PLANNING
Full-length extremity roentgenograms are obtained and the mechanical and anatomic axes identified. Where the intramedullary alignment system is selected, the angle of the two axes indicates the appropriate angle of the bushing to be used in conjunction with the intramedullary rod and the femoral locating device, thereby assuring that the distal femoral cut will be perpendicular to the mechanical axis. It is helpful to draw the femoral and tibial resection lines on the film as an intraoperative reference.

Radiographic templates are overlaid on the films to estimate the appropriate size of the prosthesis. The femoral component is sized on the lateral view. The A/P size is critical to the restoration of normal kinematics and quadriceps function.

INSTRUMENTATION RATIONALE
SPECIALIST® instrumentation was designed to meet the requirements of all total-knee replacement procedures, to fully assure precise and dependable resection of the recipient bone and to serve a variety of surgical options. The instruments may be customized to meet any special requirements of the individual surgeon.

Preparation may be initiated at either the femur or the tibia. The instruments may be employed with either the intra- or extramedullary alignment approach. Bone resection is made at the appropriate level as determined through calibrated stylus assembly. A selection is offered of slotted and surface-cutting blocks. Spacer blocks are provided for extension and flexion gap evaluation. Patellar instrumentation is available for compatible preparation of either resurfaced or inset patellar implants.

CRUCIATE-RETAINING/SUPPLEMENTING PROCEDURE
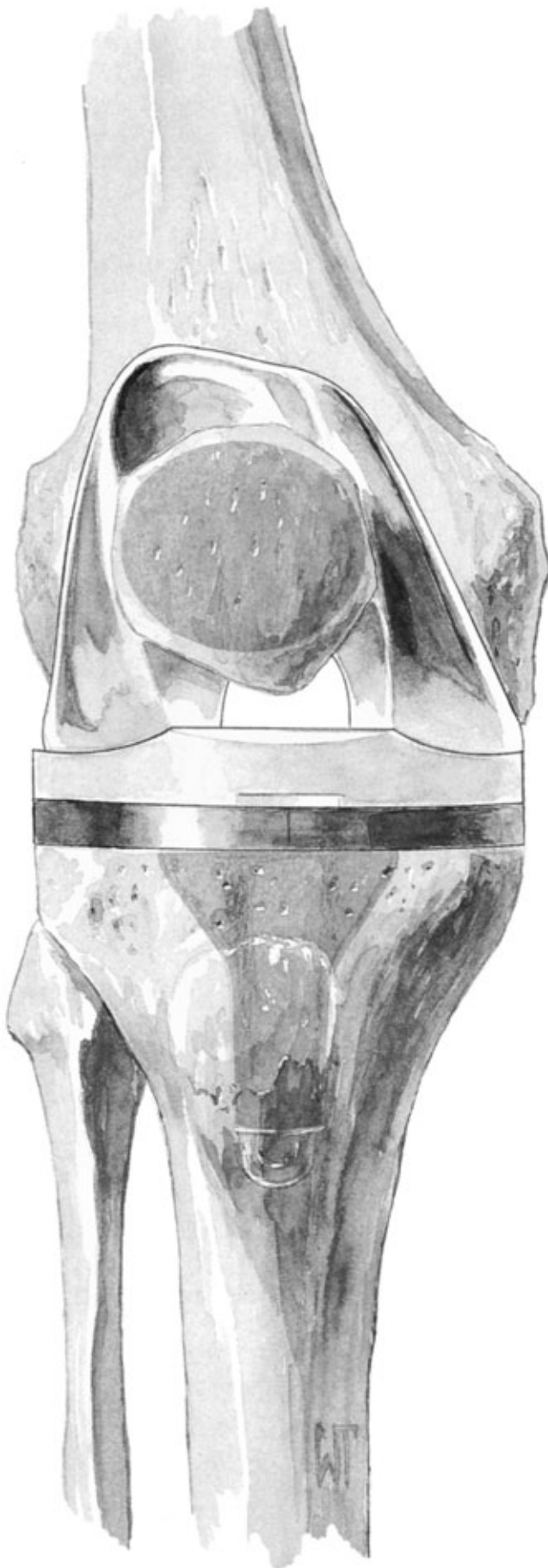
Richard D. Scott, MD

Associate Clinical Professor
of Orthopaedic Surgery,
Harvard Medical School

Orthopaedic Surgeon,
Brigham and Women's Hospital
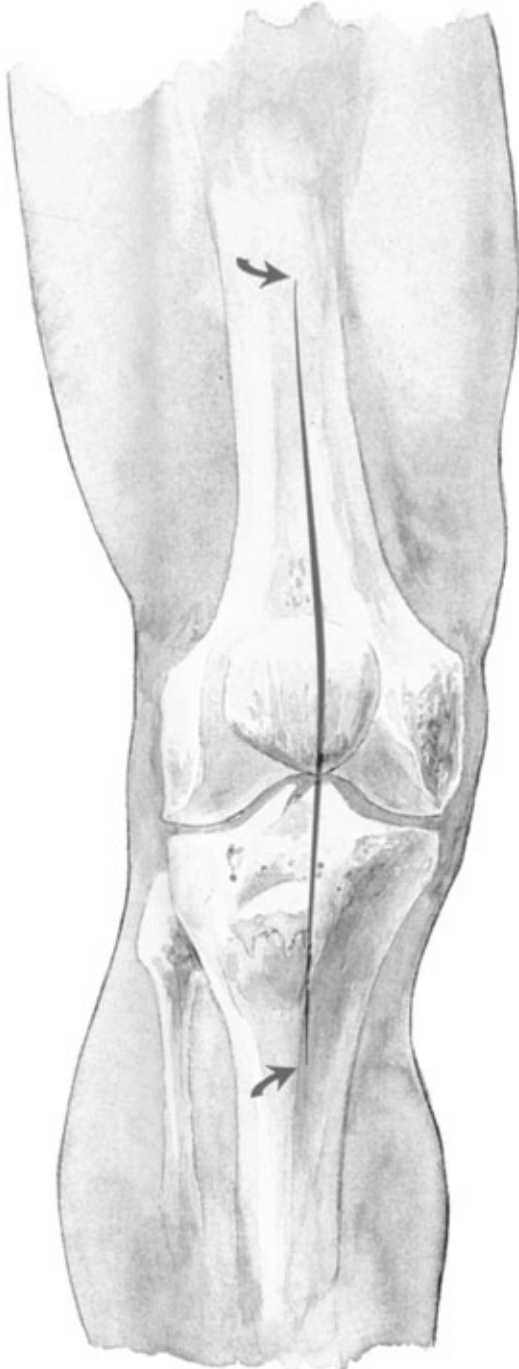and New England Baptist Hospital,
Boston, Mass.

Thomas S. Thornhill, MD

Associate Clinical Professor
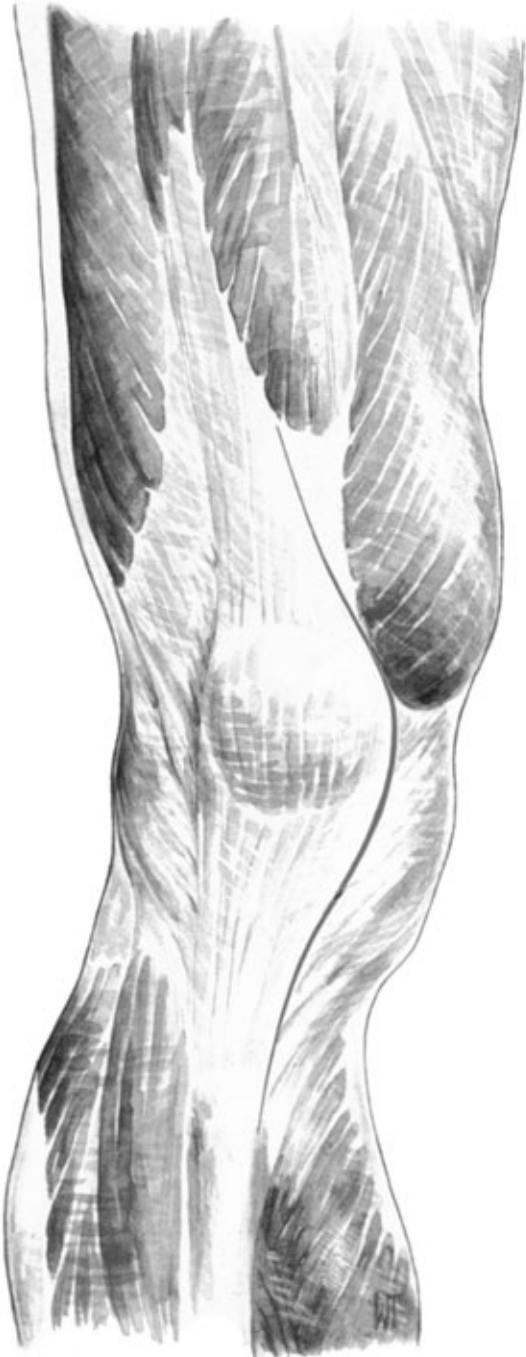of Orthopaedic Surgery,
Harvard Medical School

Orthopaedic Surgeon,
Brigham and Women's Hospital
Boston, Mass.

THE SURGICAL APPROACH

The skin incision is longitudinal and, where possible, straight. It is initiated proximally from the midshaft of the femur and carried over the medial third of the patella to the medial margin of the tibial tubercle.

The joint is entered through a medial parapatellar capsular approach, extended proximally to the inferior margin of the rectus femoris and distally to the medial margin of the tibial tubercle.

NB Where indicated, the subvastus or the lateral approach may be used.

EXPOSURE

Exposure and preliminary balance must be based on the patient's preoperative deformity and soft-tissue stability. The following is for mild varus deformity.

With the knee in extension, the patella is everted laterally. The medial tibial periosteum is elevated and a narrow 90-degree Hohmann retractor positioned subperiosteally around the medial border of the medial condyle. Residual periosteum is dissected posteromedially to the level of the insertion of the *semimembranosus.* The knee is flexed and a partial meniscectomy performed. Any residual ACL is excised.

NB see Appendix I for discussion of soft-tissue balance.
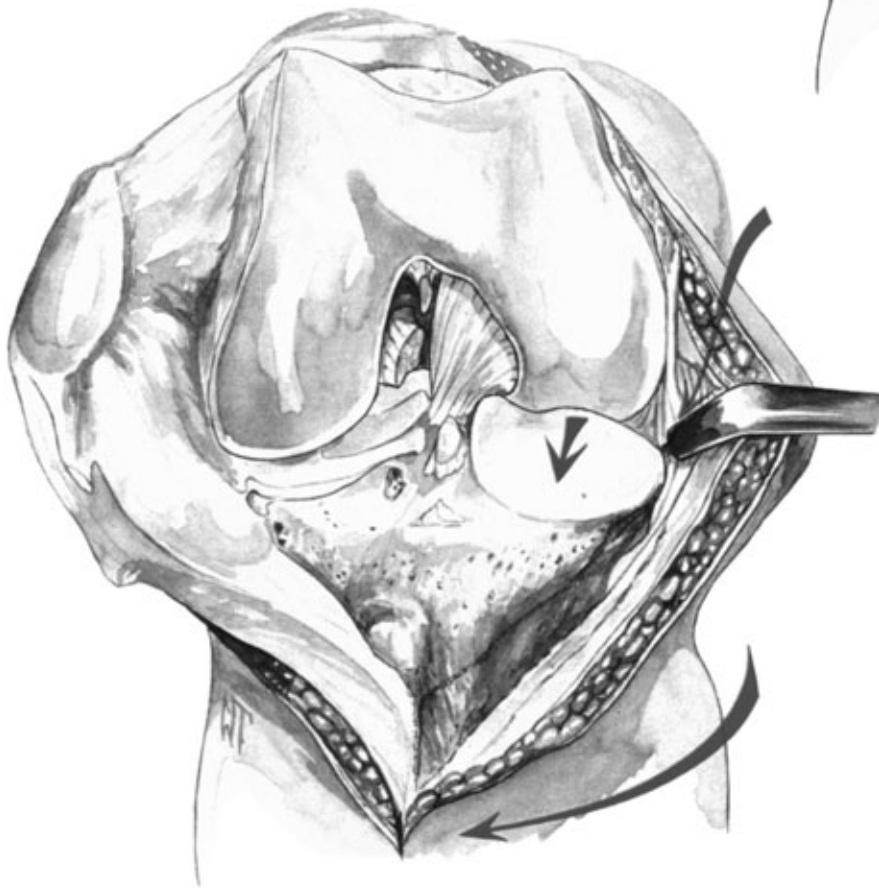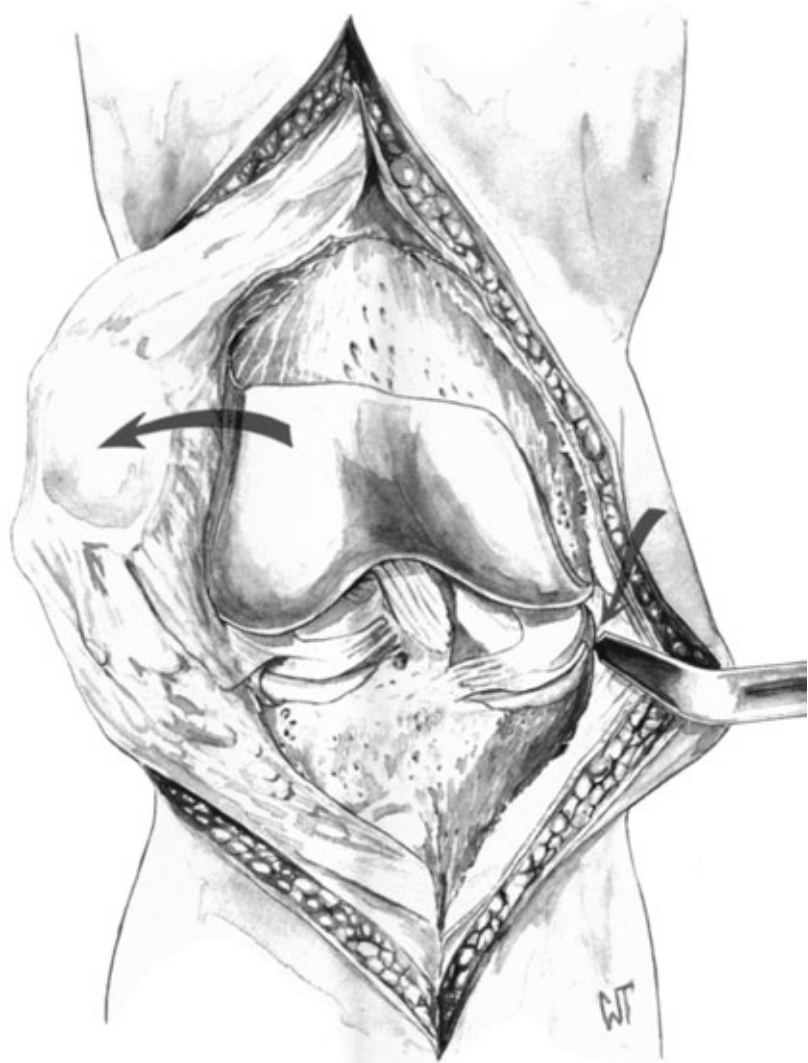
With the knee in 90 degrees of flexion, the tibia is externally rotated with postero-medial dissection, bringing its medial condyle clear of the femur. Medial menis-cectomy is completed, and attention directed to the lateral side.

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A 90-degree Hohmann retractor is positioned between the everted patella and the distolateral femur exposing the lateral patellofemoral ligament, which is incised with electrocautery.

The retractor is repositioned at the interval of the iliotibial tract and the tibial attachment of the capsule. The capsule is dissected free from the infra-patellar fat pad. The lateral interior genicular artery is ligated. The insertion of the iliotibial tract is identified and the capsule dissected from the lateral tibial condyle. The retractor is repositioned against the lateral tibial condyle, which is exposed. Lateral meniscectomy is performed.

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ENTERING THE MEDULLARY CANAL

The medullary canal is entered at the midline of the femoral trochlea 3 mm anterior to the origin of the PCL to a depth of about 5-7 cm using a $^5/_{16}$ inch drill.

Care is taken that the drill avoid the cortices. It is helpful to palpate the distal femoral shaft as the drill is advanced. The drill hole may be biased anteromedially to facilitate unobstructed passage of the long intramedullary rod to the diaphyseal isthmus. Where indicated, the canal is irrigated.

THE INTRAMEDULLARY ROD

The long intramedullary rod is introduced slowly into the canal to the level of the isthmus to confirm unobstructed passage. The rod is fluted to relieve intramedullary pressure and permit the release of bone matter, avoiding embolization. It is subsequently withdrawn.

THE FEMORAL LOCATING DEVICE

The appropriate bushing, as indicated on the preoperative films, is assembled to the locating device with the appropriate RIGHT/LEFT designation to the anterior.

The device is assembled, in turn, over the intramedullary rod and secured with the lateral set screw such that rotation is controlled by the T-handle. The rod is repositioned in the medullary canal.

Bushings are provided in 5 degrees, 7 degrees and 9 degrees, to correspond to the angle predetermined in reference to the resection line drawn on the preoperative roentgenogram.

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THE EXTERNAL ALIGNMENT SYSTEM

The alignment tower is
assembled onto the femoral
locating device. The alignment
rod is passed through the hole
and advanced to the hip.
Where the rod fails to align
with the coxal reference
point, a different bushing
is selected.

*NB Where indicated, as in femoral deformity, a 0-degree bushing and a short
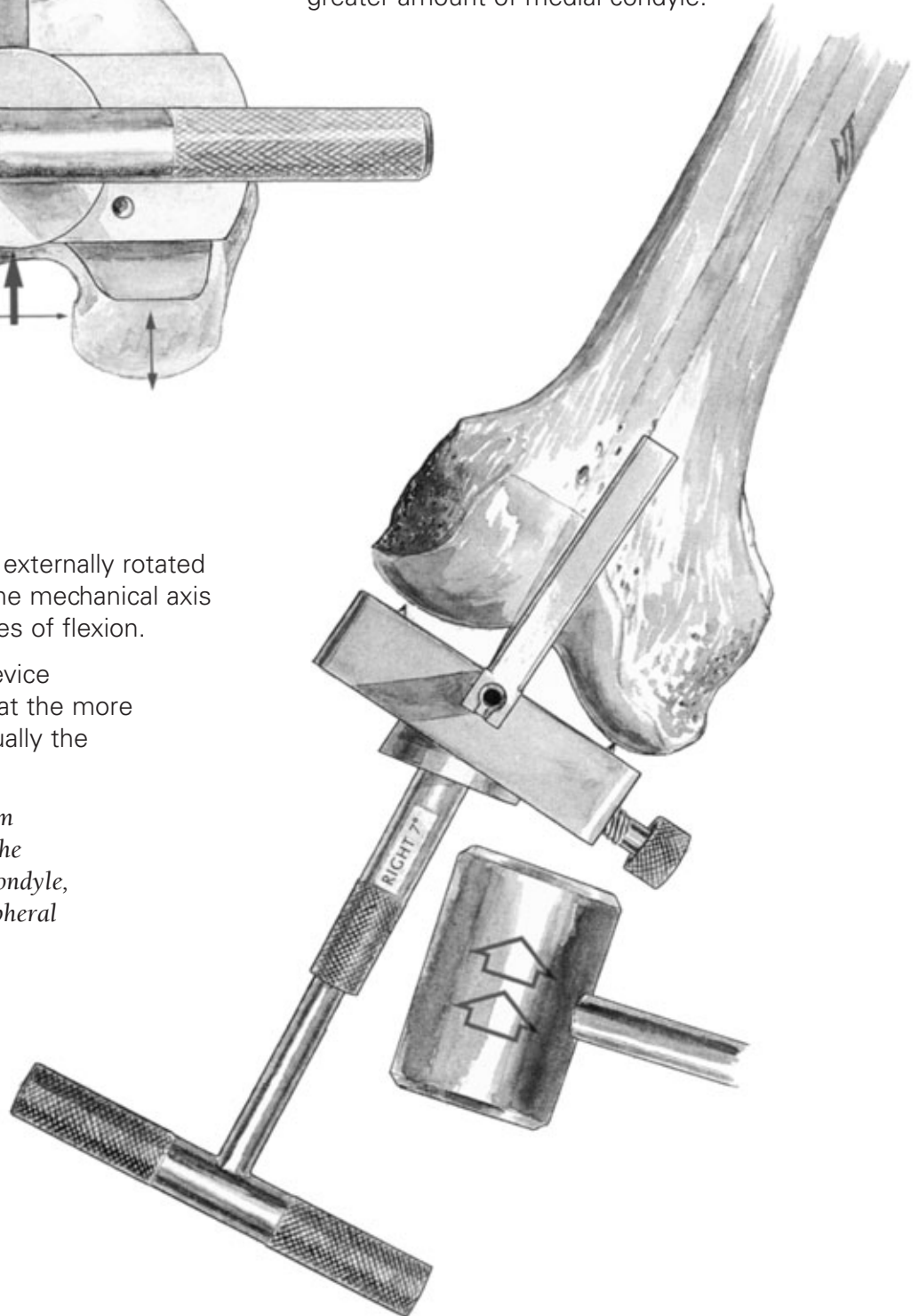intramedullary rod are substituted. See Appendix IV.*

ROTATIONAL CORRECTION

Orientation is initially determined with reference to the posterior femoral condyles, subject to subsequent correction at the A/P resection. The calibrated outrigger is centered at the femoral trochlea, placing it in slight external rotation and exposing a greater amount of medial condyle.

Alternatively, it may be externally rotated until perpendicular to the mechanical axis of the tibia in 90 degrees of flexion.

The femoral locating device is tapped into position at the more prominent condyle (usually the medial).

NB It is essential that firm contact be established at the subchondral level of the condyle, clear of any residual peripheral osteophytes.

THE DISTAL FEMORAL CUTTING BLOCK

The cutting block is assembled onto the calibrated outrigger such that resection of the more prominent condyle, inclusive of residual cartilage, will correspond to the distal dimension of the femoral prosthesis. Where the femoral locating device rests on eburnated bone, resection is 2 mm less than the distal dimension of the femoral prosthesis, to allow for absent cartilage and to avoid elevation of the joint line.
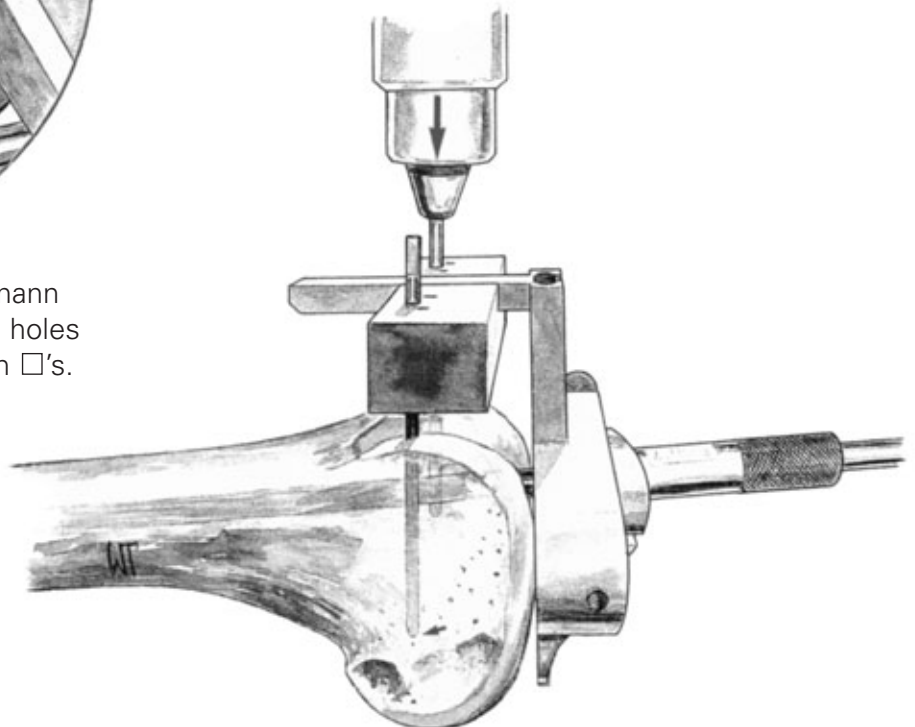
Greater or lesser resection may be indicated to accommodate flexion contracture and hyperextension, respectively.

Alternatively, the cutting block is available in a slotted version. A 1.19 mm saw blade is recommended.

Either 1/8 inch drill bits or Steinmann pins are introduced through the holes designated zero and enclosed in □'s. They are advanced into the anterior cortex.

It is easier to drill the lateral first.

THE DISTAL FEMORAL CUT

The locating device and intramedullary rod are disengaged from the cutting block, allowing the block to drop on the pins, to the anterior cortex.

The holes on the block are designated – 2, 0, +2 and +4, indicating in mm the amount of bone resection each will yield supplemental to that indicated on the calibrated outrigger.
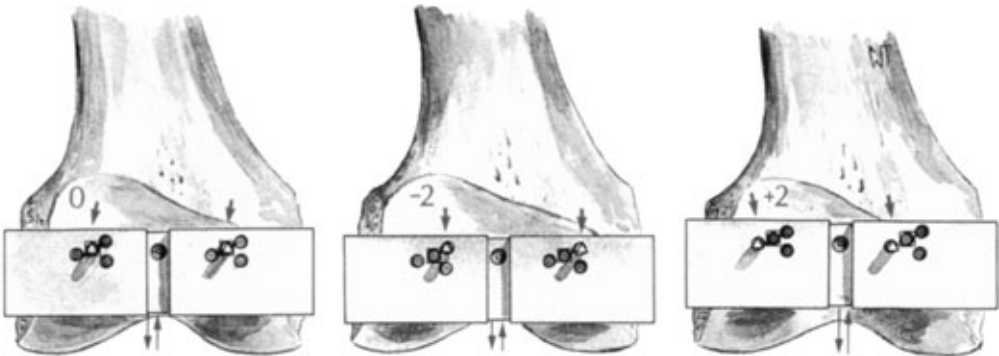
The oscillating saw blade is positioned flush to the cutting surface of the block or, where applicable, through the slots. The condyles are resected and the surface checked for accuracy.
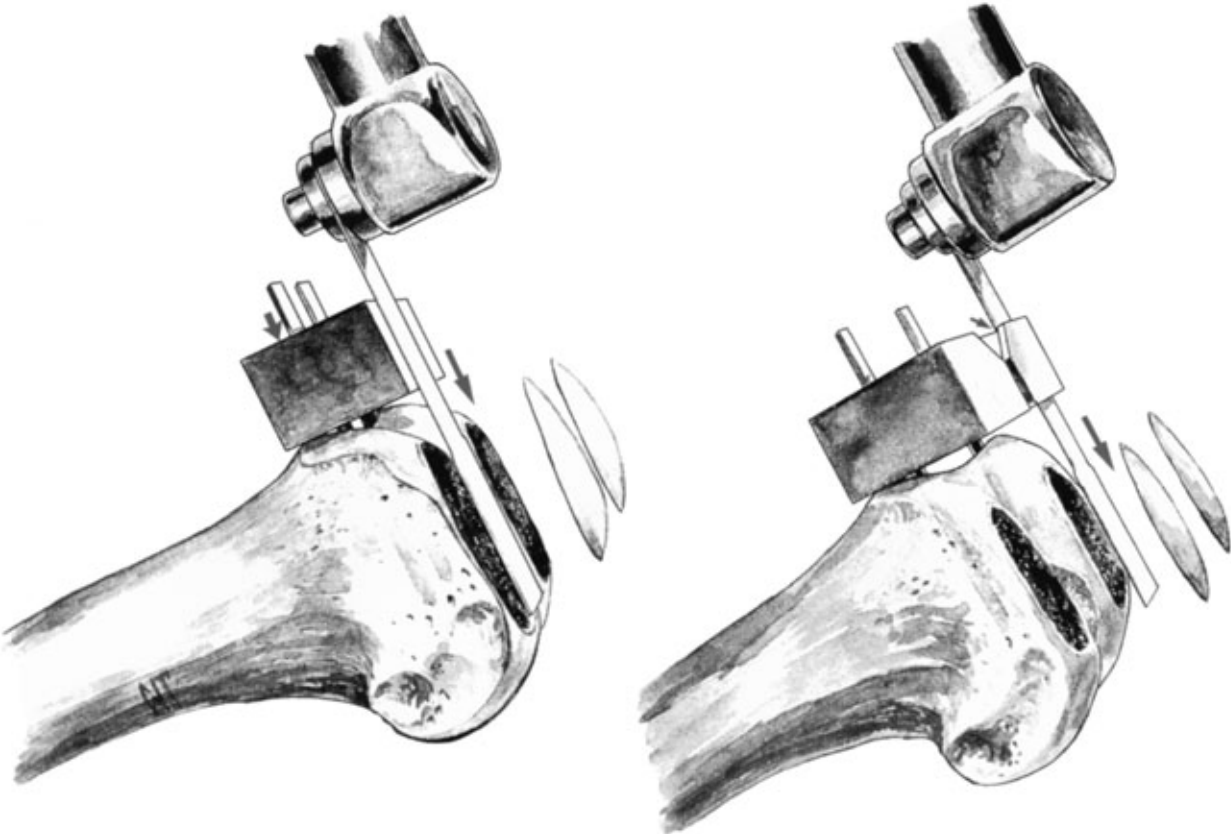
THE FEMORAL SIZING GUIDE AND STYLUS ASSEMBLY
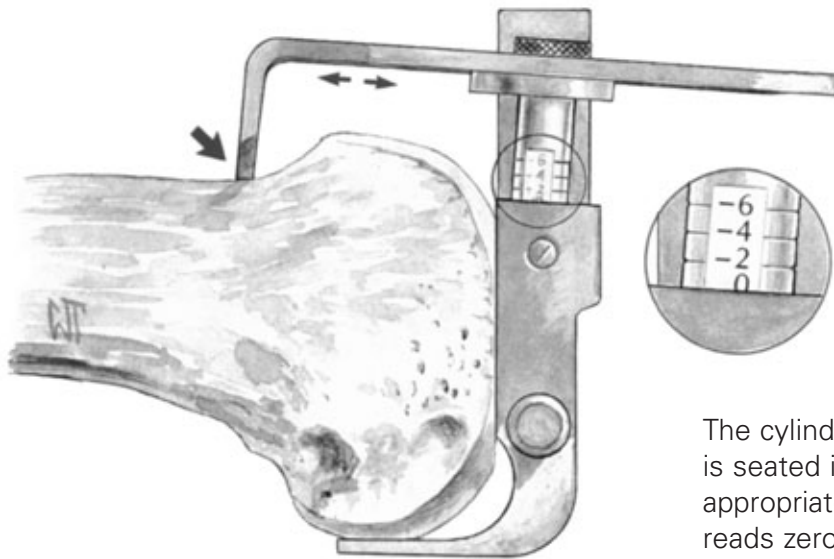
The cylinder of the stylus assembly is seated into its receptacle on the appropriate sizing (drill) guide such that it reads zero. The guide is centered, in turn, on the prepared distal femoral surface.

The stylus is passed over the anterior cortex immediately proximal to the articular surface. Where it is impeded, the anterior cut will produce femoral notching and the next larger sizing (drill) guide is indicated. Where the problem is minimal, it may be addressed by noting the drill holes with methylene blue and adjusting them slightly to the anterior.
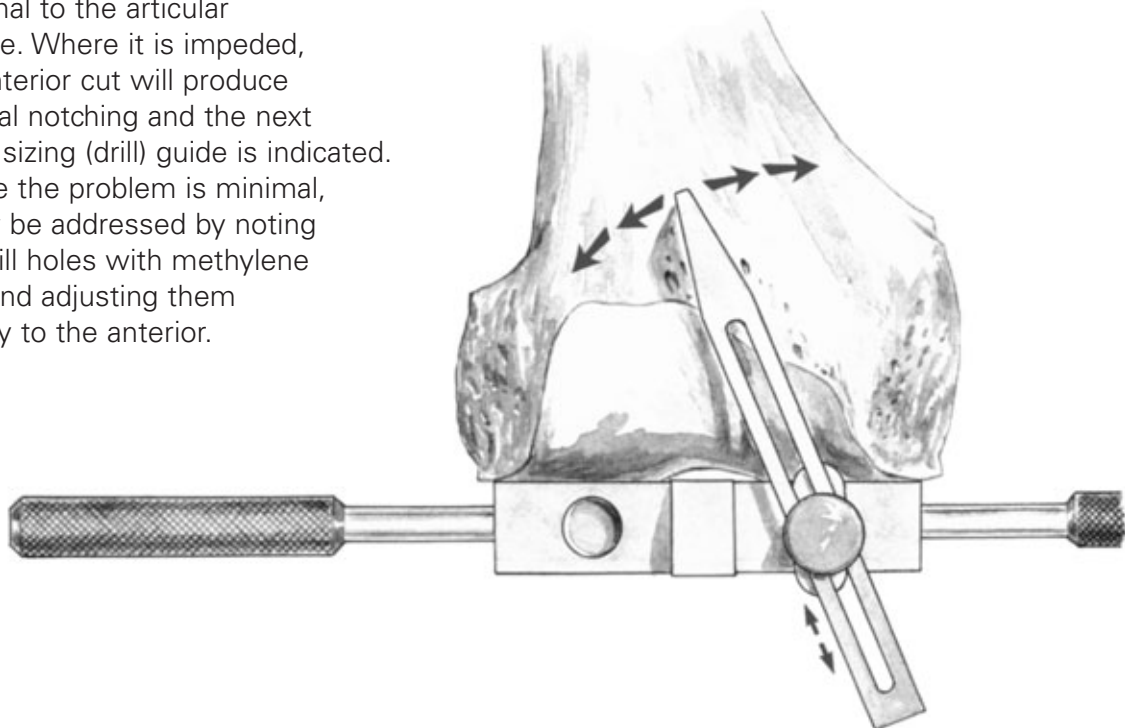
ROTATIONAL ALIGNMENT

The sizing (drill) guide skids are positioned against the posterior condyles. This determines rotational alignment. Where either condyle is deficient, the guide is rotated such that it lies perpendicular to the mechanical axis of the tibia.

NB Alternatively, the tibia may be prepared first, wherein the A/P femoral cuts are based on the relationship of the condyles to the prepared tibial surface.
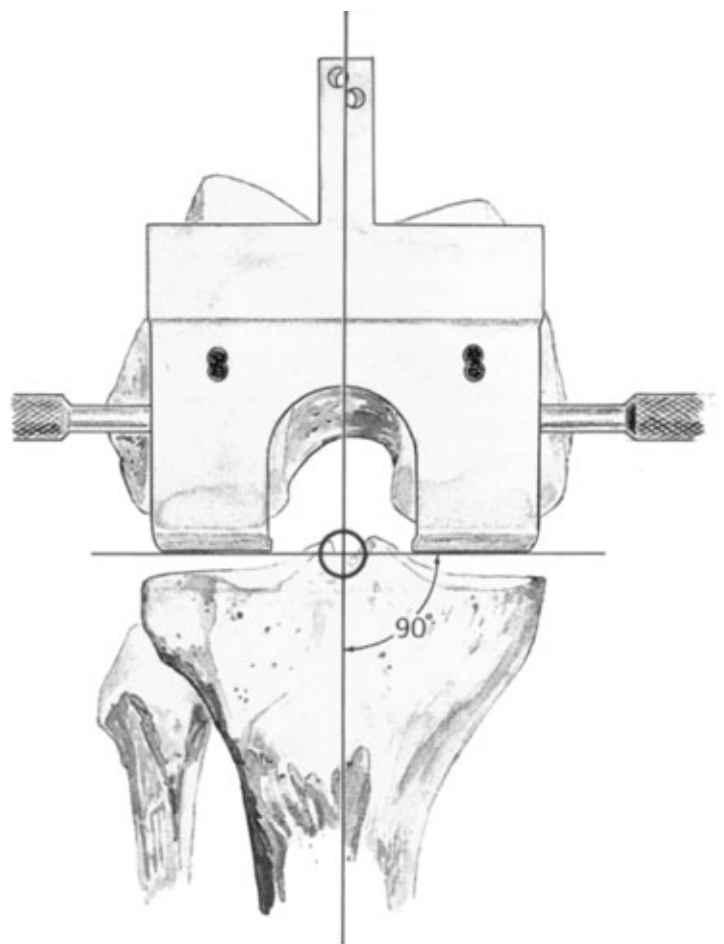
Where the guide is pinned in neutral rotation using the posterior holes, it will position the A/P cutting block such that 8 mm will be resected from the posterior condyle, corresponding to the posterior dimension of the prosthesis.

Where, as in most cases, the tibia is resected at 90 degrees to its mechanical axis, the femoral component is positioned in ~3 degrees of external rotation to produce flexion-gap symmetry. Accordingly, the lateral posterior and medial anterior holes are selected, yielding 8 mm lateral and 10-11 mm medial resection. The cutting block, thus positioned, will yield a cut in 3 degrees of external rotation, promoting flexion-gap symmetry, and enhancing patellar tracking. It will reduce soft-tissue release for tight medial flexion gap and allow commensurate rotation of the tibial component.

Occasionally, more than 3 degrees of external rotation is indicated for flexion-gap symmetry. Following removal of peripheral osteophytes, with 90 degrees of flexion and the collateral ligaments tensed with laminar spreaders, the external tibial alignment device is positioned with its upper platform raised to the level of the holes made through the sizing (drill) guide, which should lie parallel to the platform. Where more external rotation is indicated, the medial hole is repositioned anteriorly. In valgus deformity with lateral condylar hypoplasia, the lateral hole is repositioned posteriorly.
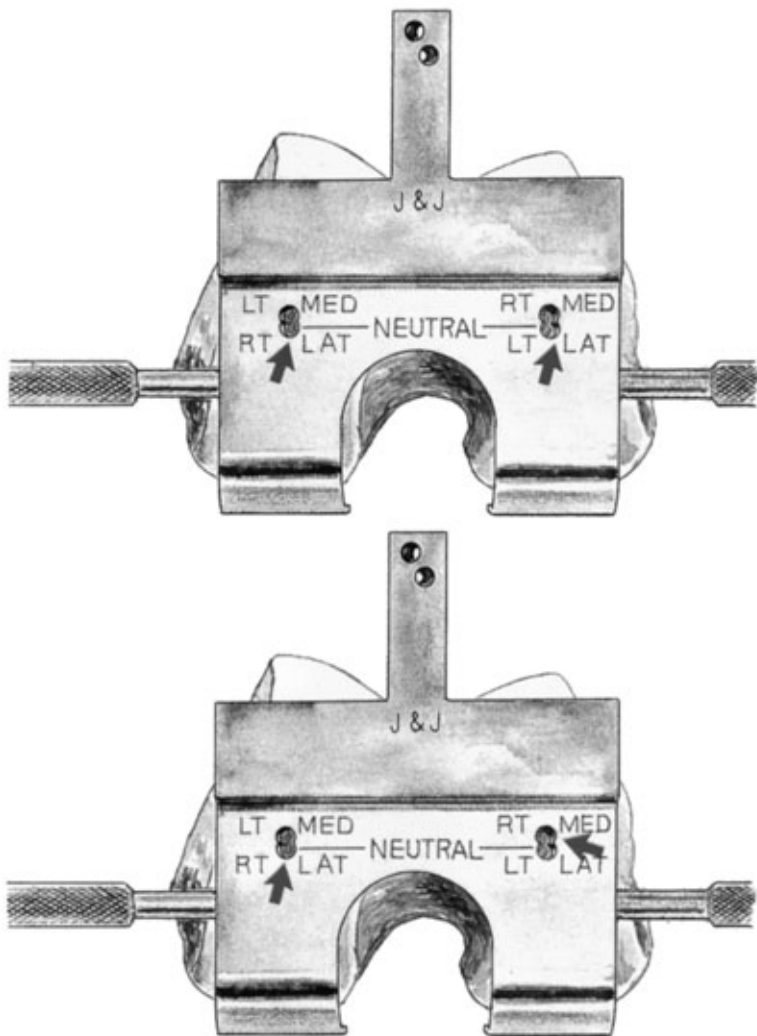
ANTERIOR AND POSTERIOR FEMORAL CUTS

The drill guide is removed and the corresponding A/P cutting block seated into the drill holes and flush to the prepared surface. The anterior and posterior cuts are performed with an oscillating saw. Care is taken that the posterior cruciate and collateral ligaments be protected. The cuts are checked for accuracy and the block removed.
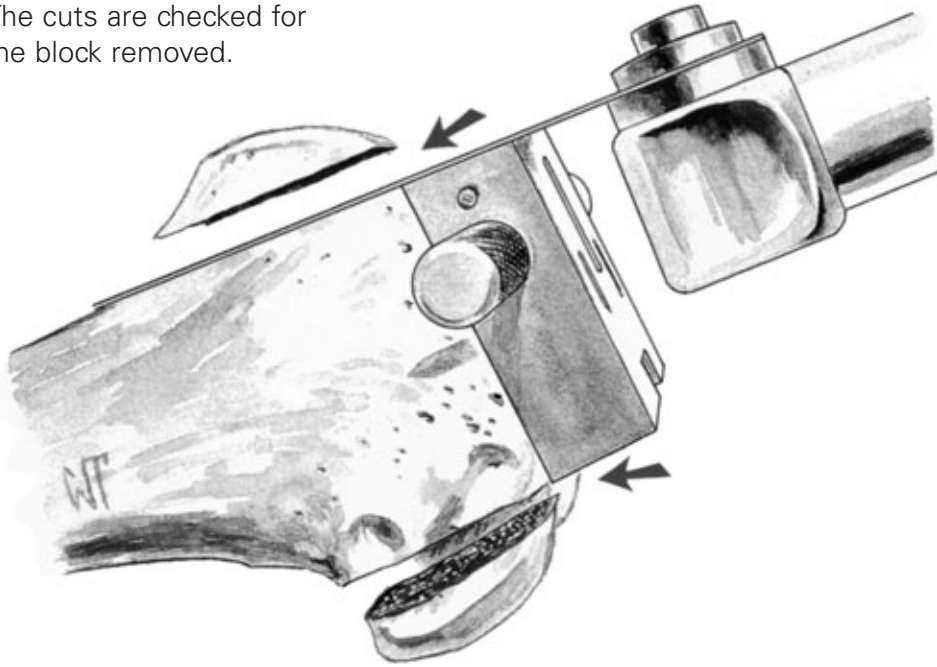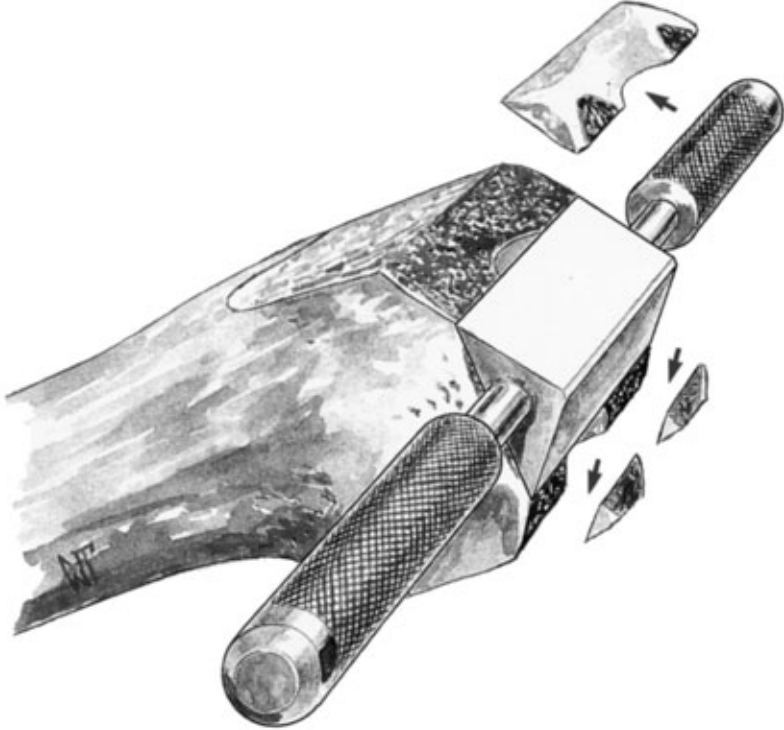
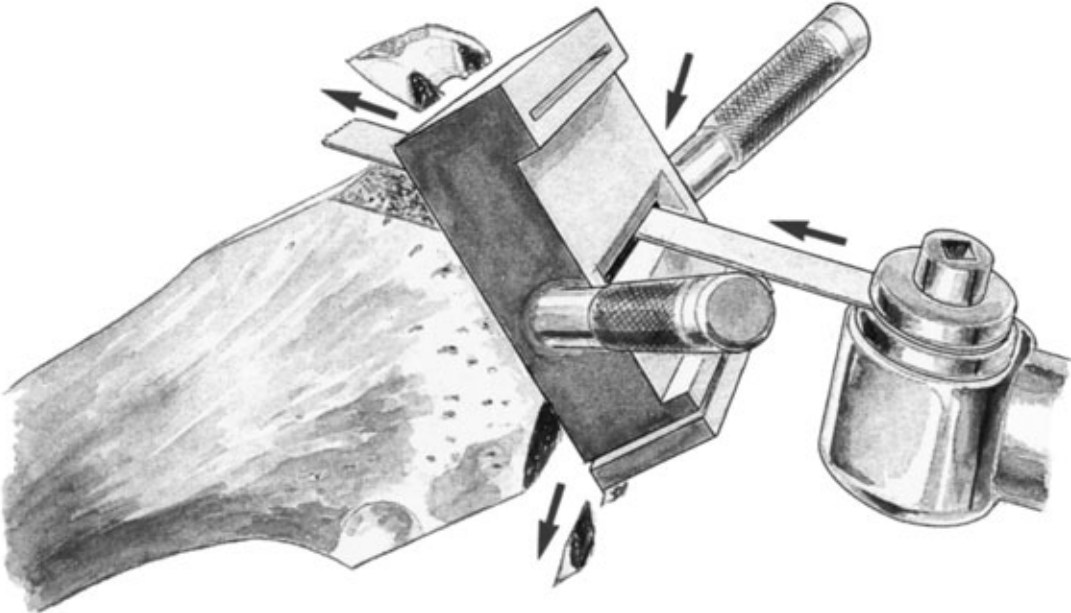Alternatively, one may elect to make the cuts with the slotted A/P chamfer block. A 1.19 mm saw blade is recommended.
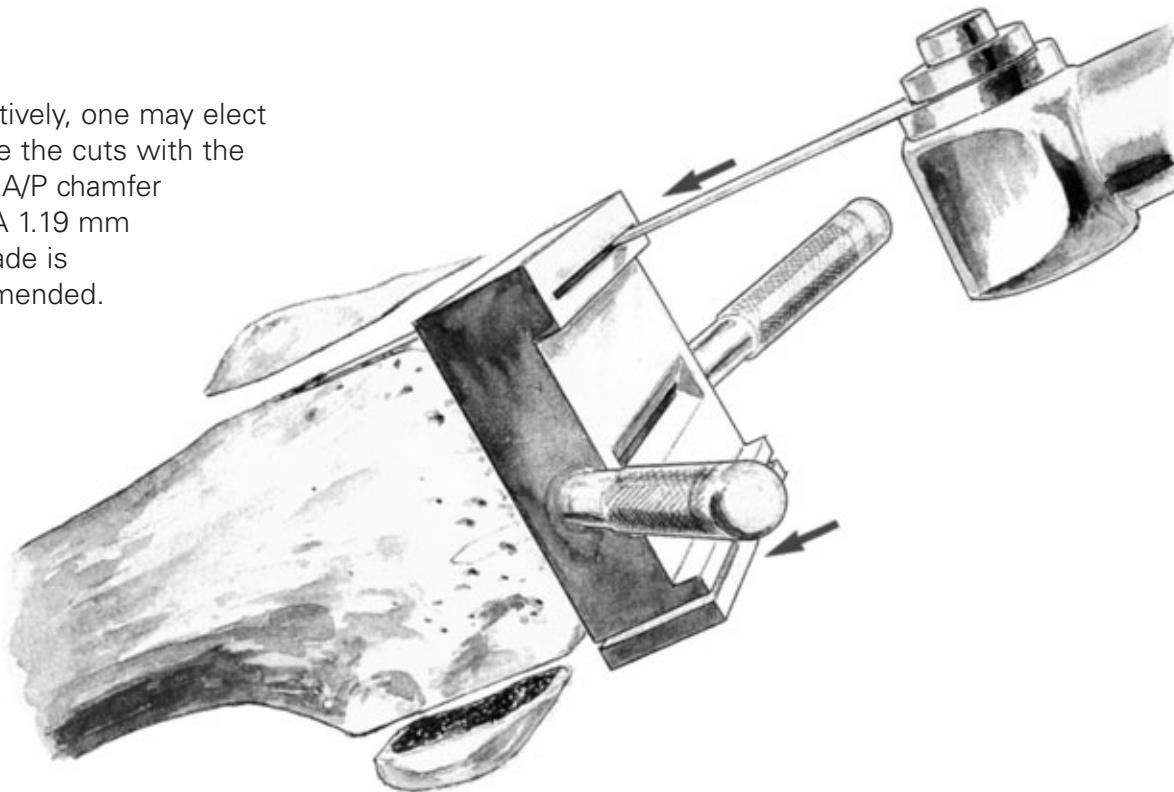
CHAMFERS

The appropriate chamfer block is seated in the drill holes,
the chamfers performed and the block removed.

Alternatively, the chamfers are made
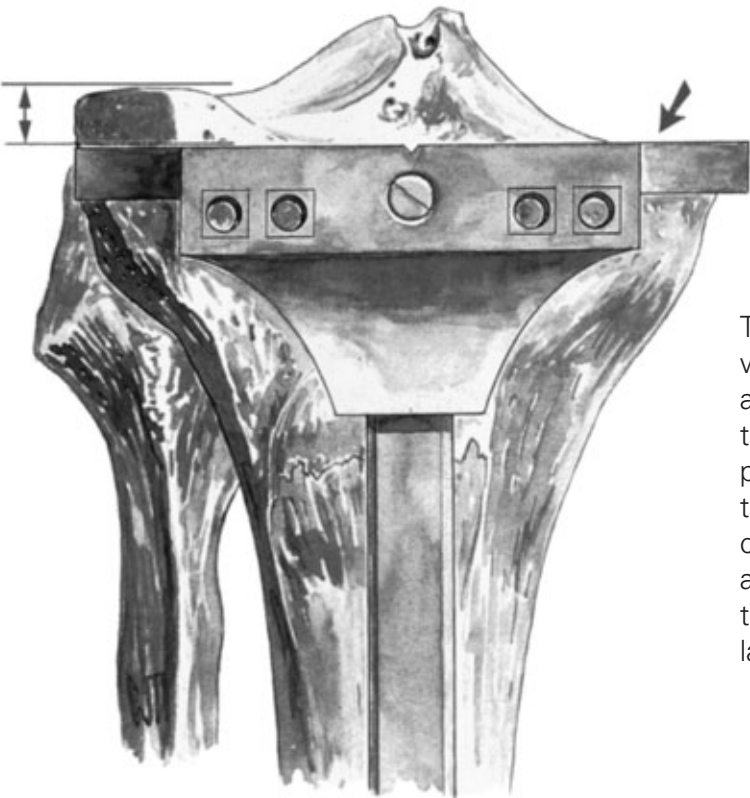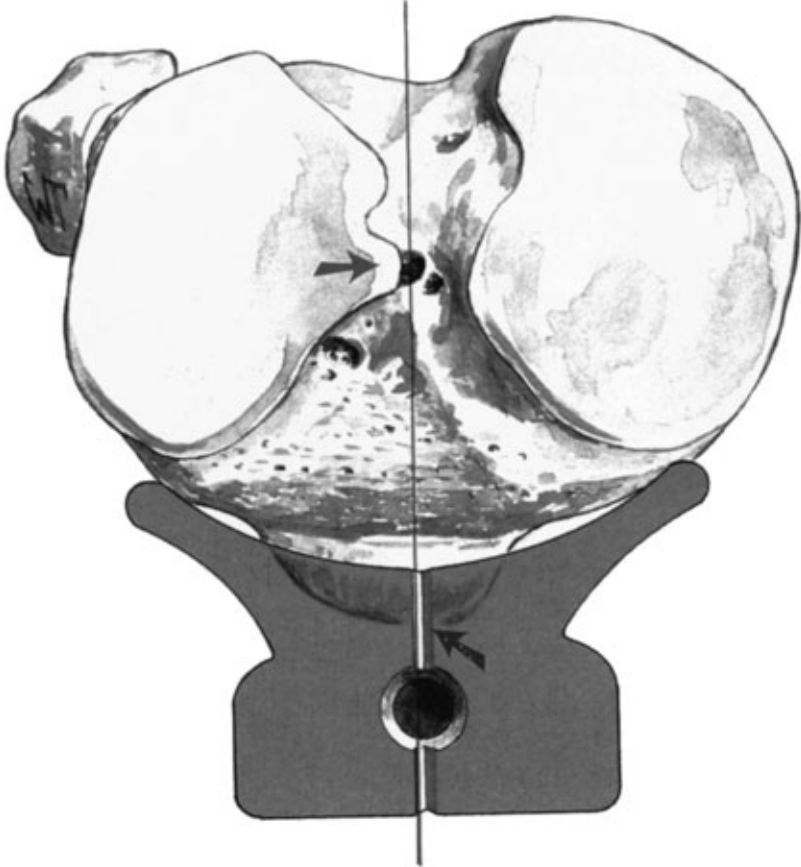with the slotted A/P block.

TIBIAL ALIGNMENT

The knee is placed in maximal flexion with the tibia distracted anteriorly and stabilized.

The malleolar clamp of the tibial alignment device is positioned immediately proximal to the malleoli. The platform is raised to the level of the condyles.

THE UPPER PLATFORM

The upper platform is aligned with the medial third of the tibial tubercle and the medial margin of the lateral intercondylar eminence with the arms against the anterior cortex at the approximate level of resection.
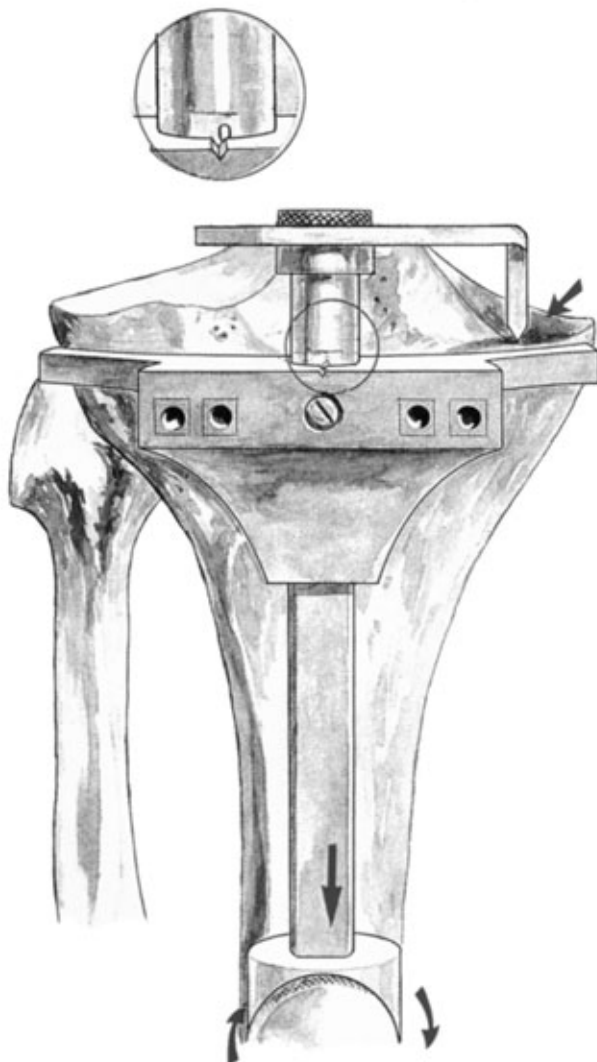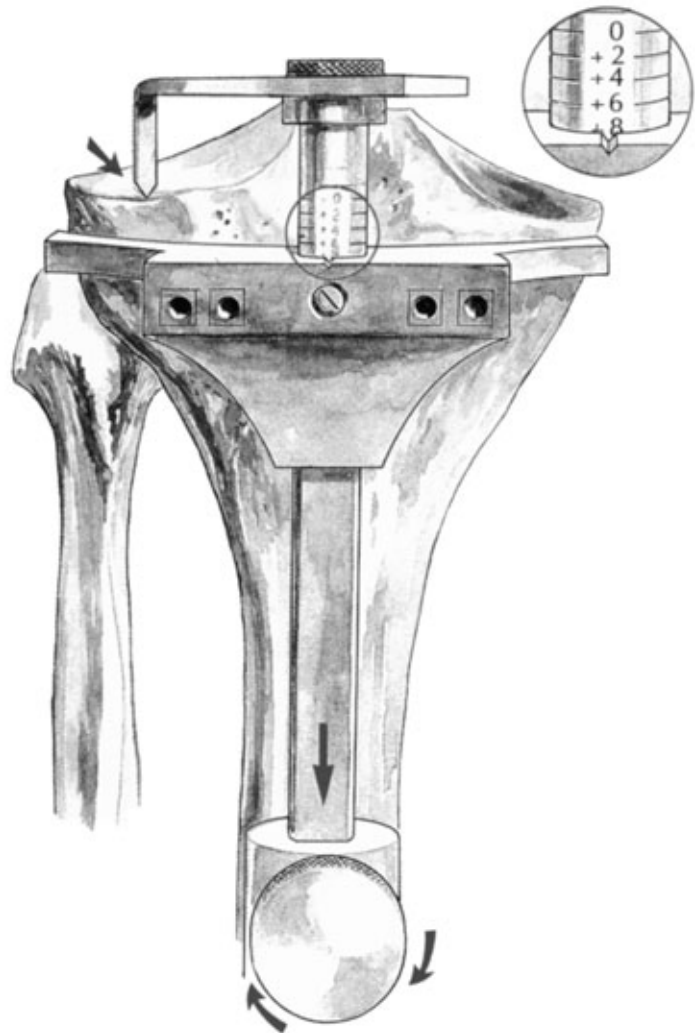

The exact level of resection will vary according to patient anatomy. As the mediolateral transverse plane of the tibial plateau is usually 3 degrees from the perpendicular and the projected cut is perpendicular to the anatomic axis, more bone is typically removed from the lateral condyle.

THE TIBIAL STYLUS

The stylus determines the exact level of resection.

The cylinder of the stylus assembly is seated in its receptacle on the platform and adjusted to the appropriate level. It is calibrated at 2 mm levels, indicating the amount of bone and residual cartilage to be resected.

A level of +8 or +10 is suggested where resection is based on the less involved condyle. The platform is adjusted such that the stylus rests on the center of the condyle.

The level of 0 is selected where resection is based on the more involved condyle and does not result in excessive contralateral resection. The platform is secured by the large anterior setscrew.

NB Where this indicates greater than 10 mm of resection from the contralateral condyle, a higher level is indicated. The deficiency is augmented with cement, bone graft or a modular wedge, as the situation dictates.

See Appendix III for Modular Plus Wedge augmentation.
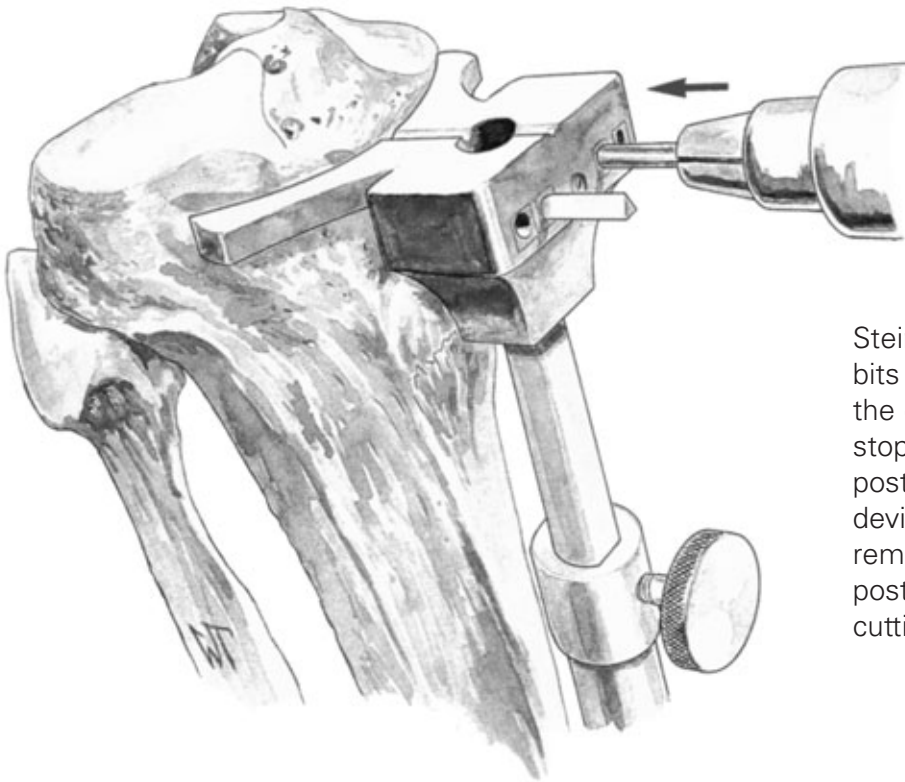
LOWER ALIGNMENT

The lower assembly is translated anteroposteriorly to align it parallel to the tibial axis. Where posterior slope is desired, the lower assembly is advanced anteriorly (5 mm advancement will produce approximately 1-degree additional slope). Up to 5 degrees of slope is generally appropriate for a cruciate sparing device. Further adjustments, where indicated, are made with the cutting blocks *(see below)*.
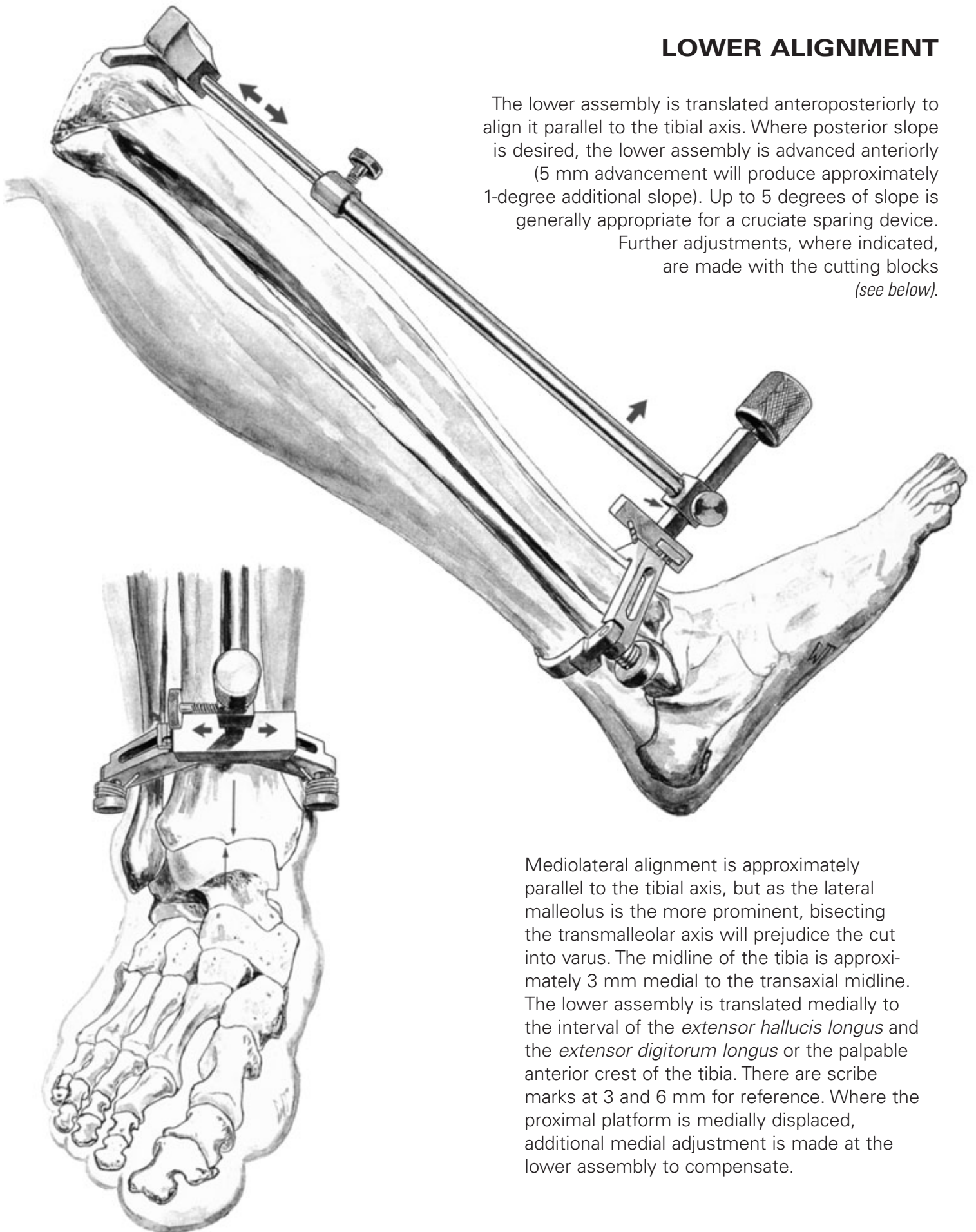
Mediolateral alignment is approximately parallel to the tibial axis, but as the lateral malleolus is the more prominent, bisecting the transmalleolar axis will prejudice the cut into varus. The midline of the tibia is approximately 3 mm medial to the transaxial midline. The lower assembly is translated medially to the interval of the *extensor hallucis longus* and the *extensor digitorum longus* or the palpable anterior crest of the tibia. There are scribe marks at 3 and 6 mm for reference. Where the proximal platform is medially displaced, additional medial adjustment is made at the lower assembly to compensate.
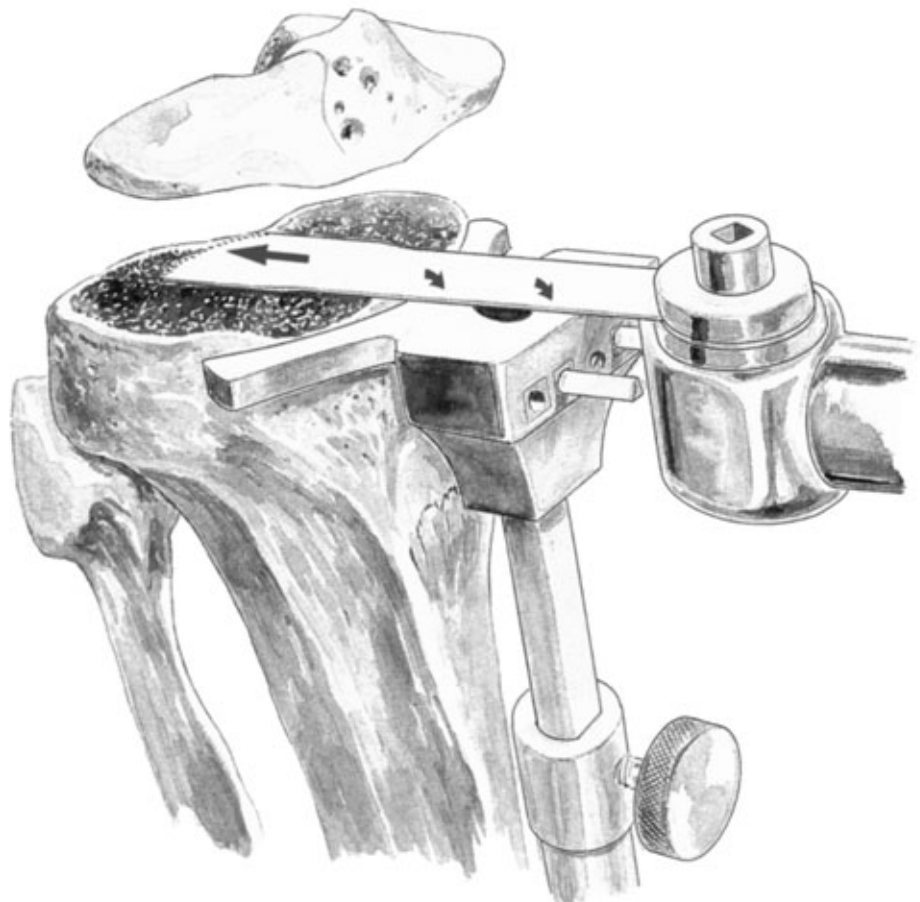
SECURING THE PLATFORM

Steinmann pins or 1/8 inch drill bits are introduced through the central holes into the tibia stopping well short of the posterior cortex. The entire device is subsequently removed, leaving the pins postitioned to accept the cutting block.
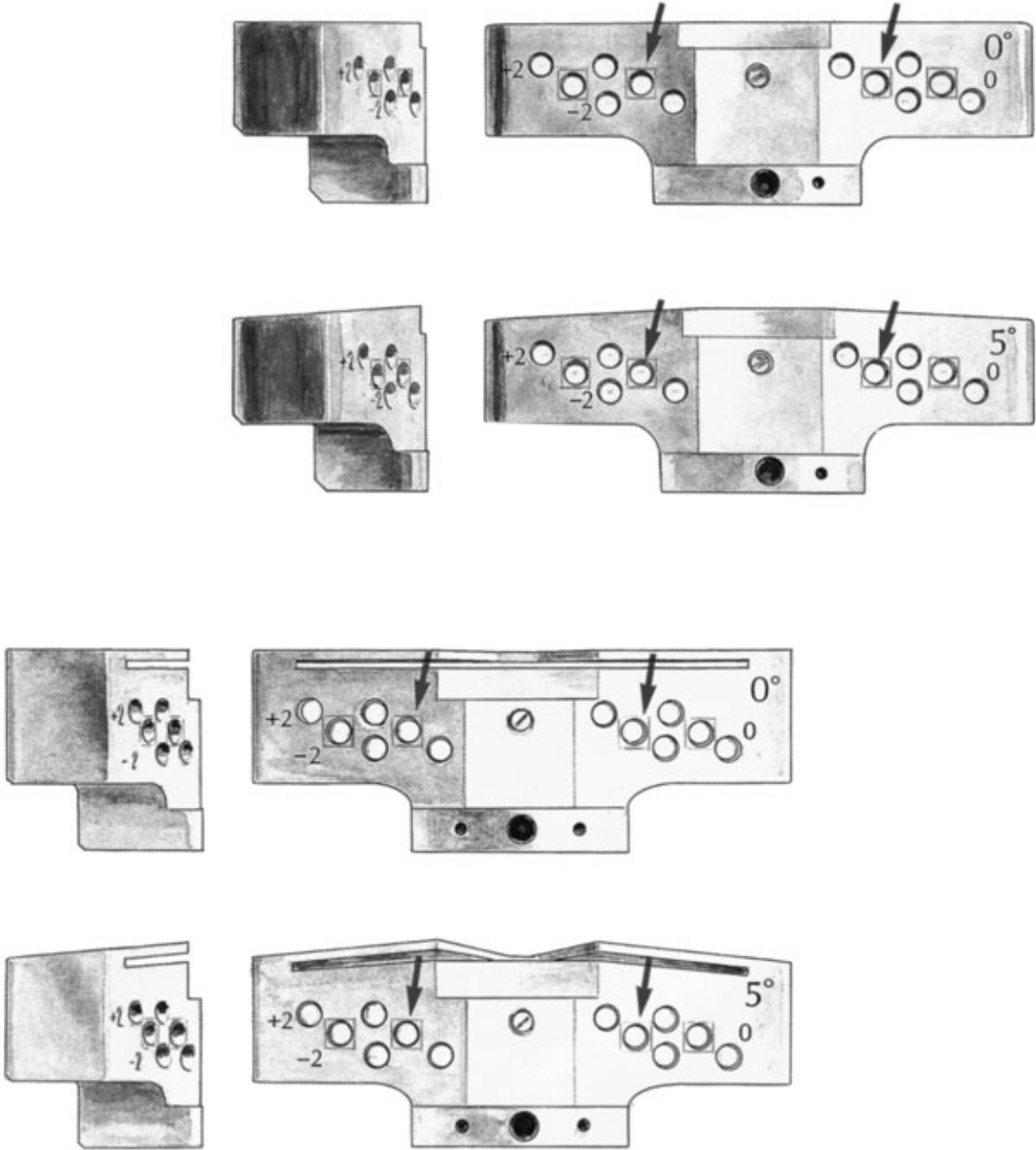
Alternatively, the platform itself may serve as the cutting guide.

The oscillating saw is employed conservatively, with posterior cortical resection performed with an osteotome.
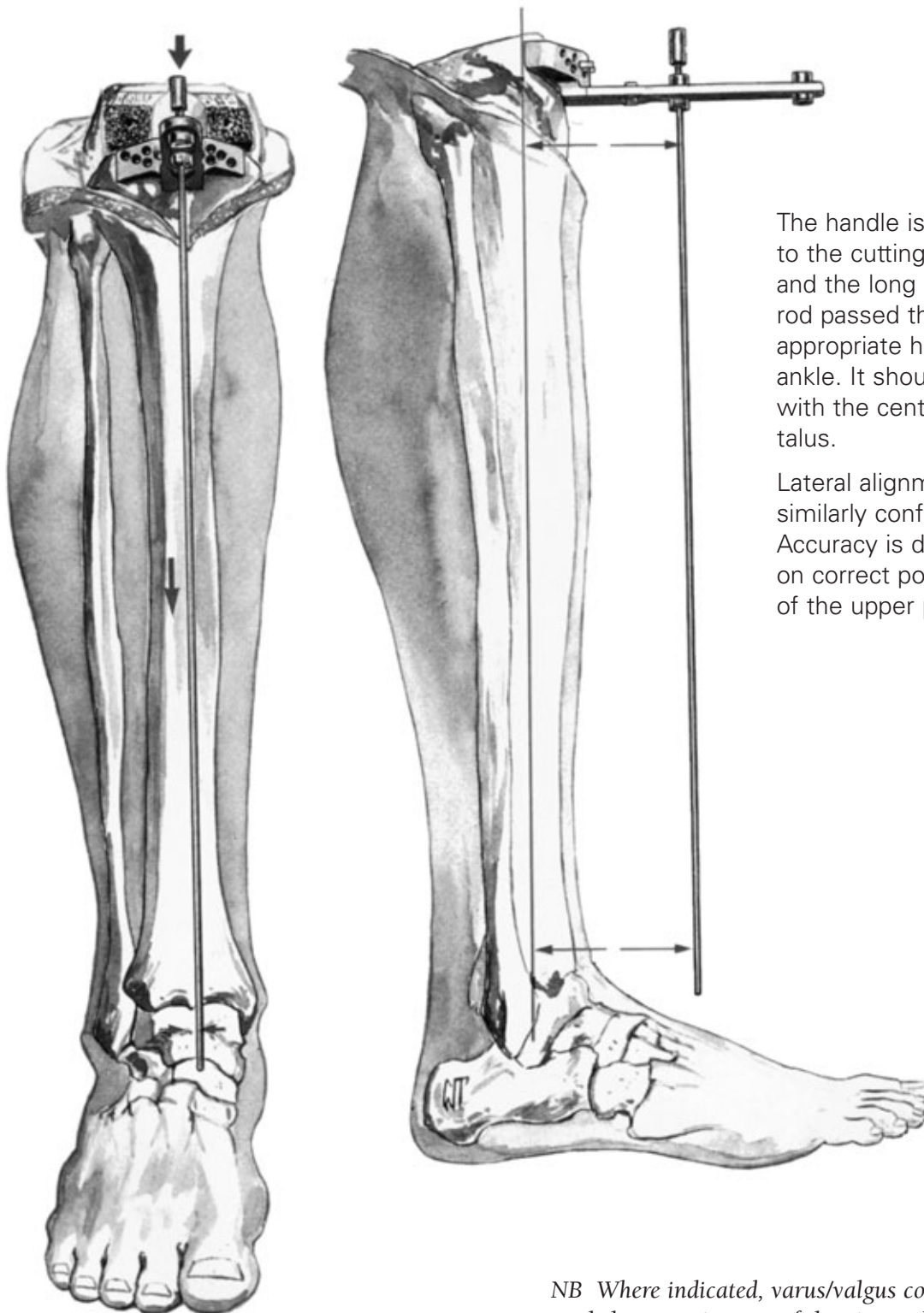
THE TIBIAL CUTTING BLOCK

Cutting blocks are provided in surface or slotted versions and in 0 degrees and 5 degrees of posterior slope. One of the 0-degree blocks is selected initially. The holes are designated -2, 0 and +2, indicating in mm a greater or lesser amount of resected bone. The block is positioned onto the Steinmann pins using the 0 holes (the holes enclosed in □'s). The 5-degree block will give 5 degrees of additional posterior slope to that already established by the tibial alignment guide.

THE TIBIAL ALIGNMENT HANDLE

The handle is coupled to the cutting block and the long alignment rod passed through the appropriate hole to the ankle. It should align with the center of the talus.

Lateral alignment is similarly confirmed. Accuracy is dependent on correct positioning of the upper platform.

NB Where indicated, varus/valgus corrections are made by removing one of the pins and allowing the block to pivot on the other. The pin is subsequently repositioned through a more peripheral hole.
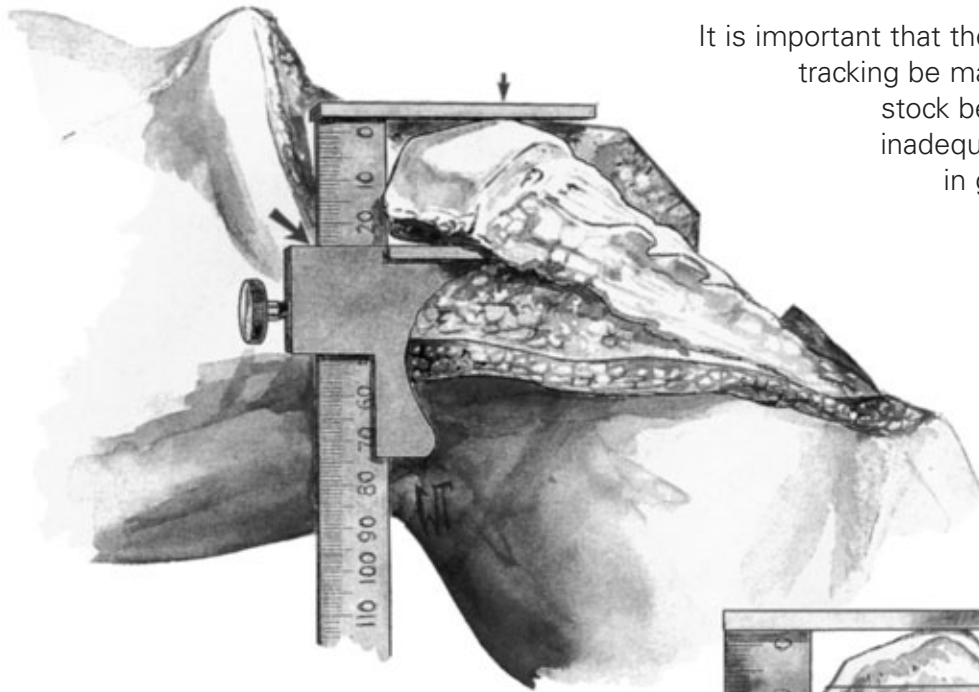
TIBIAL RESECTION

An entry slot is cut with a narrow oscillating saw into the intercondylar eminence anterior to the attachment of the PCL and an osteotome positioned to shield the ligament. Resection is made with the blade held flush to the cutting surface.
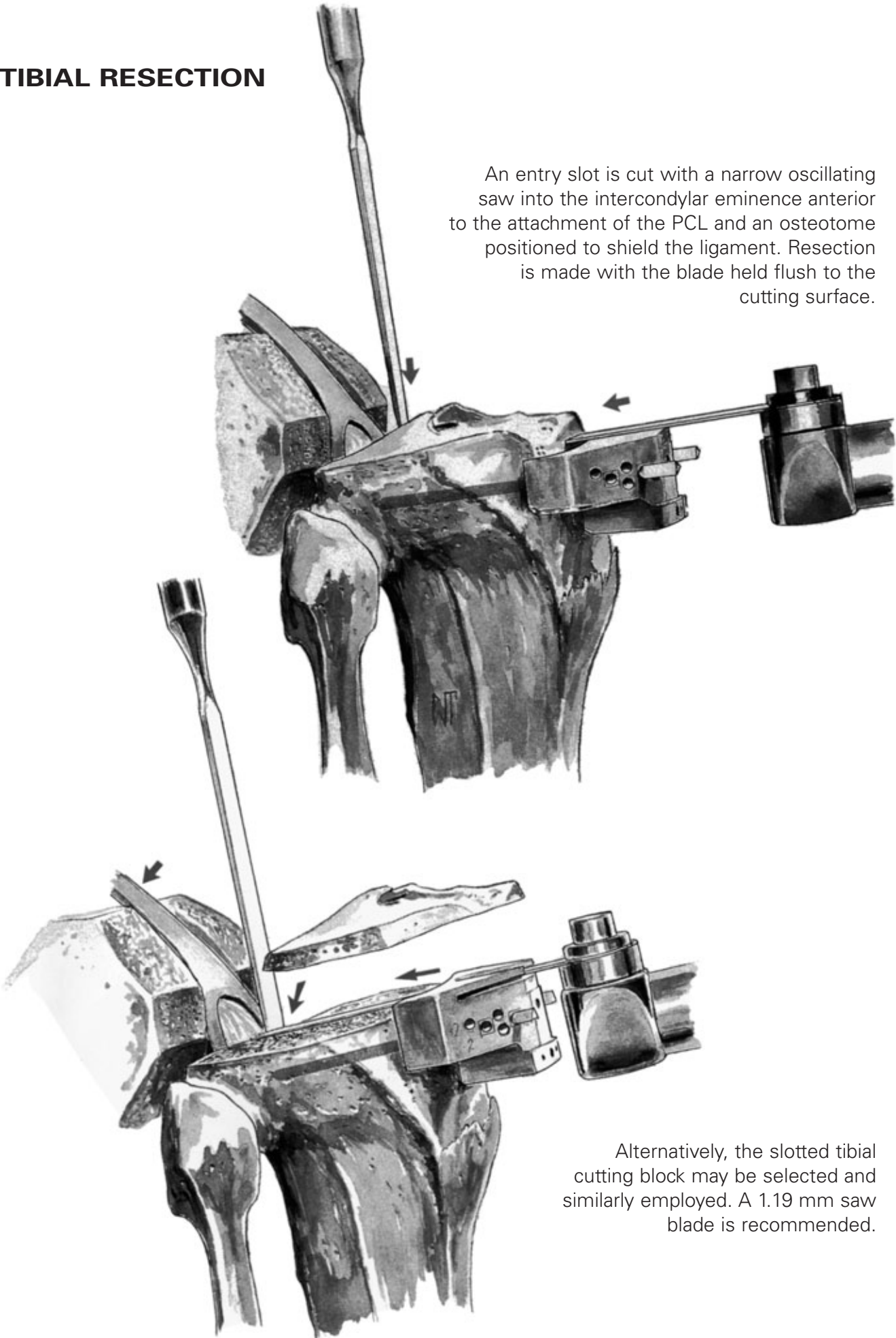
Alternatively, the slotted tibial cutting block may be selected and similarly employed. A 1.19 mm saw blade is recommended.

PATELLAR RESURFACING

It is important that the sagittal dimension and accurate tracking be maintained and that adequate bone stock be preserved. Problems arise from inadequate or oblique resection resulting in greater thickness to the complex, asymmetric positioning of the implant, subsequent patellar tilt and implant wear.

It is important that sufficient soft-tissue be freed at the prepatellar bursa to position the calipers at the anterior cortex.
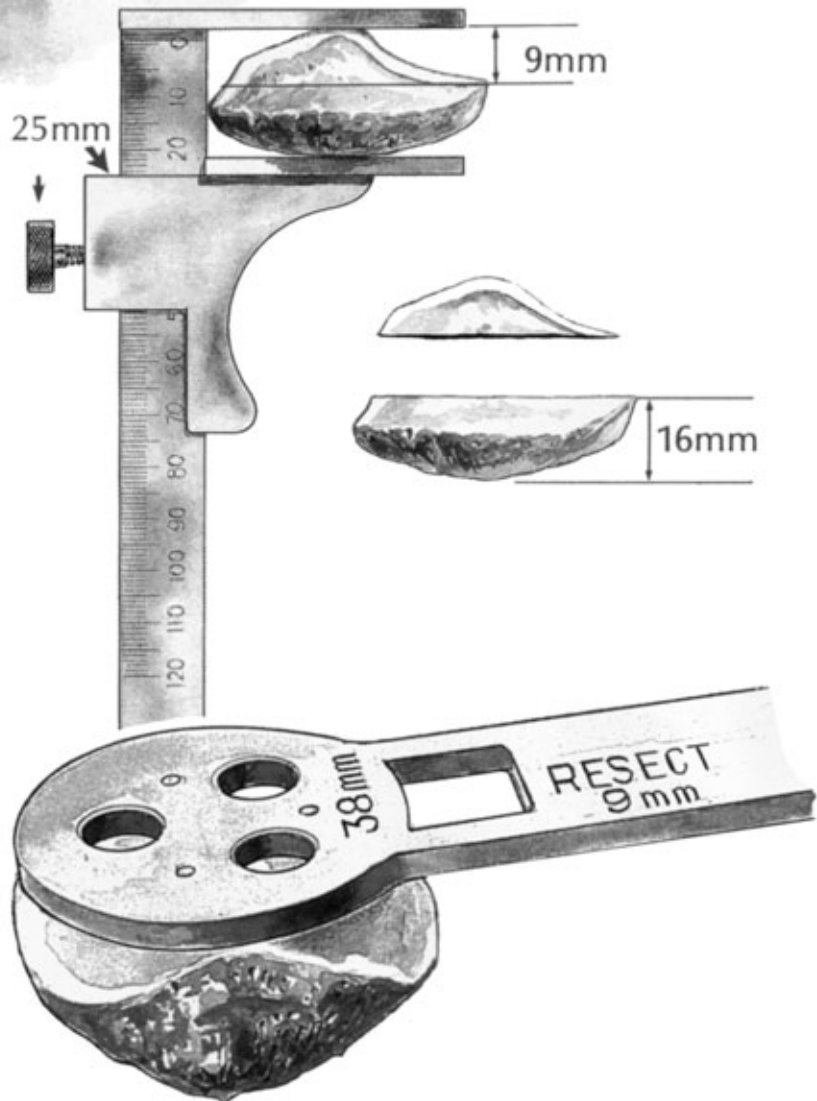
The greatest sagittal dimension is at the median ridge. The normal range is 20-30 mm. The dimension is established and an amount corresponding to the size of the selected implant subtracted. The remainder equals the target dimension following resection. Where the patella is small, a minimal residual dimension of 12 mm should be maintained.

Example: From a patella 25 mm thick, 9 mm of articular surface is resected, yielding 16 mm of residual bone to accommodate the 38 mm implant.

The template is selected that most adequately covers the articular surface without overhang. The handle is positioned laterally. Where bone is deficient on the lateral side, the next smaller size is selected, but positioned slightly to the medial to enhance patellar tracking.

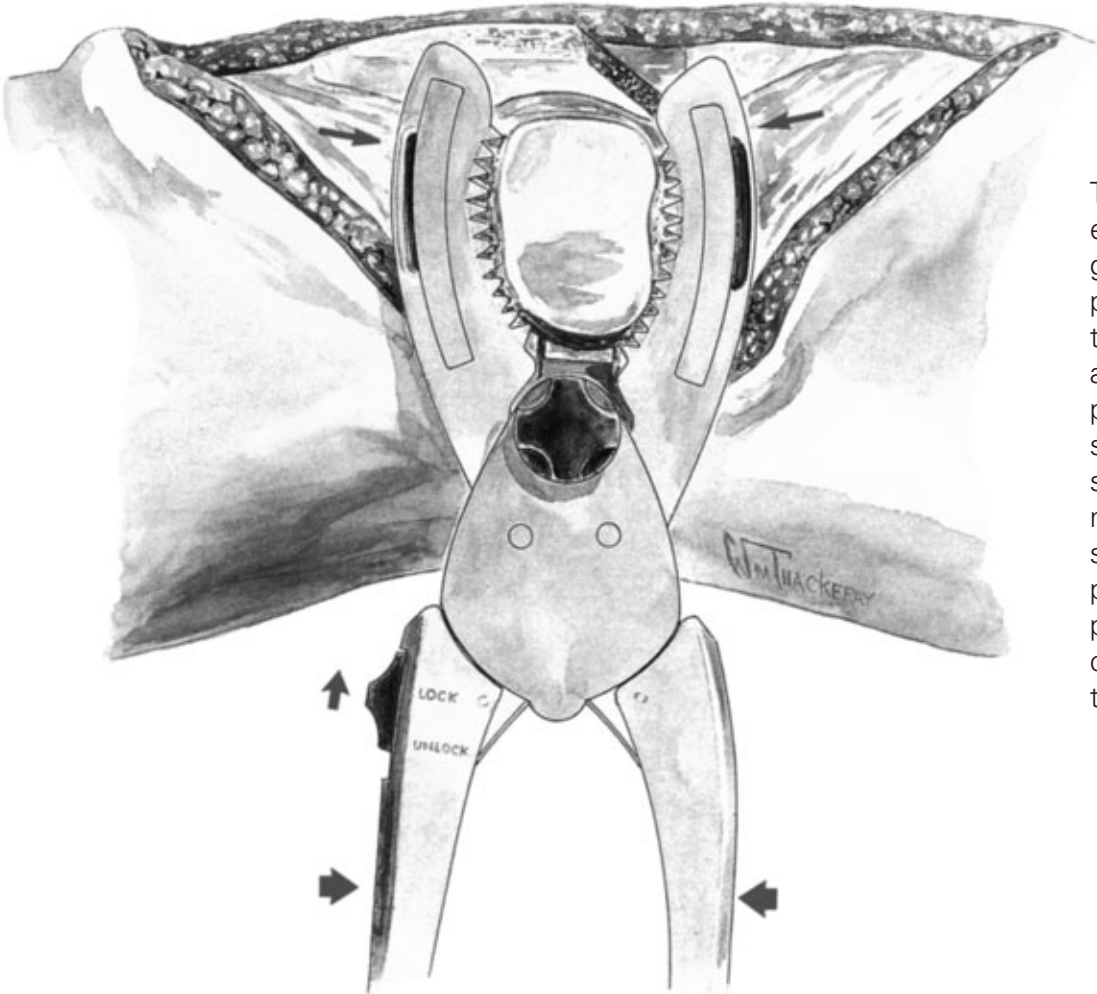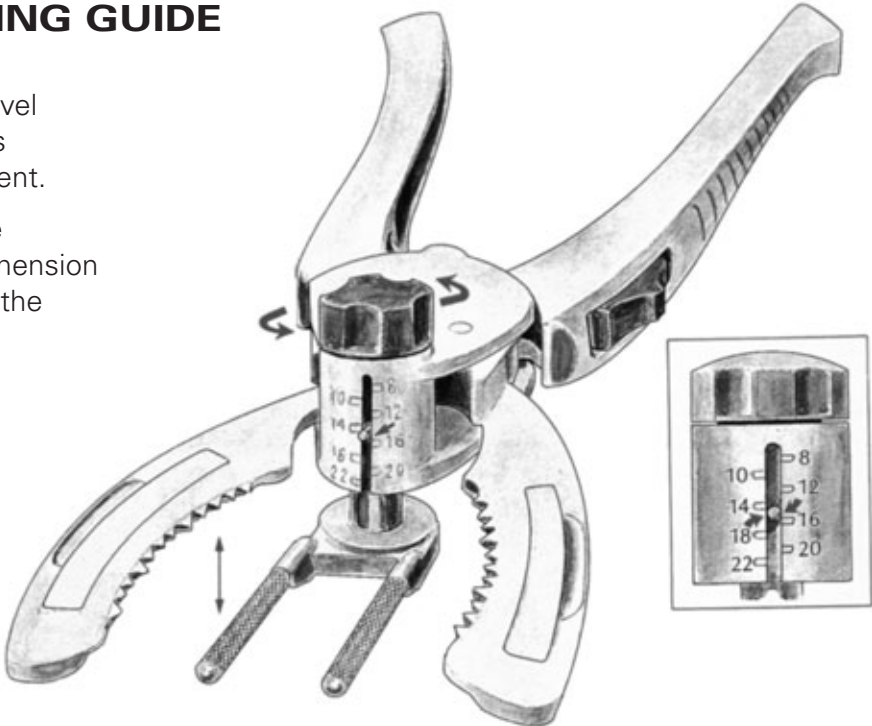The amount of appropriate bone resection (indicated on the template) is noted.

Where the P.F.C. Σ patellar component size is 32 mm, resection is 8 mm.
Where it is 35 mm, resection is 8.5 mm.
Where it is 38 mm, resection is 9 mm.
Where it is 41 mm, resection is 11.5 mm.

THE PATELLAR CUTTING GUIDE

Synovial tissue is cleared to the level of the insertions of the quadriceps mechanism and the patellar ligament.
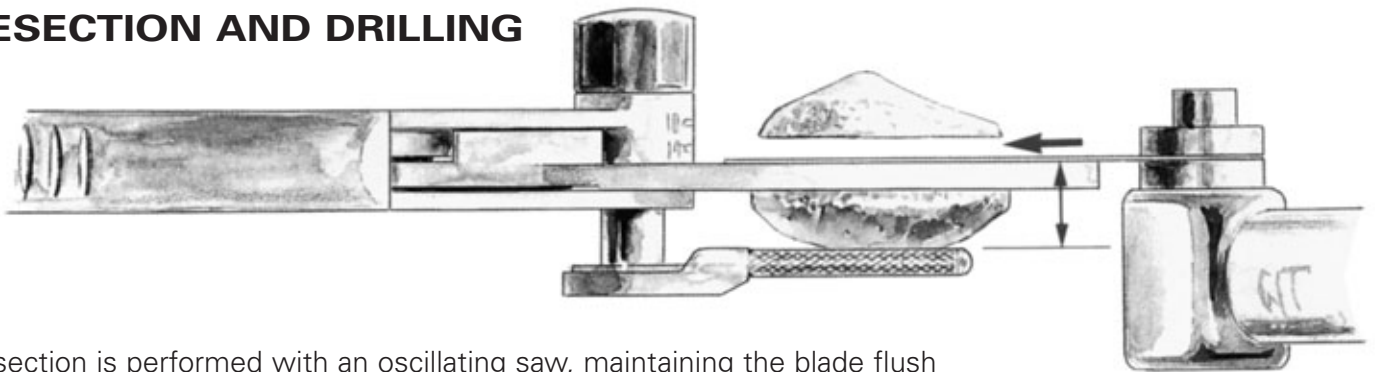
The prongs of the knurled fork are adjusted to the predetermined dimension of residual patella as indicated on the calibrated column.
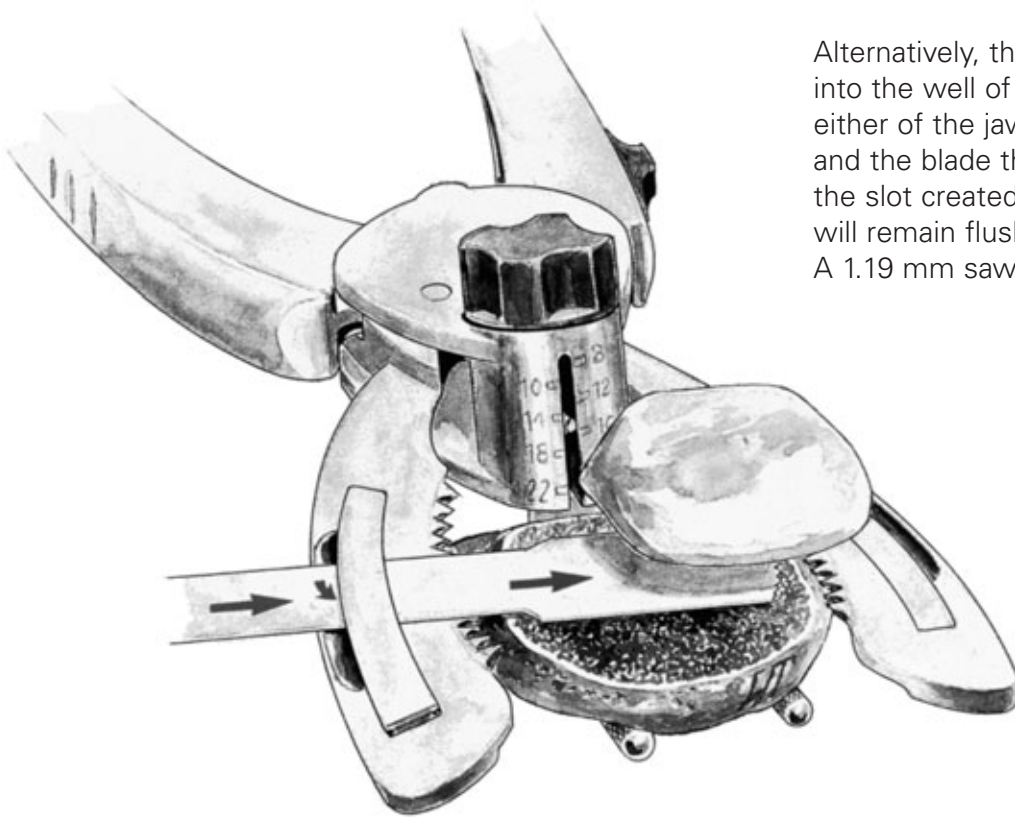

The leg is placed in extension, the cutting guide positioned with the prongs of the fork deep to the prepatellar bursa and against the anterior patellar cortex with the serrated jaws at the superior and inferior margins of the articular surface. The switch is placed to the LOCK position and the jaws closed to firmly engage the patella.
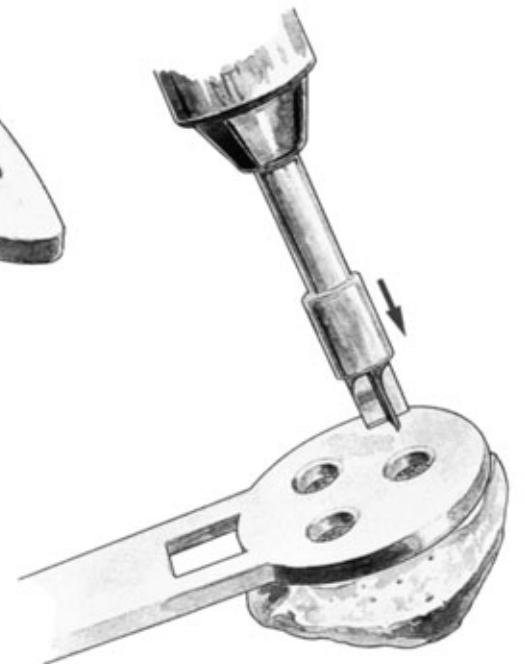
RESECTION AND DRILLING

Resection is performed with an oscillating saw, maintaining the blade flush to the cutting surface. The guide is subsequently removed and the residual dimension checked with calipers, laterally, medially, proximally and distally. All measurements should be equivalent. Asymmetry is addressed with the saw or a bone rasp.

Alternatively, the saw blade is inserted into the well of the cutting surface of either of the jaws. The insert is lifted and the blade thereby confined within the slot created, ensuring that the cut will remain flush to the cutting surface. A 1.19 mm saw blade is recommended.

The previously selected template is positioned onto the cut surface with the handle positioned laterally, such that two drill holes lie at the medial side, one at the lateral. The template is firmly engaged to the resected surface and the holes fashioned with the appropriate drill bit. Where a slightly undersized component is to be used, slight medial bias will facilitate tracking. Depth penetration is governed by the drill bit collar.

THE TRIAL TIBIAL COMPONENT

The knee is placed in maximal flexion, the tibia subluxed anteriorly with the tibial retractor. The tibial tray is selected which provides the greatest coverage of the prepared surface but precludes overhang anterior to the midcoronal plane. The appropriate color-coded nylon trial is selected and inserted into the tray.

NB See Appendix II for implantation of the P.F.C. Keel Tray.

THE TRIAL FEMORAL COMPONENT

With the knee in full flexion, the universal handle is assembled
to the femoral inserter and the inserter to the femoral trial.
The trial is positioned onto the prepared surface.
The leading edges are advanced equally,
parallel to the distal femoral cut,
preserving its precisely prepared
configuration.
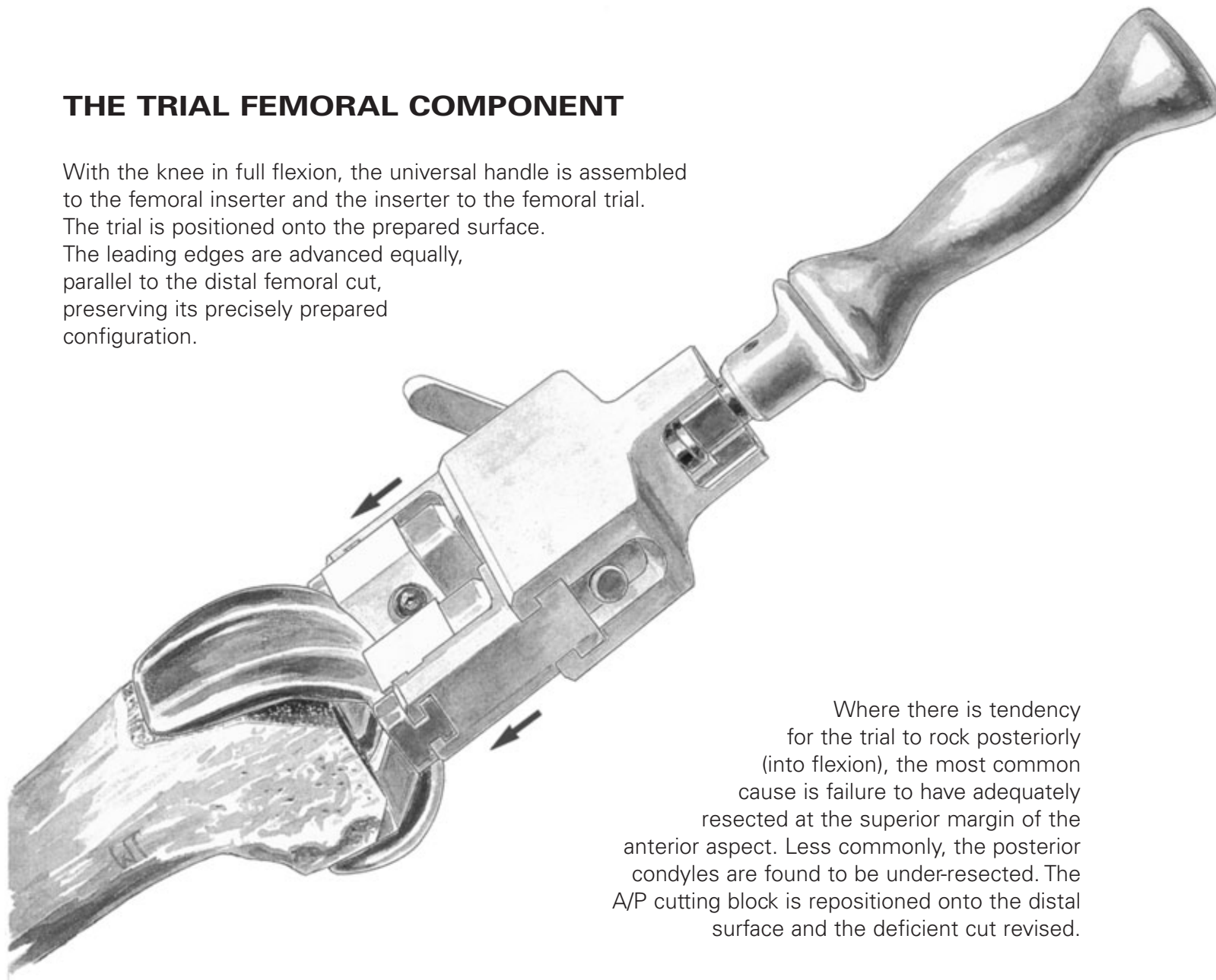
Where there is tendency
for the trial to rock posteriorly
(into flexion), the most common
cause is failure to have adequately
resected at the superior margin of the
anterior aspect. Less commonly, the posterior
condyles are found to be under-resected. The
A/P cutting block is repositioned onto the distal
surface and the deficient cut revised.
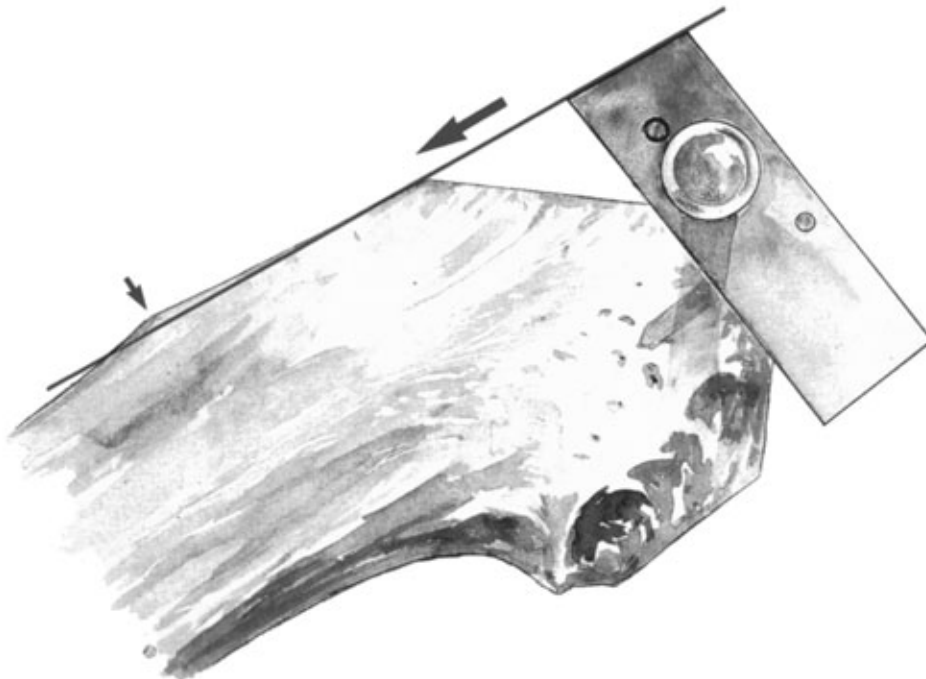
TRIAL REDUCTION

With all trial prostheses in place, the knee is carefully and fully extended, noting medial and lateral stability and overall alignment in the A/P and M/L plane. Where there is any indication of instability, the next greater size tibial insert is substituted and reduction repeated. The insert that gives the greatest stability in flexion and extension and allows full extension is selected. Where there is a tendency for lateral subluxation or patellar tilt in the absence of medial patellar influence (thumb pressure), lateral retinacular release is indicated.

Rotational alignment of the tibial tray is adjusted with the knee in full extension, using the alignment handle to rotate the tray and tibial insert into congruency with the femoral trial.
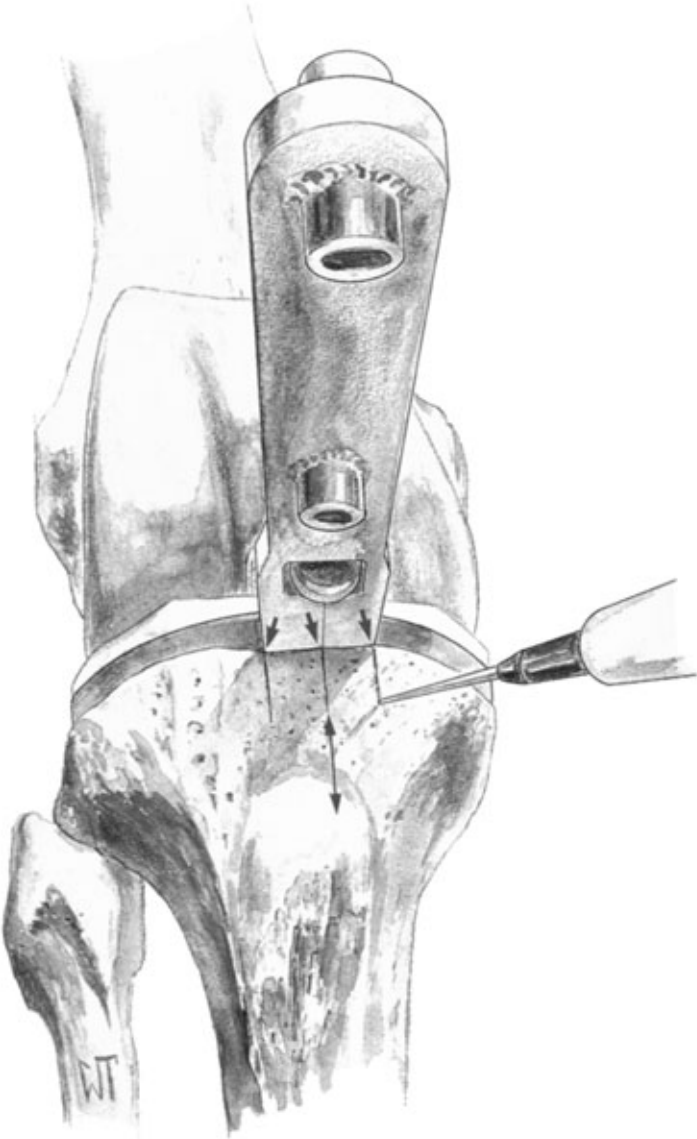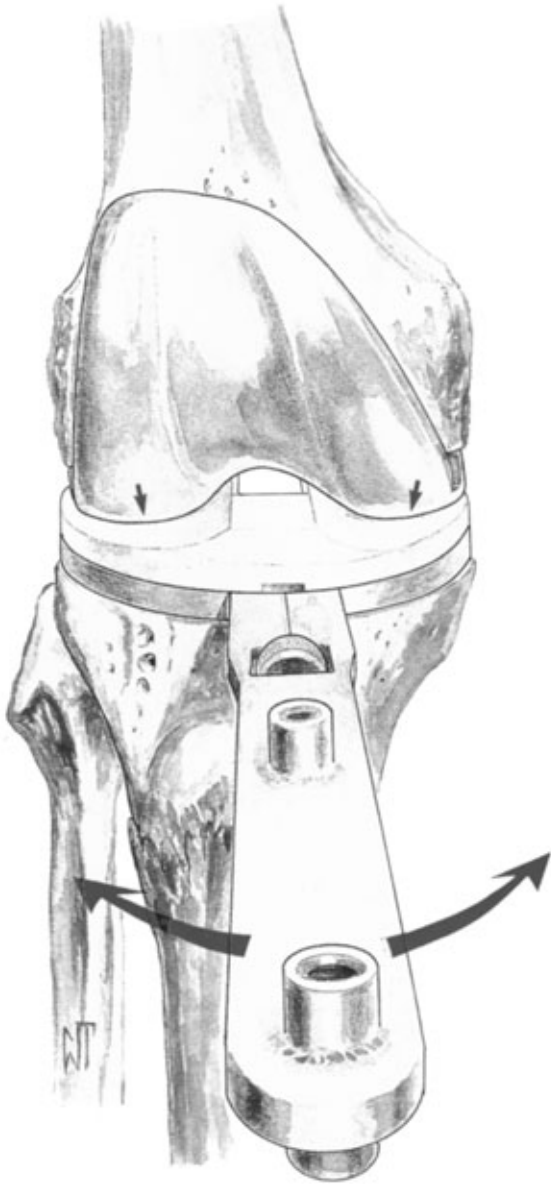
The appropriate position is marked with electrocautery on the anterior tibial cortex.

OVERALL ALIGNMENT

The tibial alignment handle
is assembled to the trial tibial
tray and the two parts
of the alignment rod to the
handle.
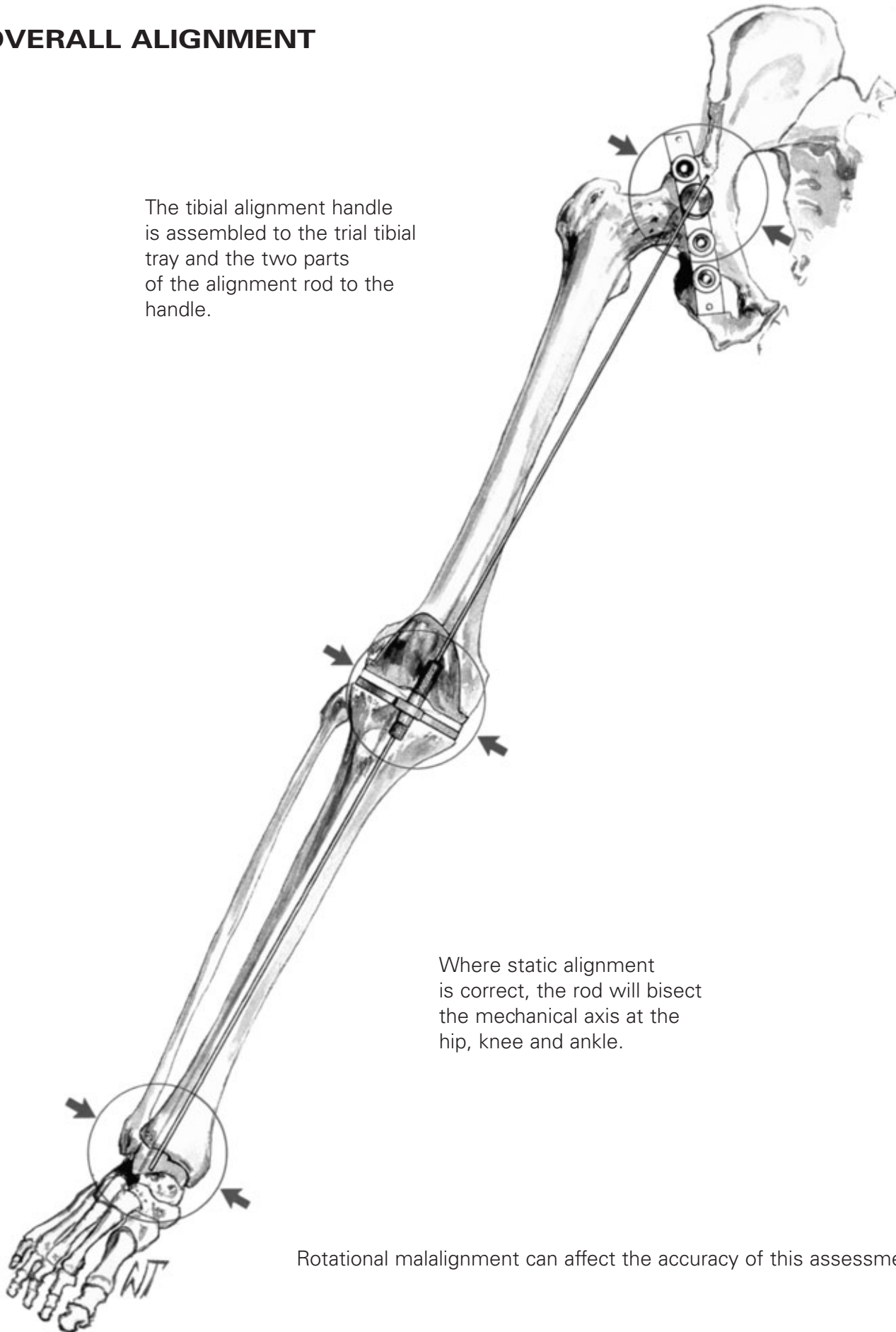
Where static alignment
is correct, the rod will bisect
the mechanical axis at the
hip, knee and ankle.

Rotational malalignment can affect the accuracy of this assessment.

PLATEAU PREPARATION

With the knee in full flexion and the tibia subluxed anteriorly, the trial tibial tray is assembled to the alignment handle and placed onto the resected tibial surface. Care is taken that proper rotational alignment with the electrocautery marks be established.

The tray is secured with two fixation pins inserted through the holes designated □.

NB *See Appendix II for implantation of the P.F.C. Keel Tray.*

THE TIBIAL DRILL

The tibial drill bushing is seated in the tray trial.

The tibial drill is advanced fully through the bushing into the cancellous bone.

Alternatively, where some portion of cancellous bone is to be retained to form a distal plug, drilling is stopped 10-15 mm above the bushing. The bone is subsequently impacted by the keel punch, plugging the medullary canal.

The drill and bushing are removed, the trial tray remains in place.

THE TIBIAL KEEL PUNCH

The keel punch is positioned on the fixation pins and fully seated with a mallet, impacting the cancellous bone into the keel configuration.

A slap hammer is used to disengage the keel punch with minimal disturbance to the site.

*NB Where a Modular Plus Wedge is indicated, see Appendix III.*
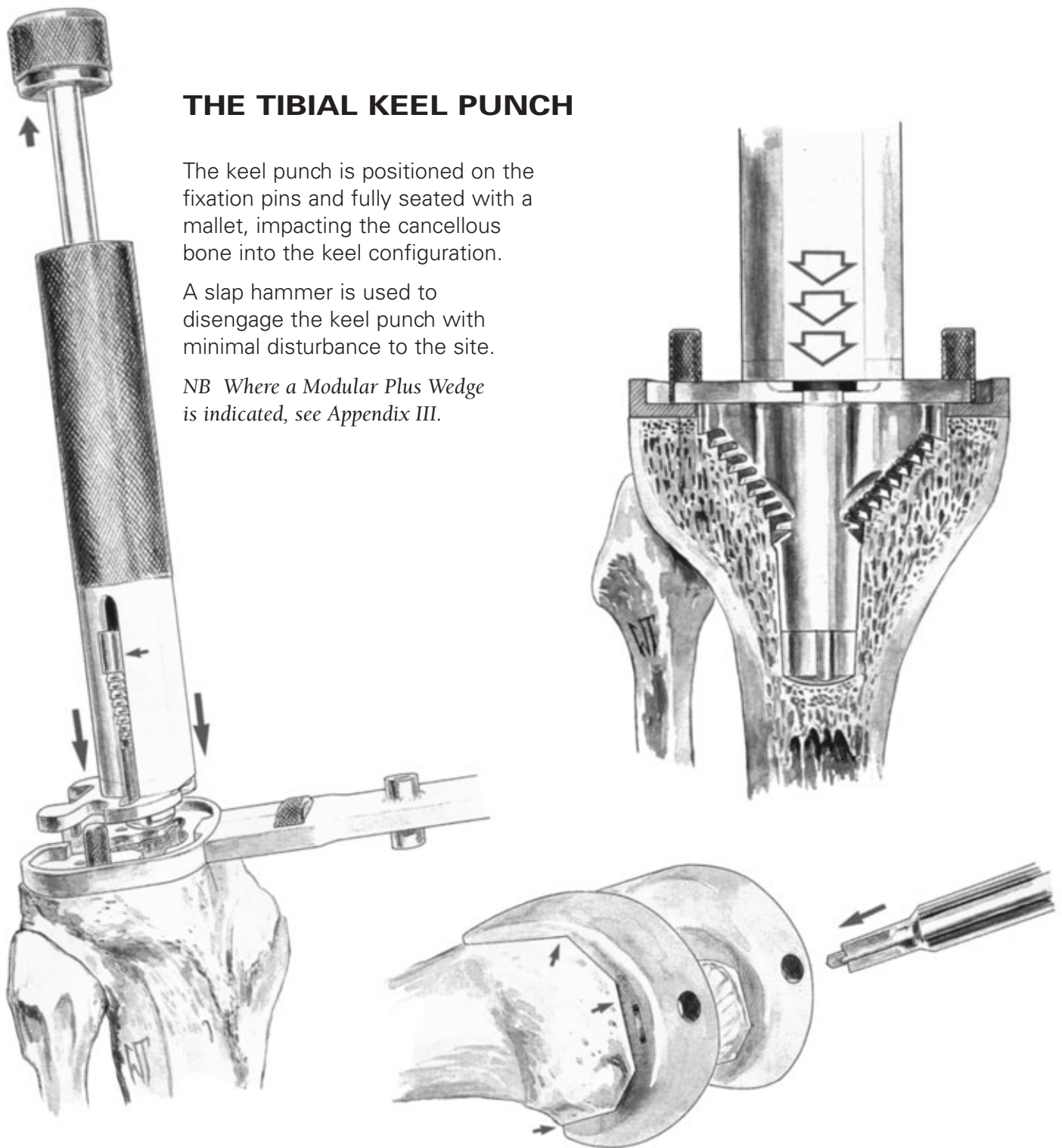
THE FEMORAL LUG DRILL

Mediolateral positioning of the femoral trial component is confirmed and receptacles prepared for the implant lugs by advancing the femoral drill through the appropriate holes.

NB Not required where a cutting block with large fixation spikes was used.

35

IMPLANTING THE COMPONENTS
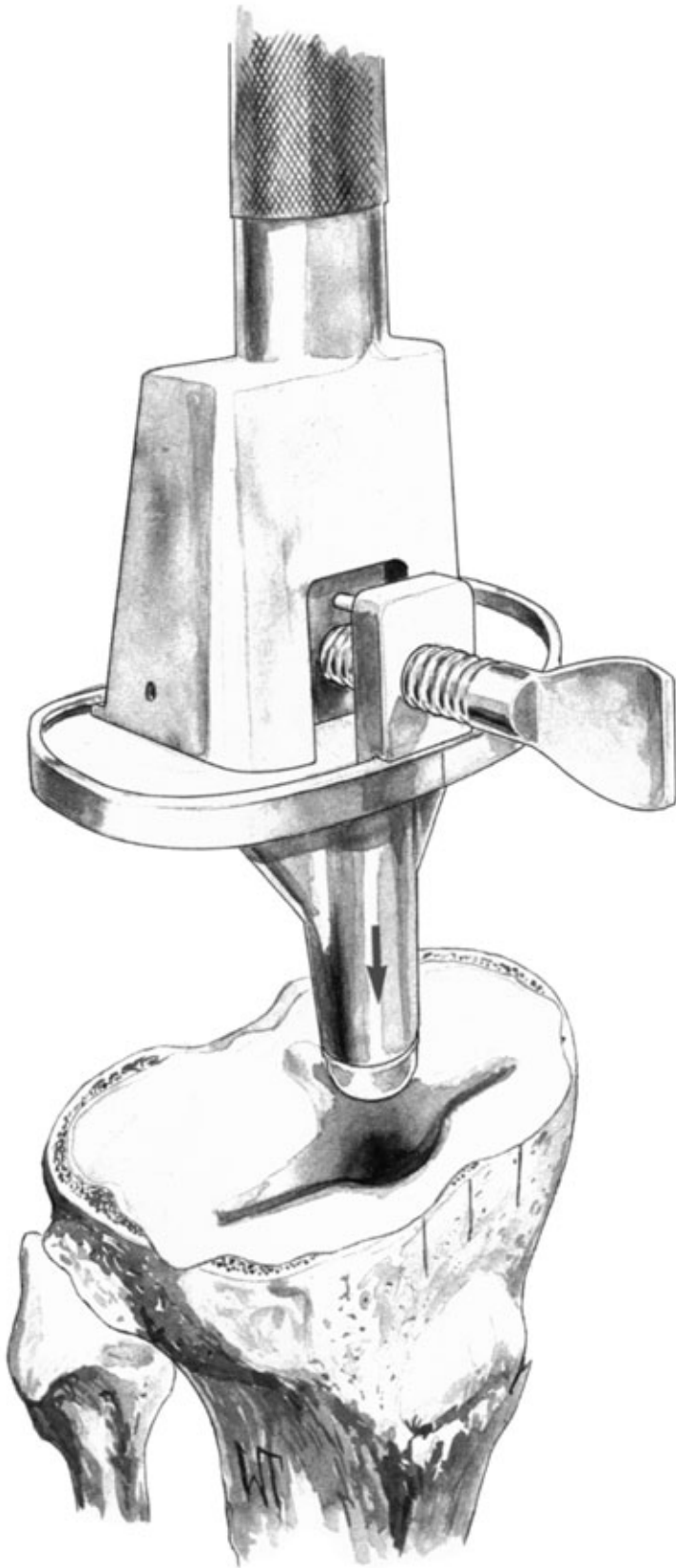
THE TIBIAL TRAY

The entire site is thoroughly cleansed with pulsatile lavage. Methyl methacrylate cement is prepared and applied by syringe or digital pressure in its low viscous state to ensure maximal penetration into the trabecular bone.

The tray is assembled to the universal tibial impactor and carefully inserted, *avoiding maltrotation.* When it is fully seated, several mallet blows are delivered to the top of the impactor. The impactor is subsequently disengaged from the implanted tray and removed.

As the cement polymerizes, a trial insert is positioned in the tray, a trial component on the prepared femur. The knee is placed in full extension to maintain pressure at the bone/tray interface. Slight valgus stress is maintained to ensure the tray not tilt into varus. When the cement has set, the knee is placed in flexion and the trial femoral component removed. All extruded cement is carefully removed with special attention to the posterior compartment.
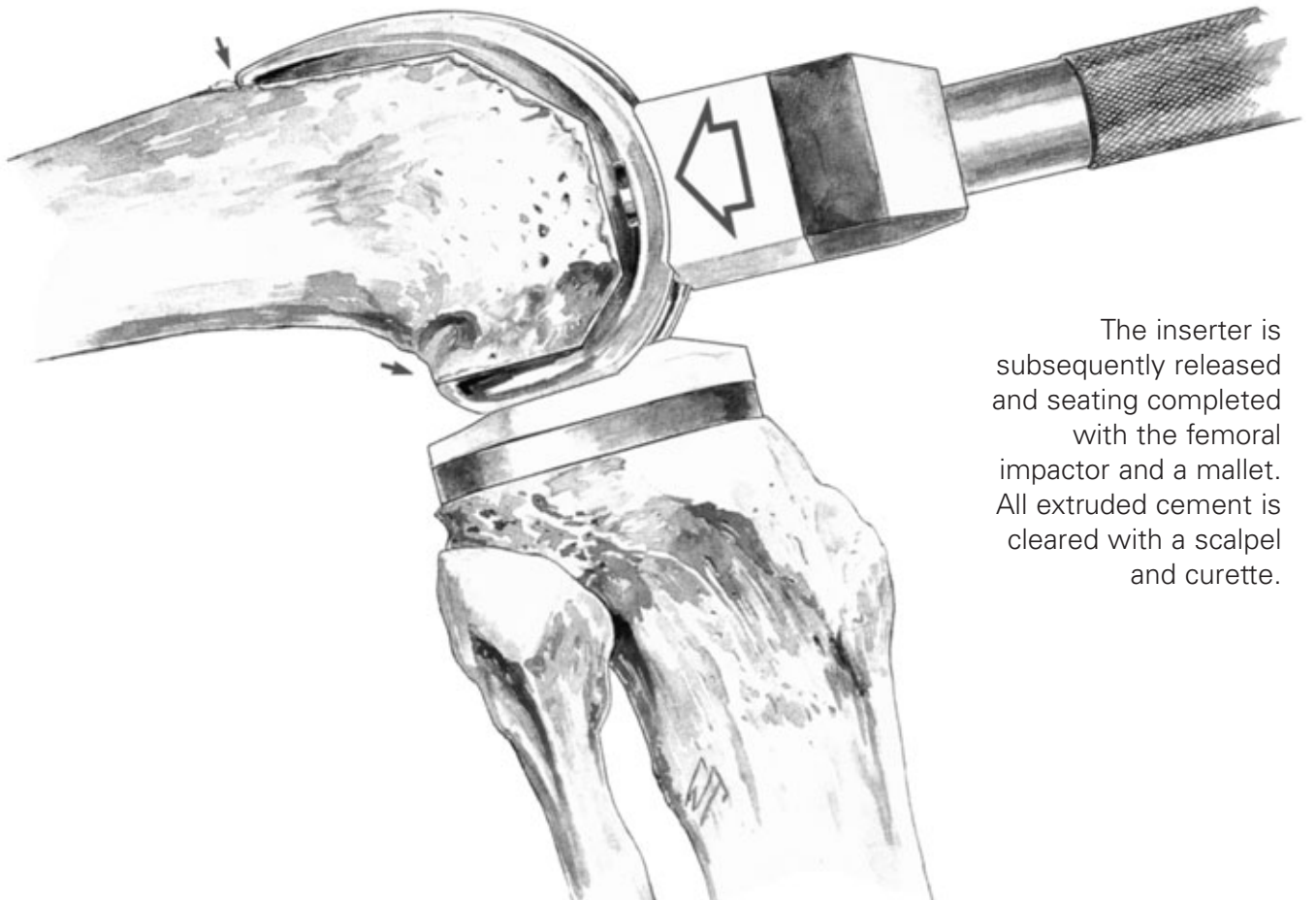
THE FEMORAL COMPONENT

The entry to the medullary canal is plugged with cancellous bone. All surfaces are thoroughly cleansed with pulsatile lavage.
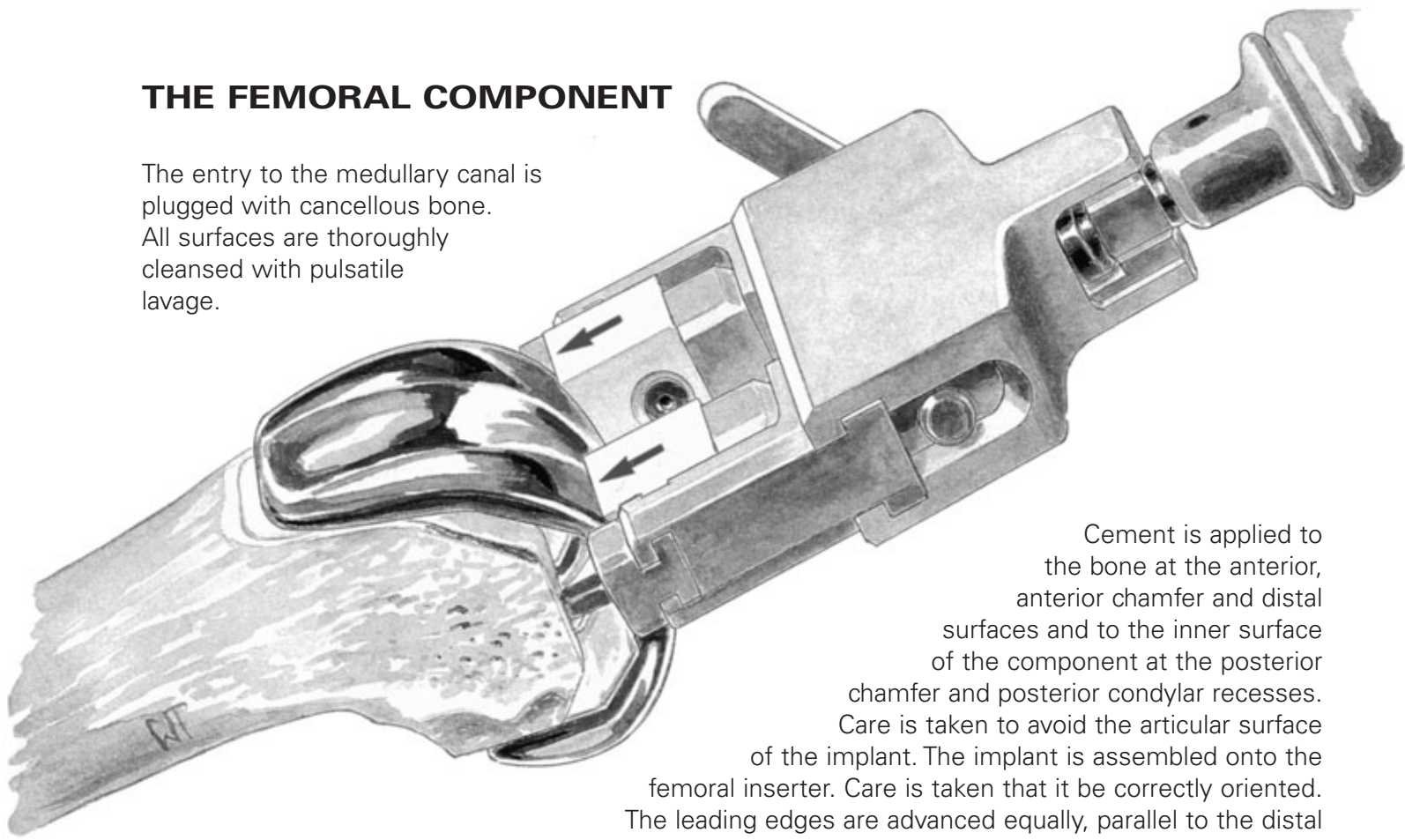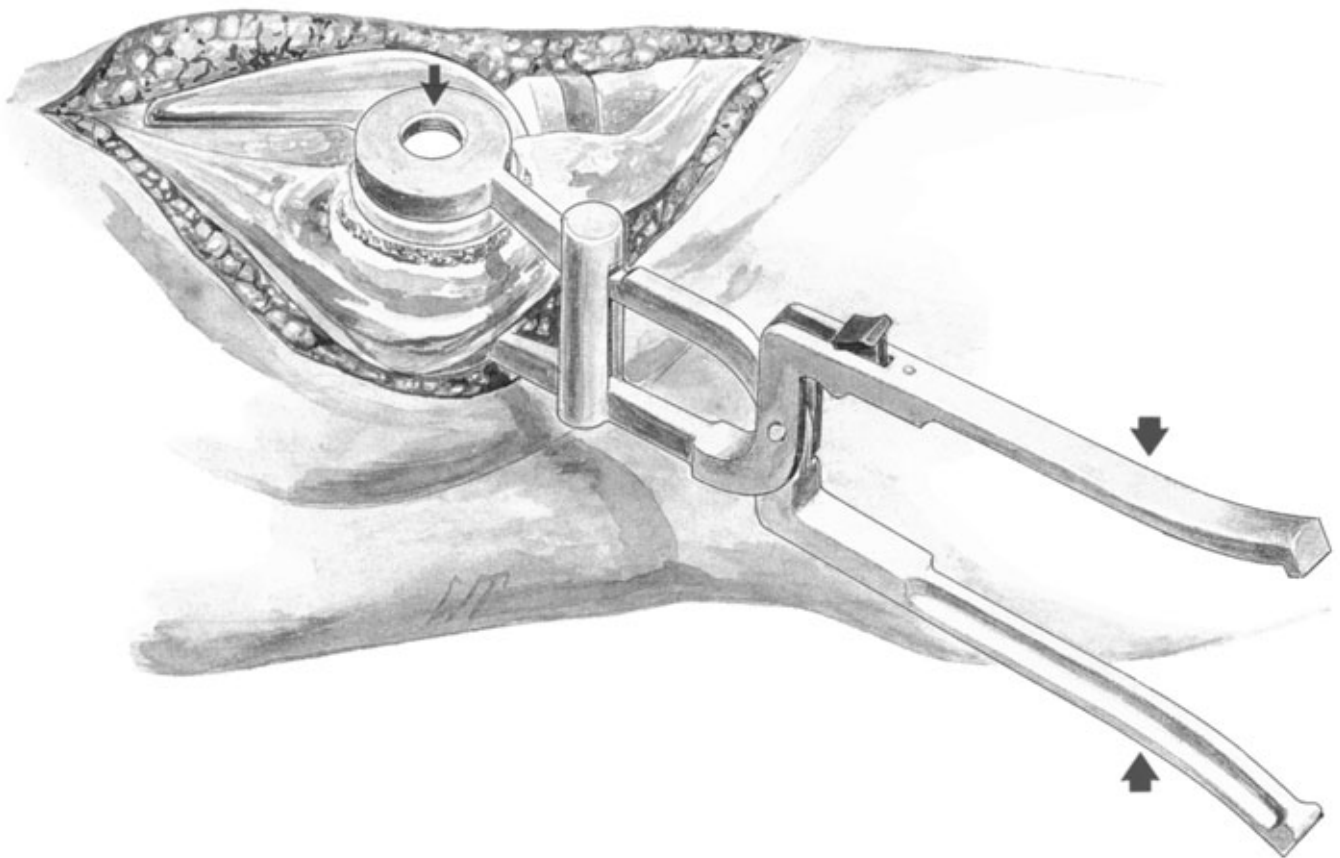
Cement is applied to the bone at the anterior, anterior chamfer and distal surfaces and to the inner surface of the component at the posterior chamfer and posterior condylar recesses. Care is taken to avoid the articular surface of the implant. The implant is assembled onto the femoral inserter. Care is taken that it be correctly oriented. The leading edges are advanced equally, parallel to the distal femoral plane, until the lugs are fully engaged.

The inserter is subsequently released and seating completed with the femoral impactor and a mallet. All extruded cement is cleared with a scalpel and curette.
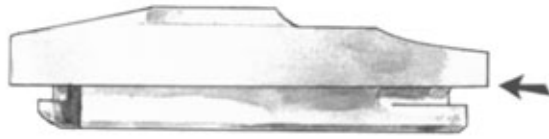
THE PATELLAR COMPONENT

The patellar implant may be cemented at the surgeon's convenience with either of the other components. The cut surface is thoroughly cleansed with pulsatile lavage. Cement is applied to the surface and the component inserted.

The patellar clamp is designed to fully seat and stabilize the implant as the cement polymerizes. It is positioned with the silicon O-ring centered over the articular surface of the implant and the metal backing plate against the anterior cortex, *avoiding skin entrapment*. When snug, the handles are closed and held by the ratchet until polymerization is complete. Excessive compression is avoided as it can fracture osteopenic bone. All extruded cement is removed with a curette.

THE TIBIAL INSERT

The trial insert is removed and the permanent insert introduced into the implanted tibial tray and seated posteriorly, its anterior margin resting on the lip.

The anterior margin is tapped with a nylon mallet, deflecting it past the lip of the tray into position. Seating is confirmed by circumferential inspection.

Alternatively, the permanent insert may be inserted at any convenient time during the cementing procedure.
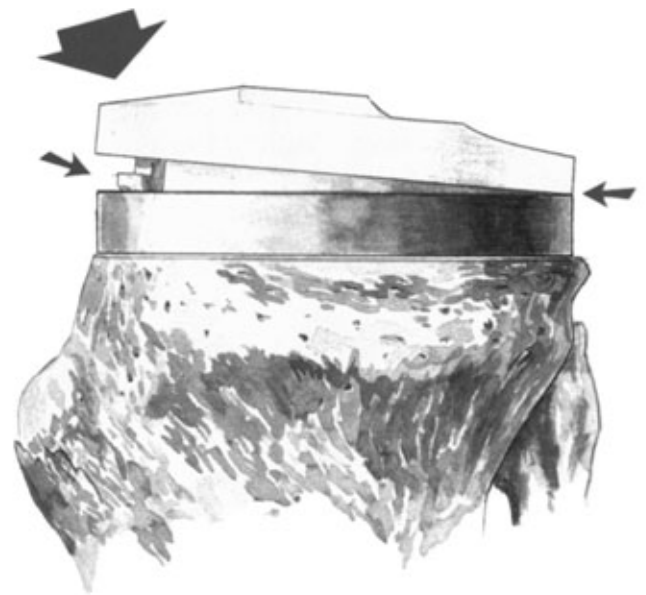
CLOSURE

The tourniquet is released and bleeding controlled by electrocautery. A closed-wound suction drain is placed in the suprapatellar pouch and brought out through the lateral retinaculum. The fat pad, quadriceps mechanism, patella tendon and medial retinaculum are reapproximated with interrupted sutures.

The knee is put through a range of motion from full extension to full flexion to confirm patellar tracking and the integrity of the capsular closing. The final range of motion is noted for postoperative rehabilitation.
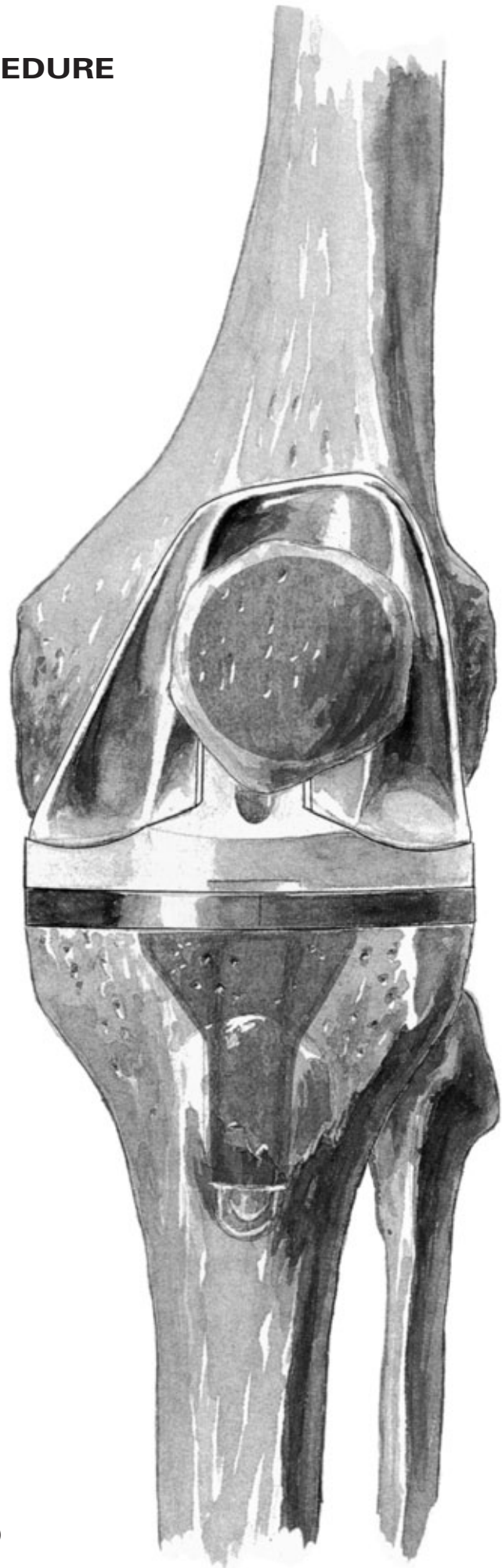
Subcutaneous tissue is reapproximated and the skin closed with sutures or staples.

CRUCIATE-SUBSTITUTING PROCEDURE

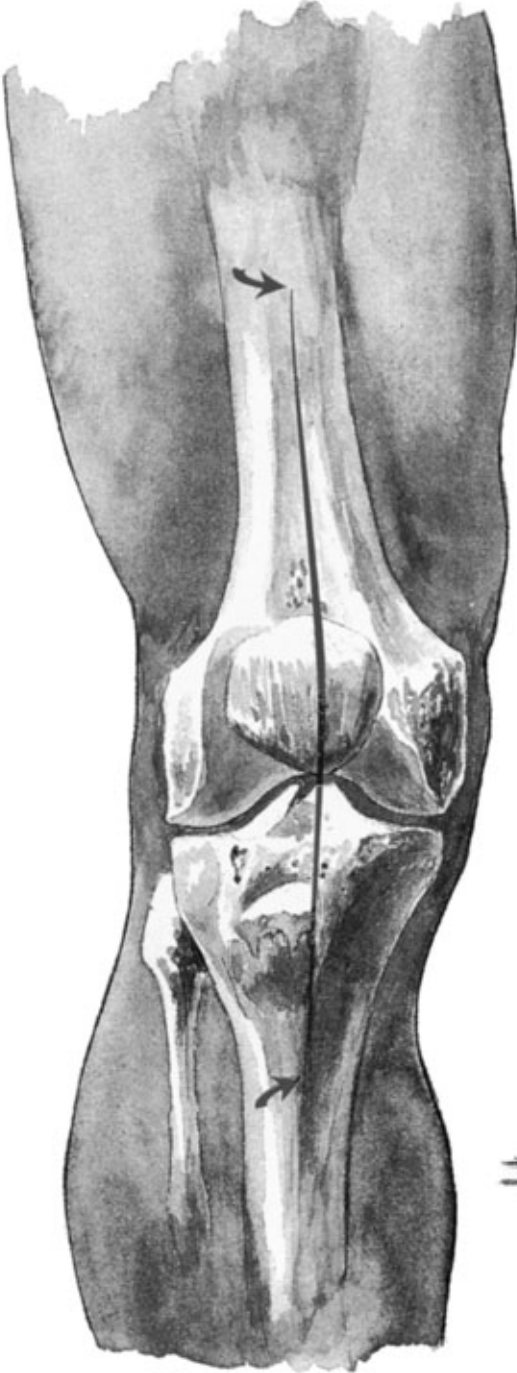**Chitranjan S. Ranawat, MD**

Clinical Professor of Orthopaedic Surgery
Cornell University Medical College

Director, Orthopaedic Surgery
Center for Total Joint Replacement
Lenox Hill Hospital
New York, N.Y.

THE SURGICAL APPROACH

The extremity is appropriately prepared and draped. A tourniquet is applied and, following application of an Esmarch bandage, inflated.

A long, straight incision is initiated 12 cm proximal to the superior margin of the patella and an equivalent distance distal to its inferior margin, reducing, thereby, the degree of skin retraction and lowering the risk of subsequent adipose tissue necrosis.
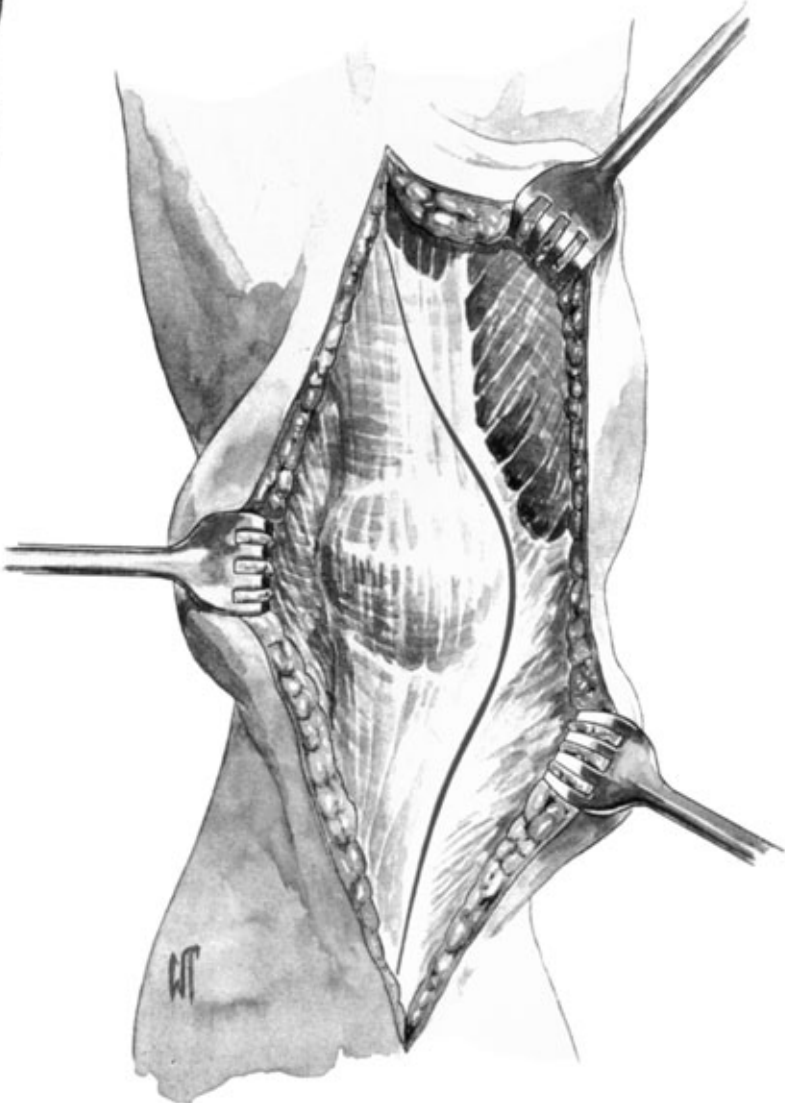

The incision is developed at the deep fascial level to the tendon of the *rectus femoris* and the patellar tendon. Undermining of the bilateral skin flaps is avoided. The tendon of the *rectus femoris* is incised and the incision carried 2-3 mm medial to the medial margin of the patella, the patellar tendon and, subperiosteally, 5 cm distal to the superior margin of the tibial tubercle.

EXPOSURE

The patella is everted laterally and the knee placed in full flexion. The cruciate ligaments and the menesci are excised *(see pages 6 and 7)*. Where indicated, preliminary soft-tissue release is performed. Where the knee is tight and in varus, a curved osteotome is passed along the medial tibial border posterior to the midcoronal plane to release the meniscotibial ligament and promote anterior subluxation of the tibia.
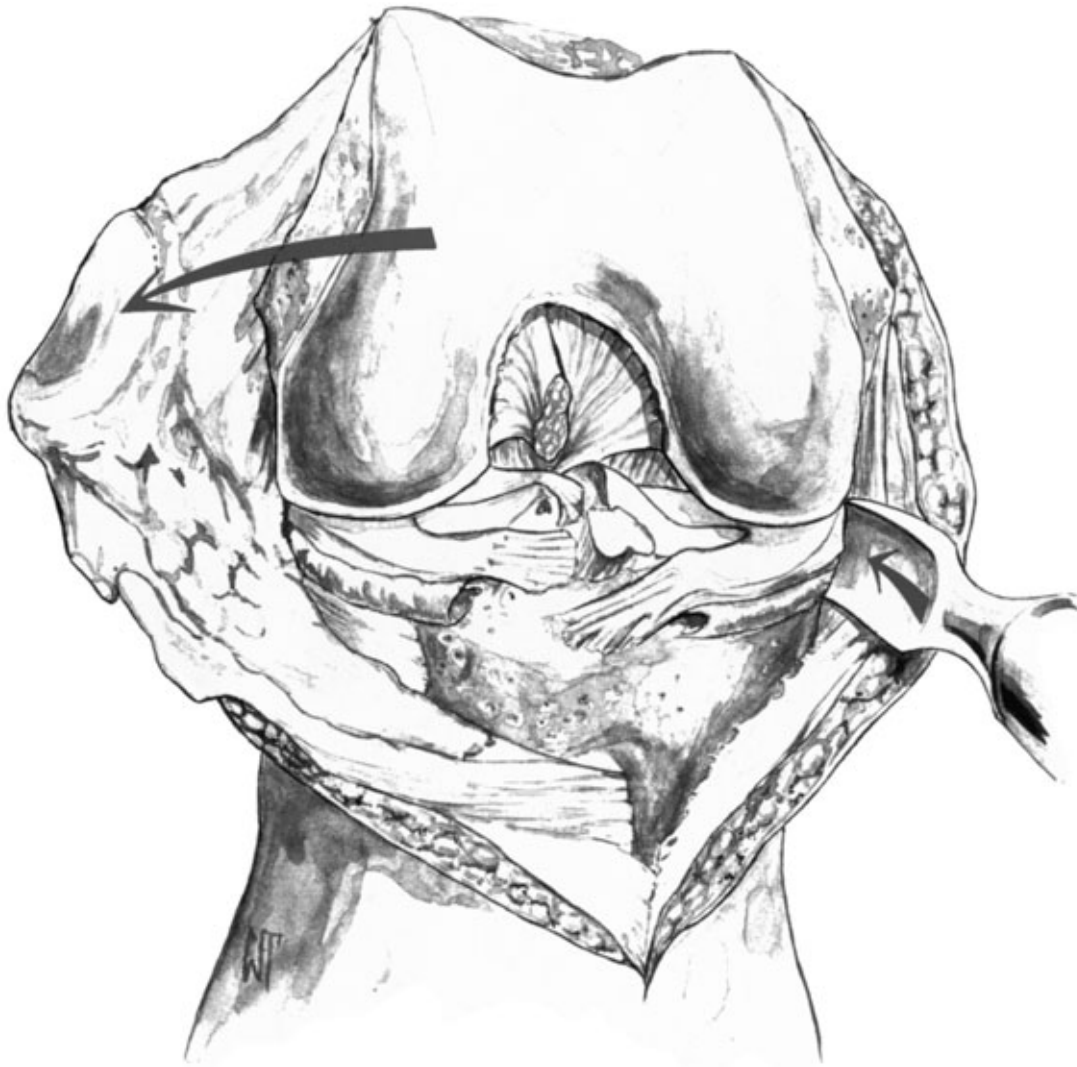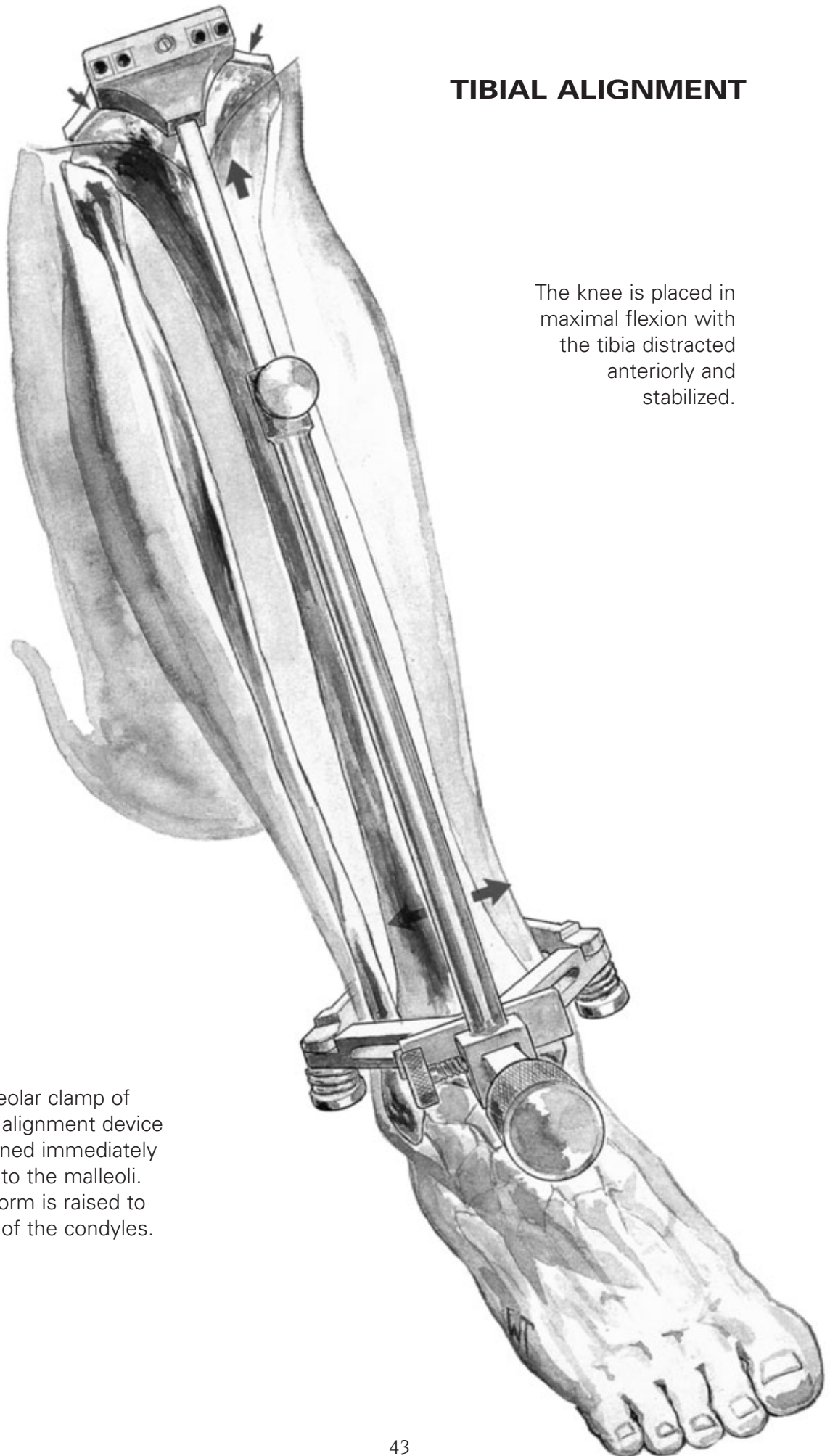

NB For discussion of soft-tissue balancing, see Appendix I.
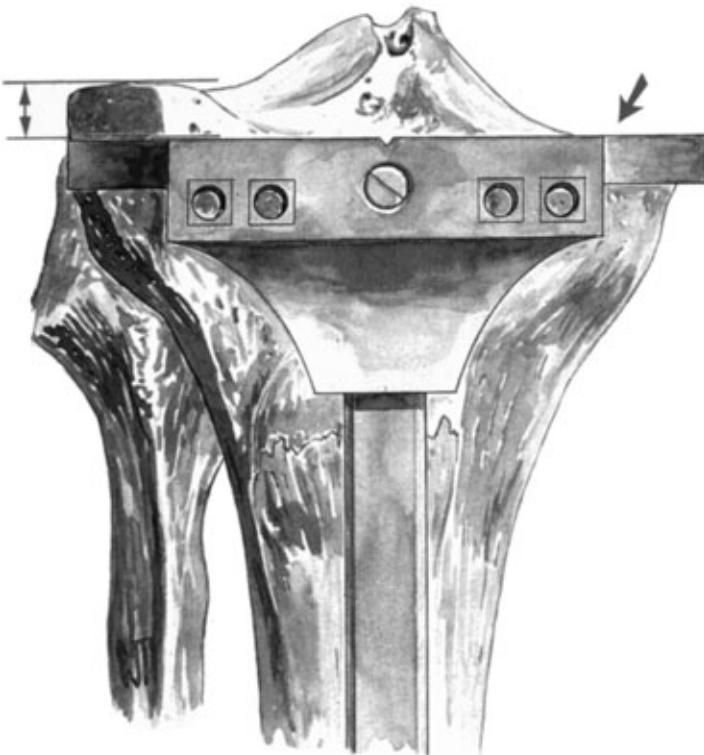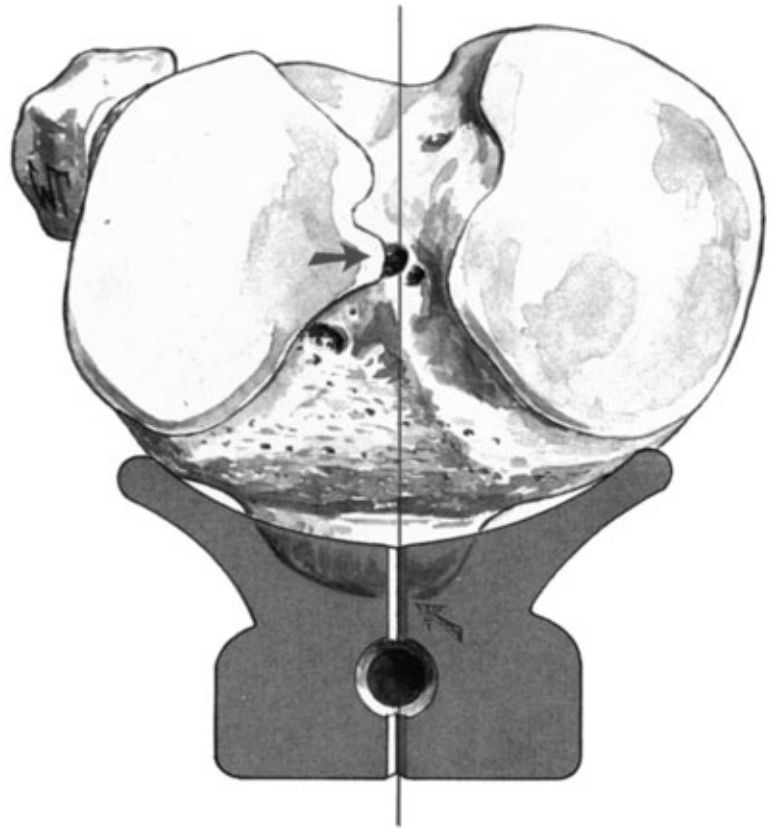
TIBIAL ALIGNMENT

The knee is placed in maximal flexion with the tibia distracted anteriorly and stabilized.

The malleolar clamp of the tibial alignment device is positioned immediately proximal to the malleoli. The platform is raised to the level of the condyles.

THE UPPER PLATFORM

The upper platform is aligned with the medial third of the tibial tubercle and the medial margin of the lateral intercondylar eminence with the arms against the anterior cortex at the approximate level of resection.
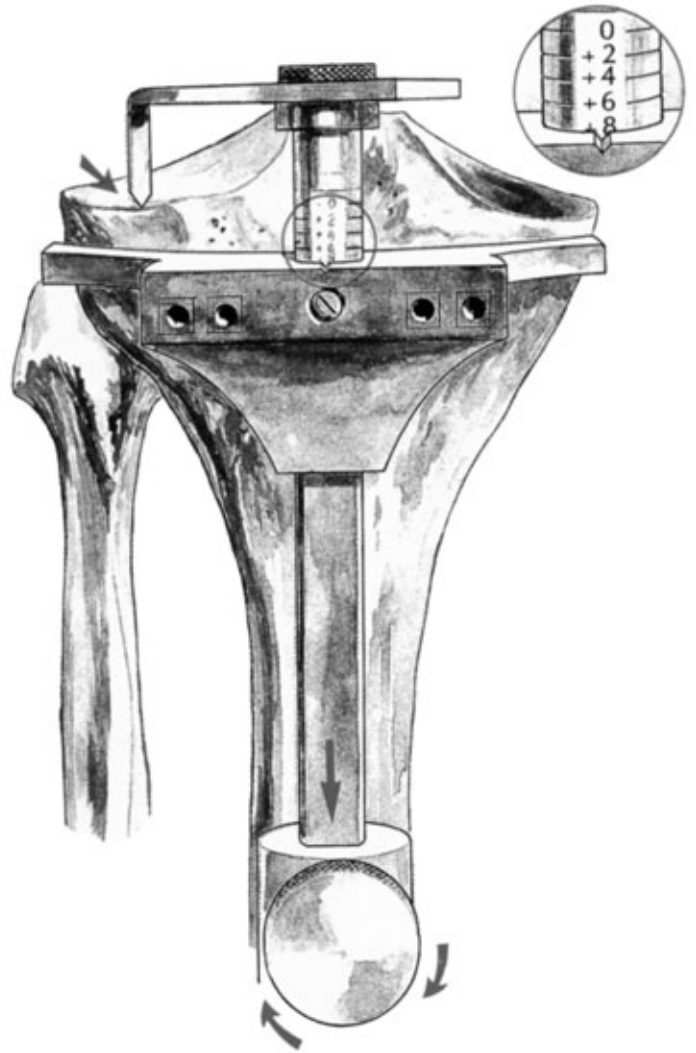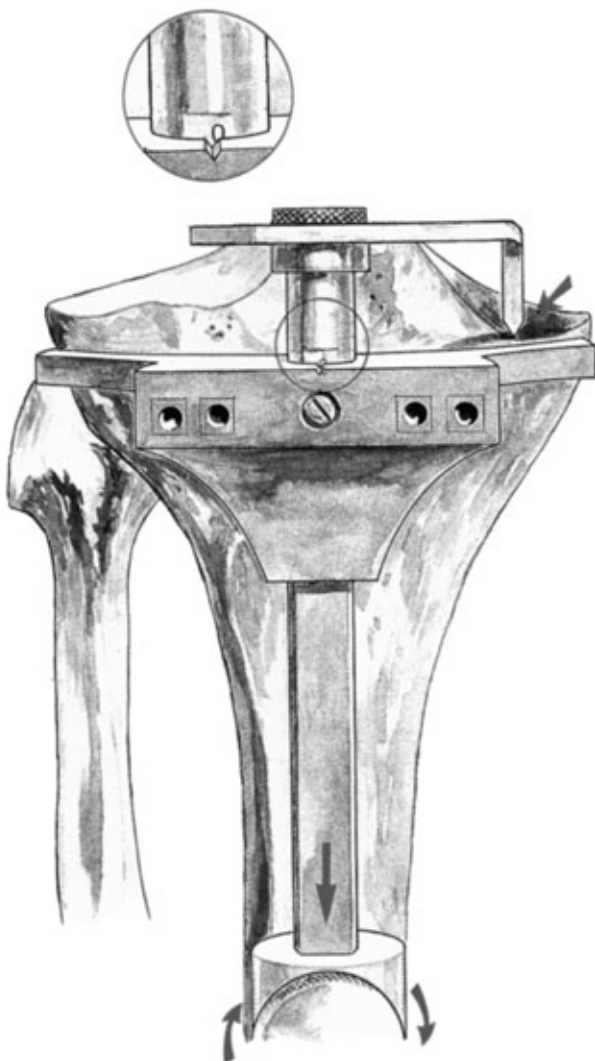

The exact level of resection will vary according to patient anatomy. As the mediolateral transverse plane of the tibial plateau is usually 3 degrees from the perpendicular and the projected cut is perpendicular to the anatomic axis, more bone is typically removed from the lateral condyle.

THE TIBIAL STYLUS

The stylus determines the exact level of resection.

The cylinder of the stylus assembly is seated in its receptacle on the platform and adjusted to the appropriate level. It is calibrated at 2 mm levels, indicating the amount of bone and residual cartilage to be resected.

A level of +8 or +10 is suggested where resection is based on the less involved condyle. The platform is adjusted such that the stylus rests on the center of the condyle.

The level of 0 is selected where resection is based on the more involved condyle and does not result in excessive contralateral resection. The platform is secured by the large anterior setscrew.
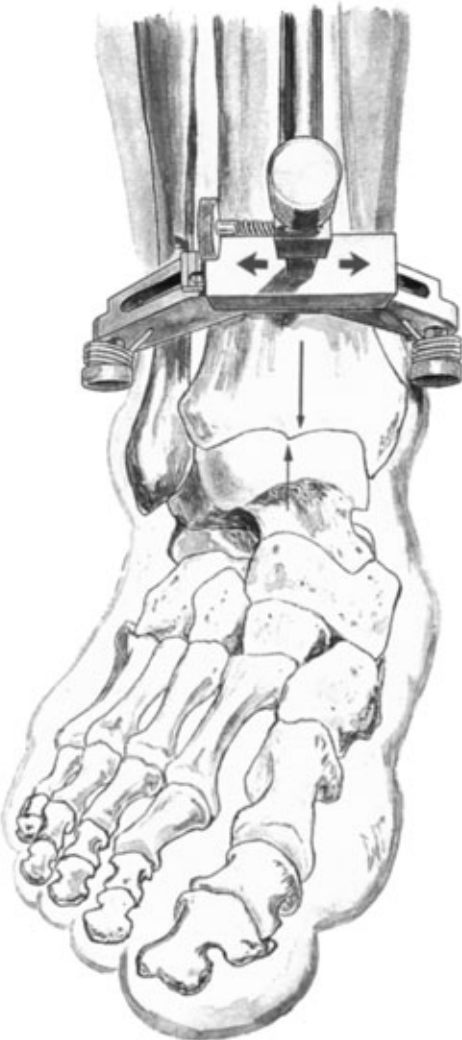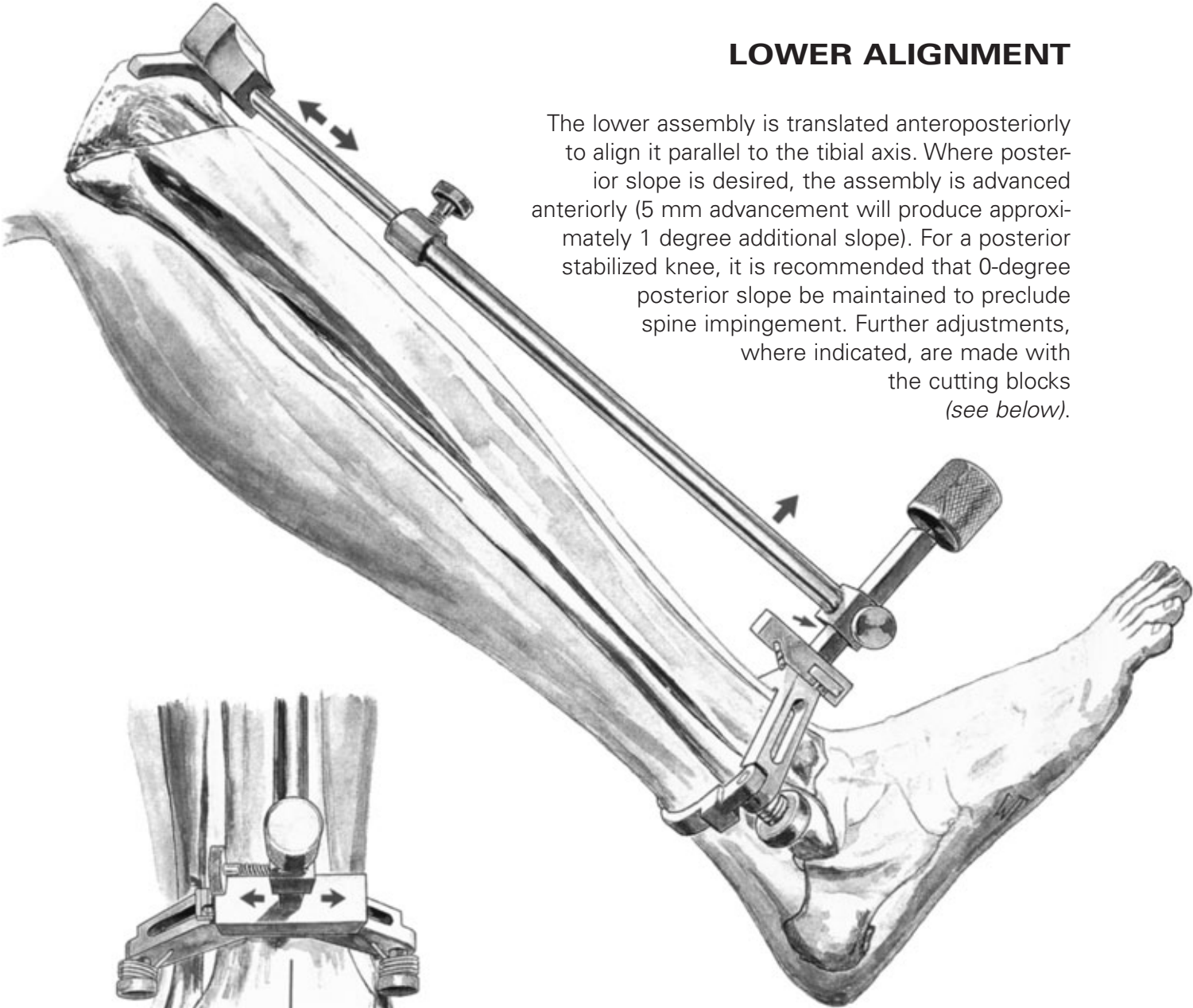
NB Where this indicates greater than 10 mm of resection from the contralateral condyle, a higher level is indicated. The deficiency is augmented with cement, bone graft or a modular wedge, as the situation dictates.

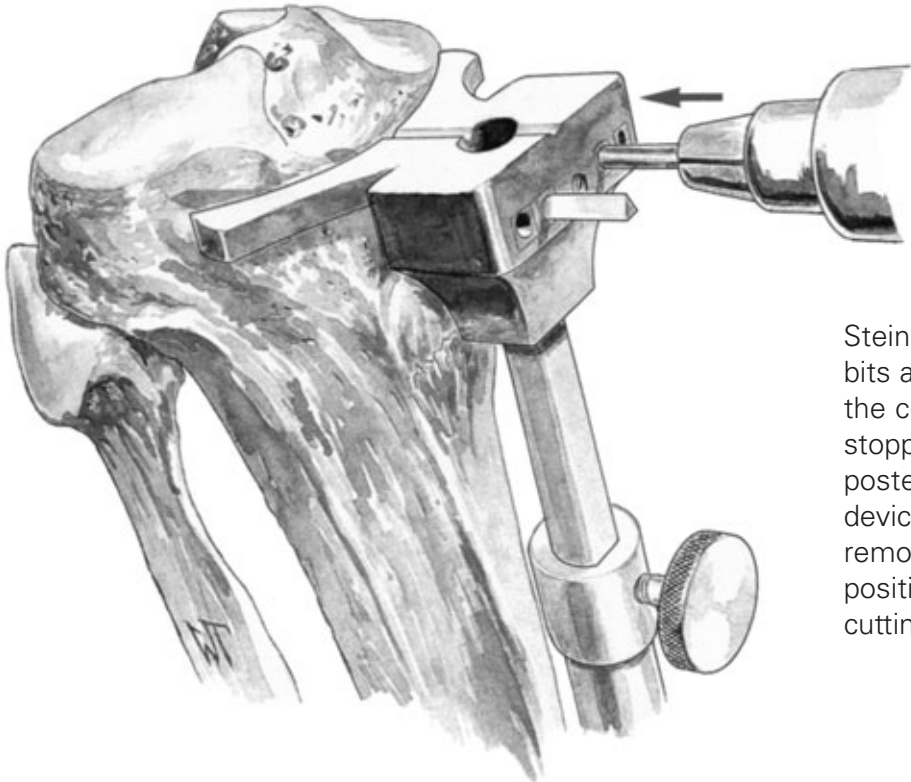*See Appendix III for Modular Plus Wedge augmentation.*

LOWER ALIGNMENT

The lower assembly is translated anteroposteriorly to align it parallel to the tibial axis. Where posterior slope is desired, the assembly is advanced anteriorly (5 mm advancement will produce approximately 1 degree additional slope). For a posterior stabilized knee, it is recommended that 0-degree posterior slope be maintained to preclude spine impingement. Further adjustments, where indicated, are made with the cutting blocks *(see below)*.

Mediolateral alignment is approximately parallel to the tibial axis, but as the lateral malleolus is the more prominent, bisecting the transmalleolar axis will prejudice the cut into varus. The midline of the tibia is approximately 3 mm medial to the transaxial midline. The lower assembly is translated medially to the interval of the *extensor hallucis longus* and the *extensor digitorum longus* or the palpable anterior crest of the tibia. There are scribe marks at 3 and 6 mm for reference. Where the proximal platform is medially displaced, additional medial adjustment is made at the lower assembly to compensate.
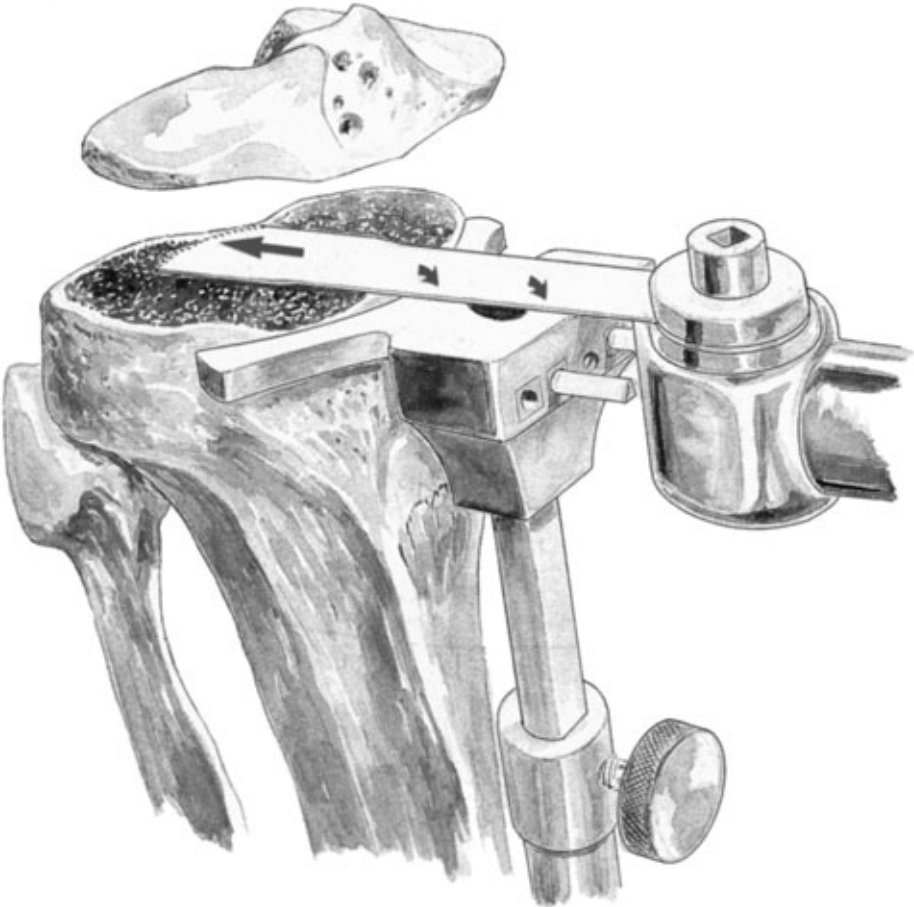
SECURING THE PLATFORM

Steinmann pins or ⅛-inch drill bits are introduced through the central holes into the tibia, stopping well short of the posterior cortex. The entire device is subsequently removed, leaving the pins positioned to accept the cutting block.
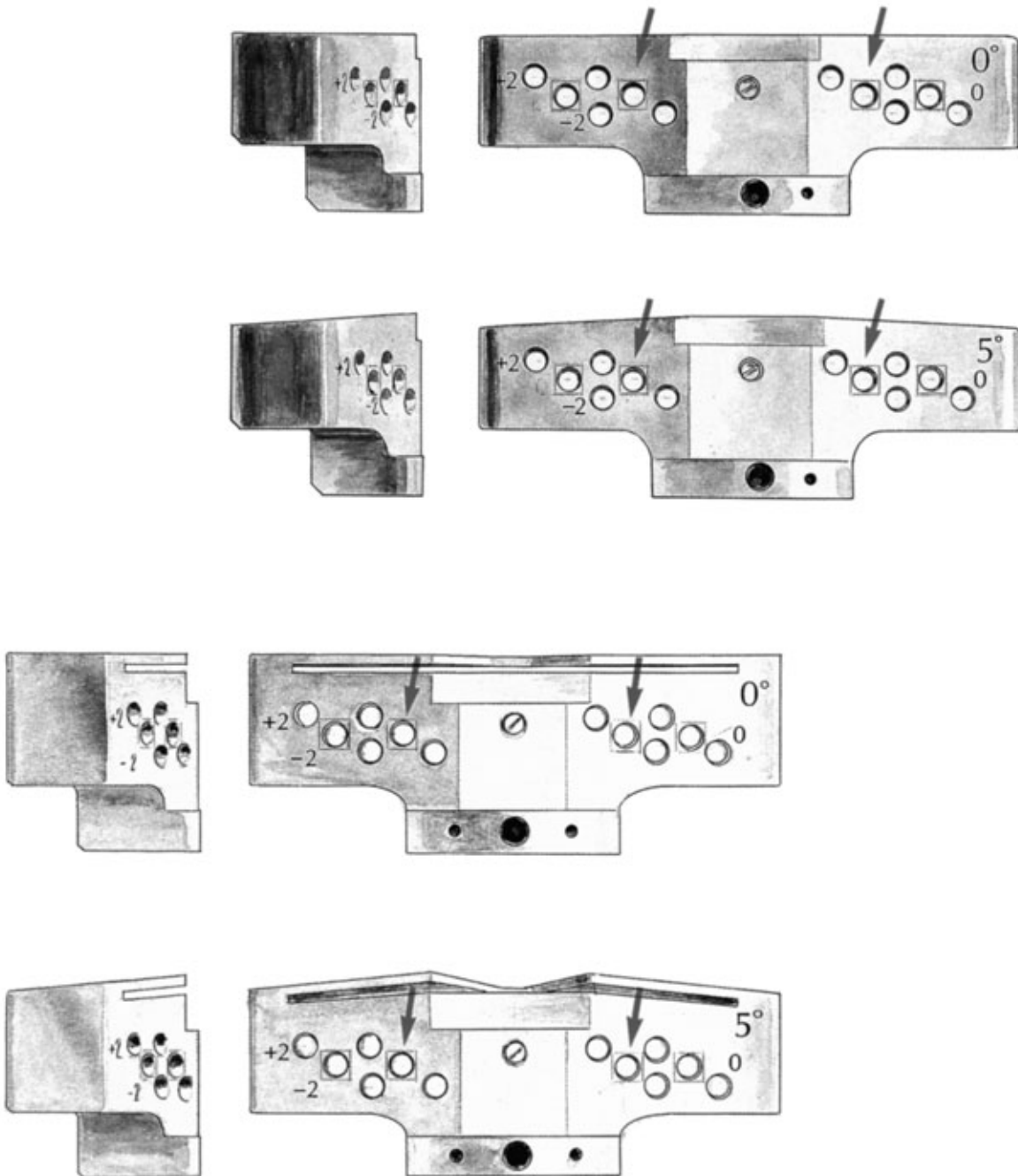
Alternatively, the platform itself may serve as the cutting guide.

The oscillating saw is employed conservatively, with posterior cortical resection performed with an osteotome.
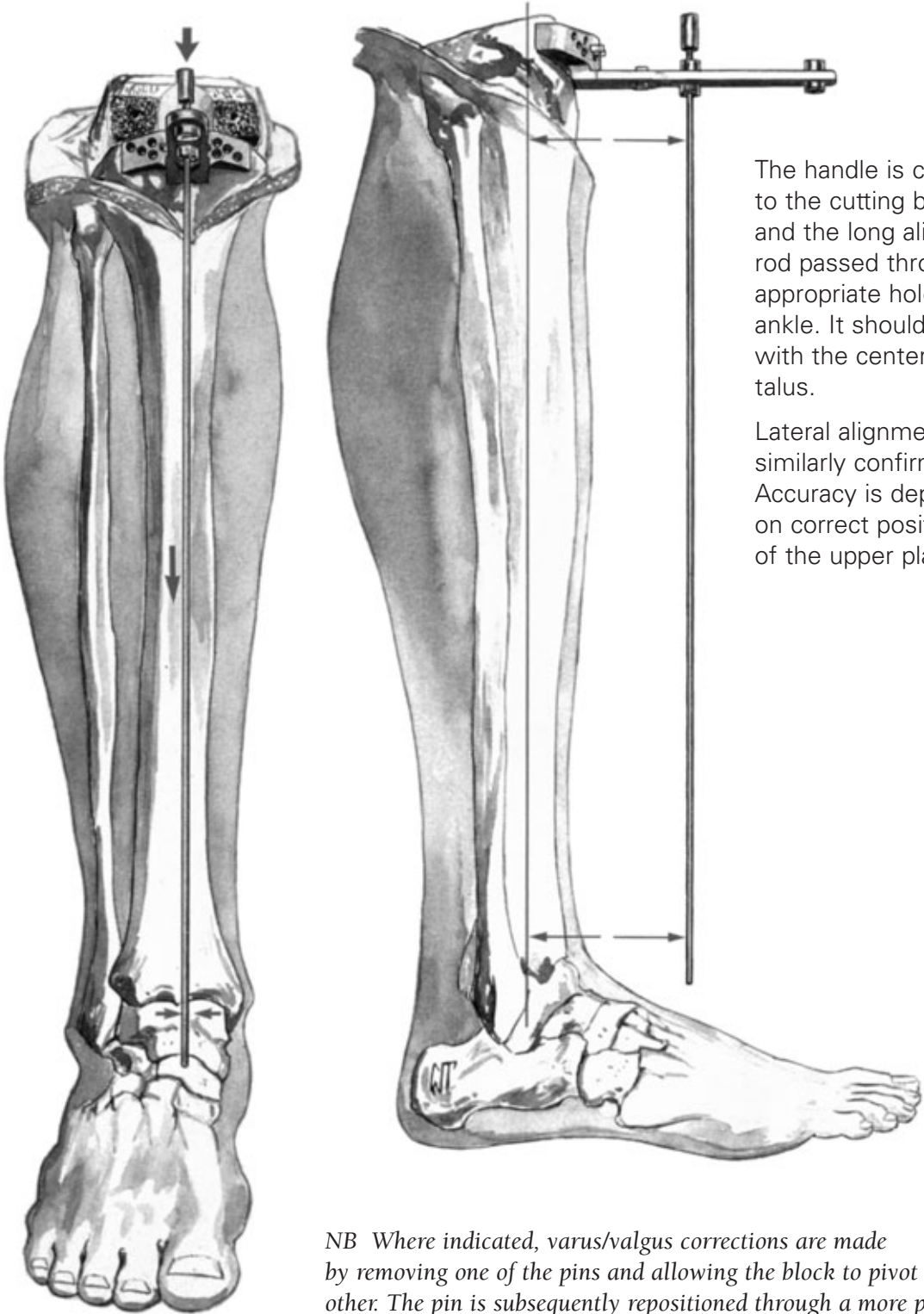
THE TITIAL CUTTING BLOCK

Cutting blocks are provided in surface or slotted versions and in 0 degrees and 5 degrees of posterior slope. One of the 0-degree blocks is selected initially. The holes are designated -2, 0 and +2, indicating in mm a greater or lesser amount of resected bone. The block is positioned onto the Steinmann pins using the 0 holes (the holes enclosed in □'s). The 5-degree block will give 5 degrees of additional posterior slope to that already established by the tibial alignment guide.
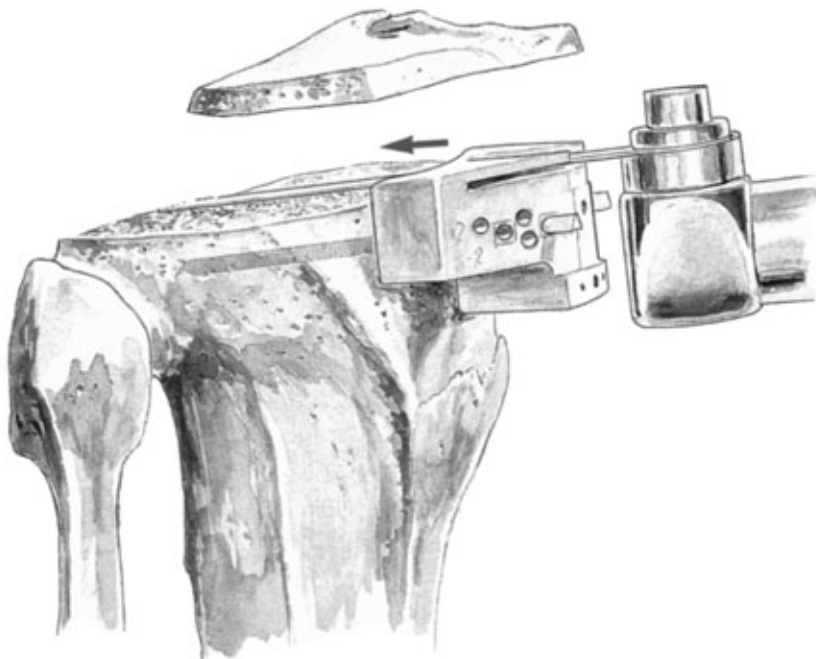
THE TIBIAL ALIGNMENT HANDLE

The handle is coupled to the cutting block and the long alignment rod passed through the appropriate hole to the ankle. It should align with the center of the talus.

Lateral alignment is similarly confirmed. Accuracy is dependent on correct positioning of the upper platform.

NB Where indicated, varus/valgus corrections are made by removing one of the pins and allowing the block to pivot on the other. The pin is subsequently repositioned through a more peripheral hole.
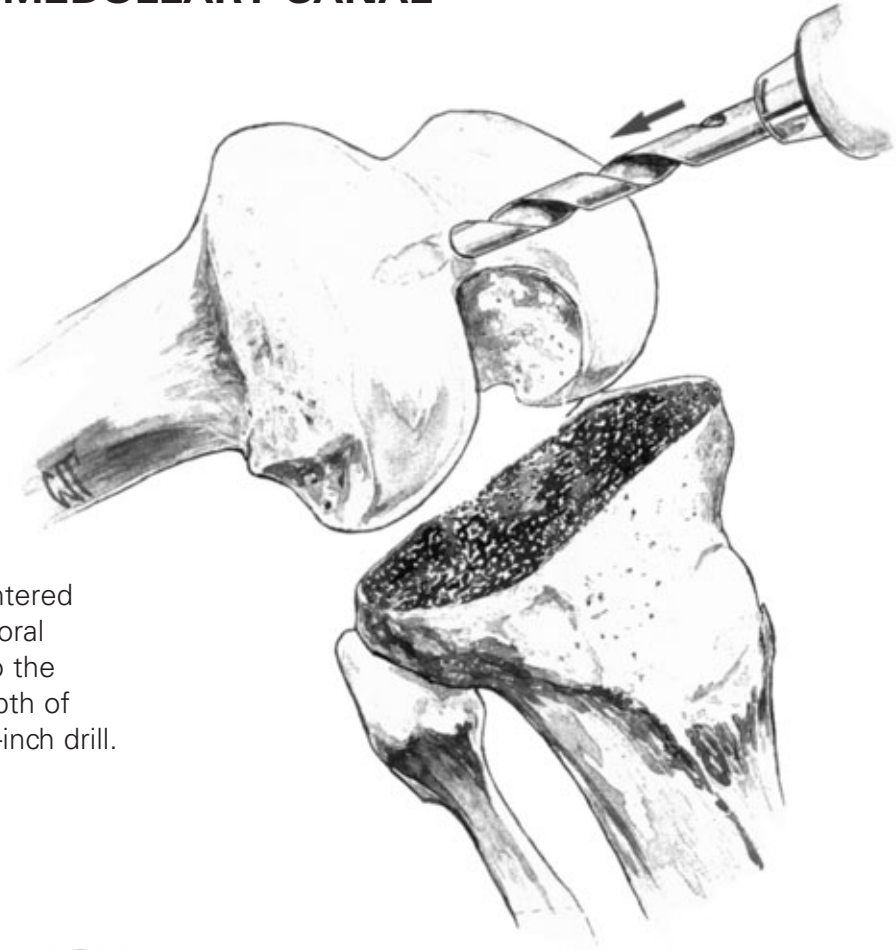
TIBIAL RESECTION

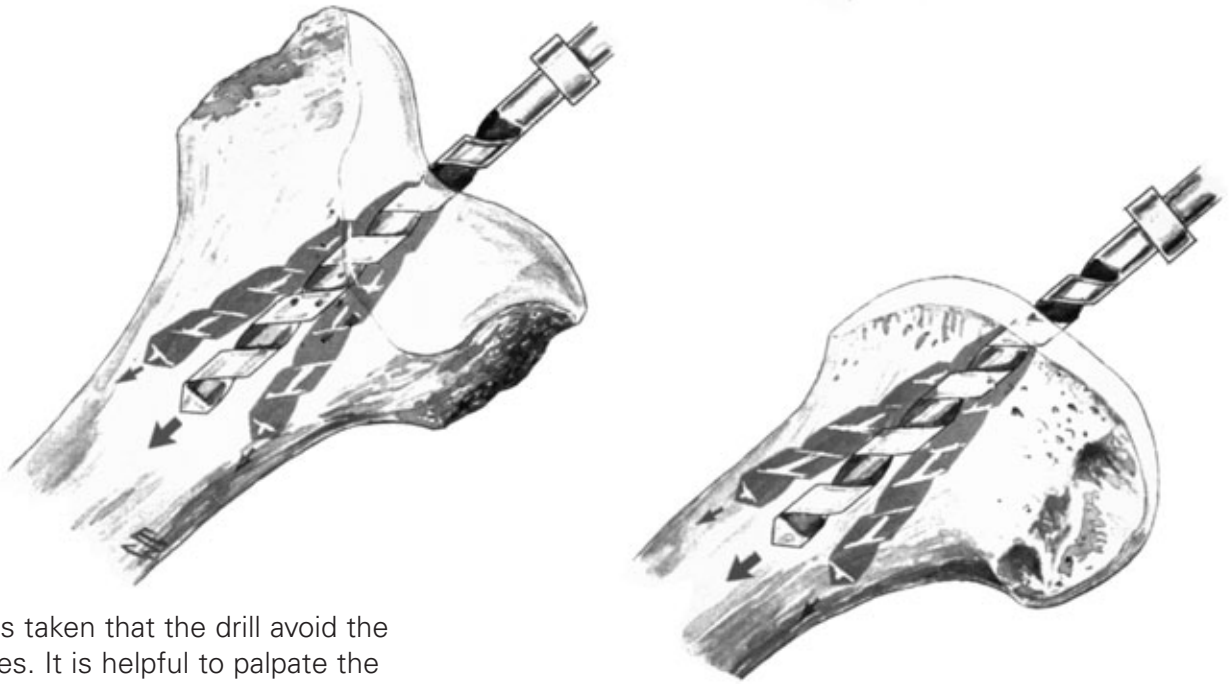Resection is performed with the blade held flush against the cutting surface of the block.
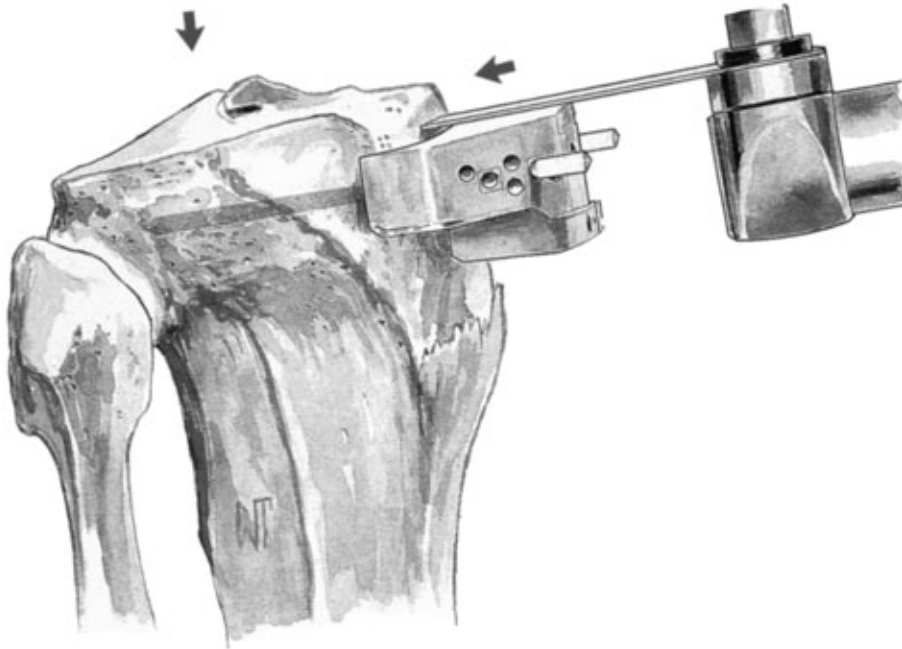
Alternatively, the slotted tibial cutting block may be selected and similarly employed. A 1.19 mm saw blade is recommended.

ENTERING THE MEDULLARY CANAL

The medullary canal is entered at the midline of the femoral trochlea 3 mm anterior to the origin of the PCL to a depth of about 5-7 cm using a $^5/_{16}$-inch drill.
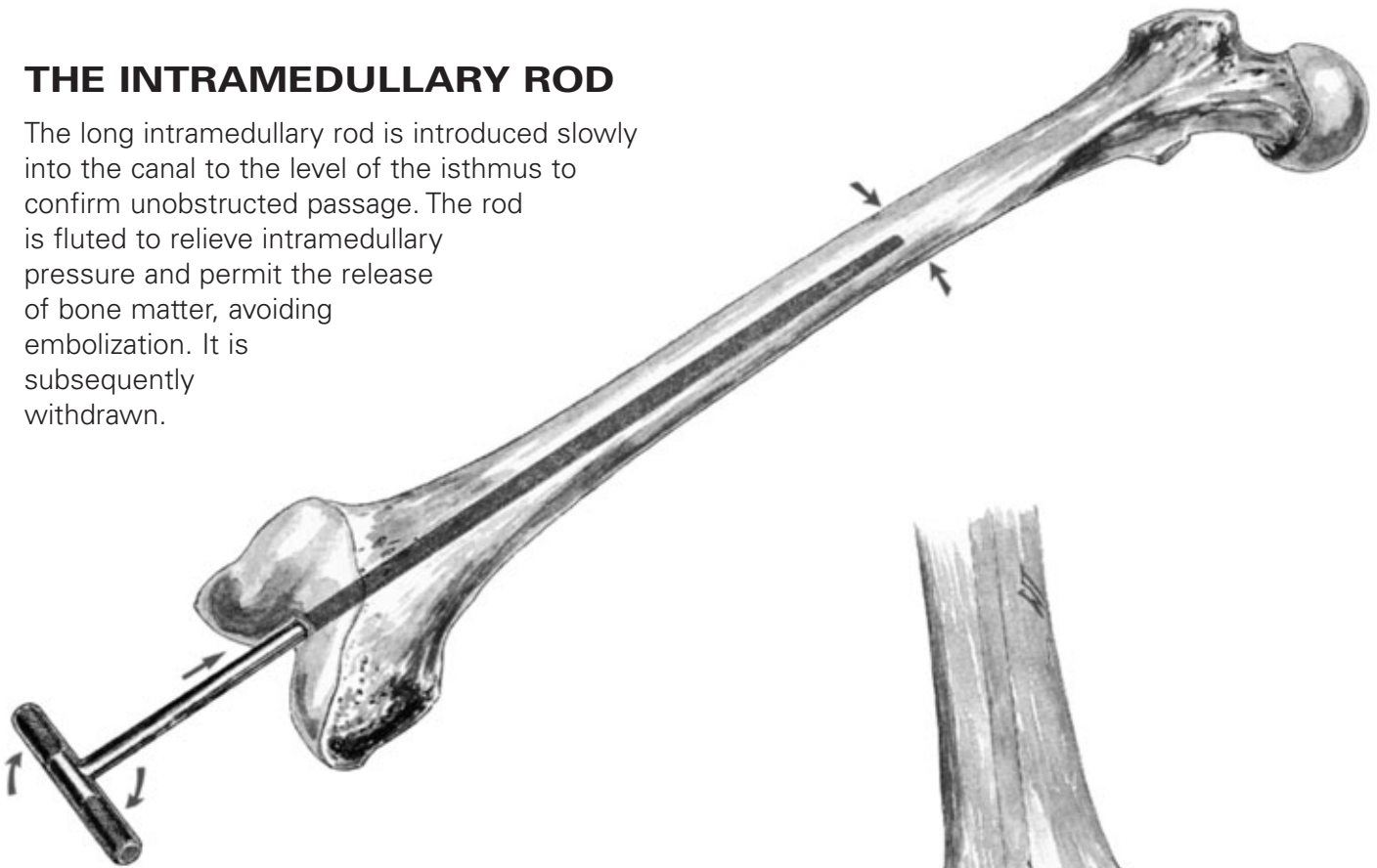

Care is taken that the drill avoid the cortices. It is helpful to palpate the distal femoral shaft as the drill is advanced.
The drill hole may be biased anteromedially to facilitate unobstructed passage of the long intramedullary rod to the diaphyseal isthmus. Where indicated, the canal is irrigated.
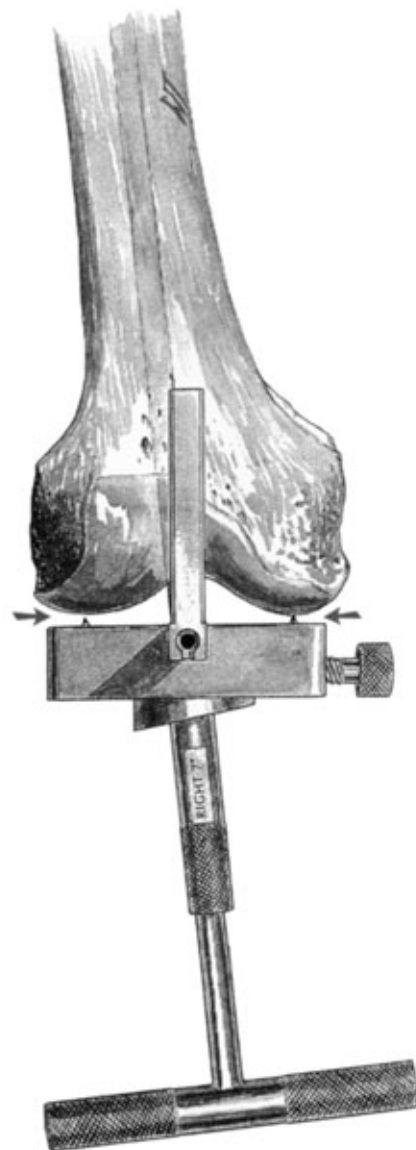
THE INTRAMEDULLARY ROD

The long intramedullary rod is introduced slowly into the canal to the level of the isthmus to confirm unobstructed passage. The rod is fluted to relieve intramedullary pressure and permit the release of bone matter, avoiding embolization. It is subsequently withdrawn.

THE FEMORAL LOCATING DEVICE

The appropriate bushing, as indicated on the preoperative films, is assembled to the locating device with the appropriate RIGHT/LEFT designation to the anterior.
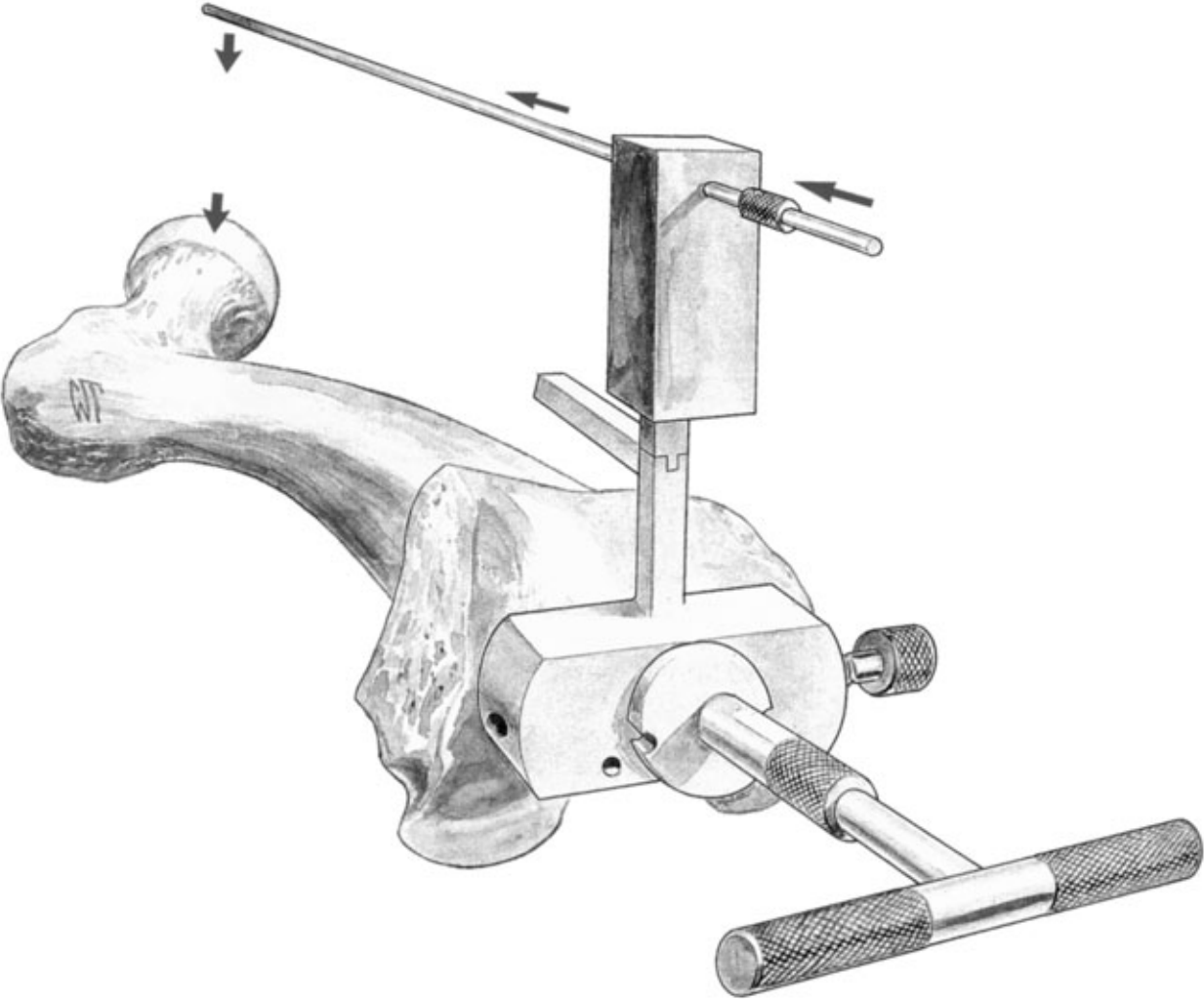
The device is assembled, in turn, over the intramedullary rod and secured with the lateral set screw such that rotation is controlled by the T-handle. The rod is repositioned in the medullary canal.

Bushings are provided in 5 degrees, 7 degrees and 9 degrees, to correspond to the angle predetermined in reference to the resection line drawn on the preoperative roentgenogram.
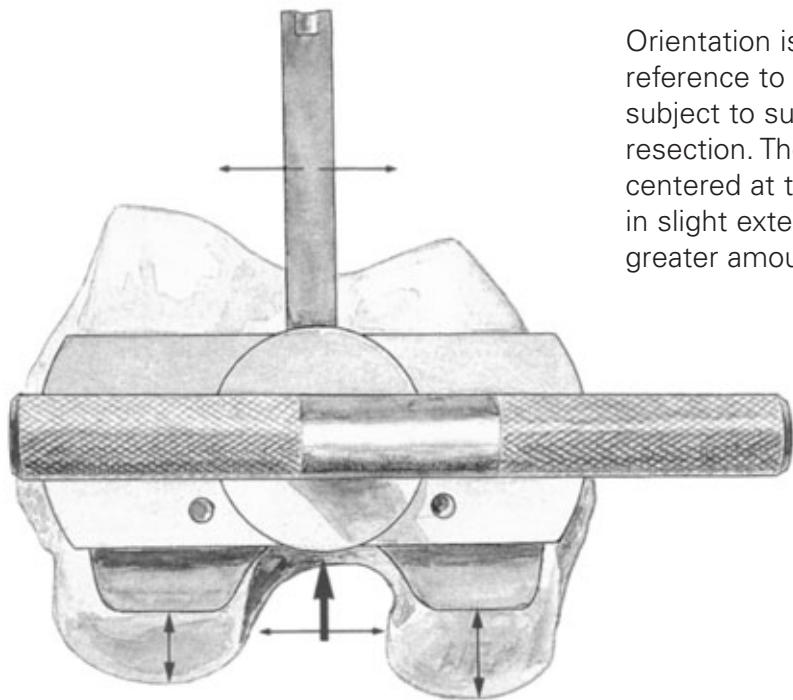
THE EXTERNAL ALIGNMENT SYSTEM

The alignment tower is
assembled onto the femoral
locating device. The alignment
rod is passed through the hole
and advanced to the hip.
Where the rod fails to align
with the coxal reference
point, a different bushing
is selected.

*NB Where indicated, as in femoral deformity, a 0-degree bushing and a short intramedullary
rod are substituted. See Appendix IV.*
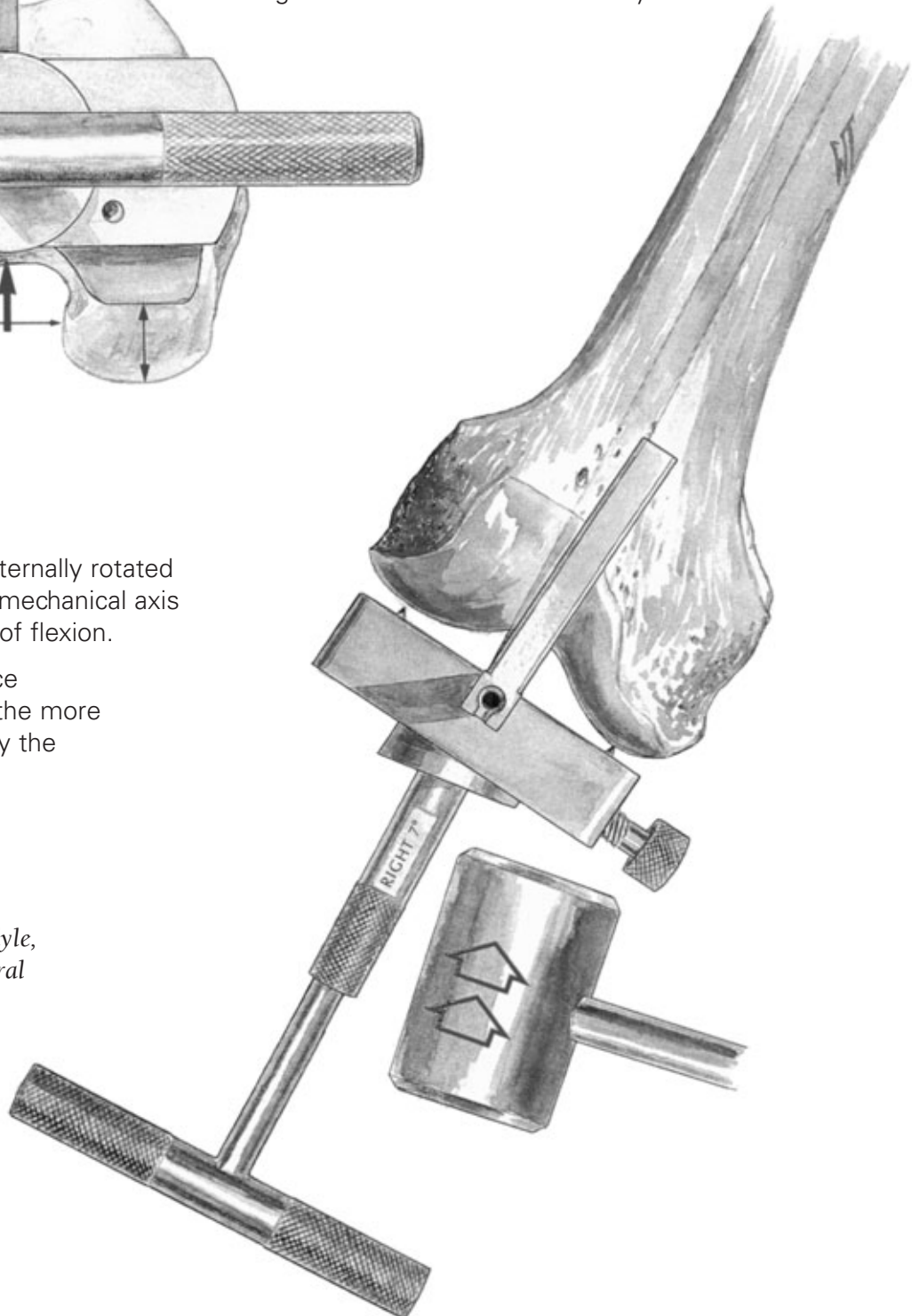
ROTATIONAL CORRECTION

Orientation is initially determined with reference to the posterior femoral condyles, subject to subsequent correction at the A/P resection. The calibrated outrigger is centered at the femoral trochlea, placing it in slight external rotation and exposing a greater amount of medial condyle.

Alternatively, it may be externally rotated until perpendicular to the mechanical axis of the tibia in 90 degrees of flexion.
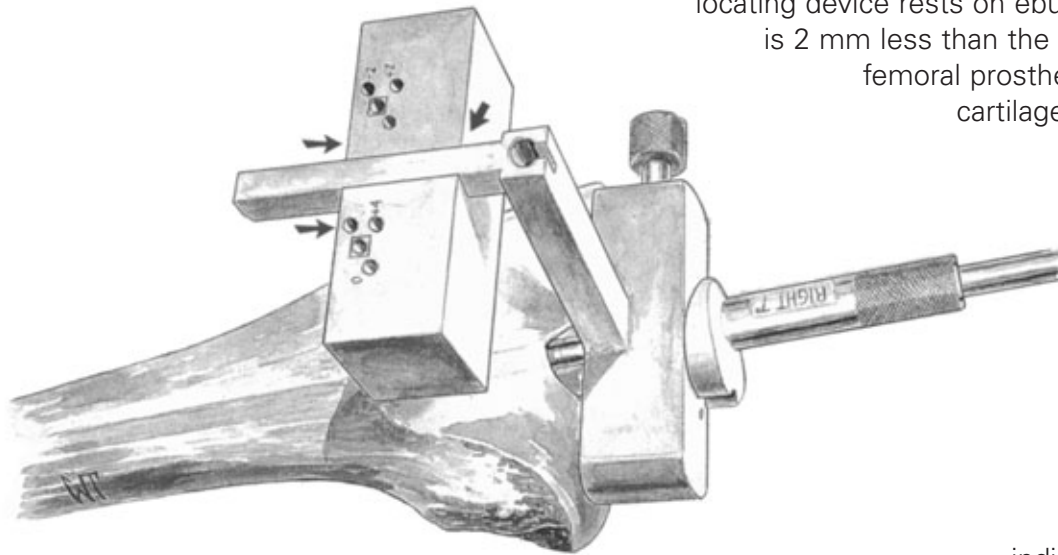
The femoral locating device is tapped into position at the more prominent condyle (usually the medial).

NB It is essential that firm contact be established at the subchondral level of the condyle, clear of any residual peripheral osteophytes.
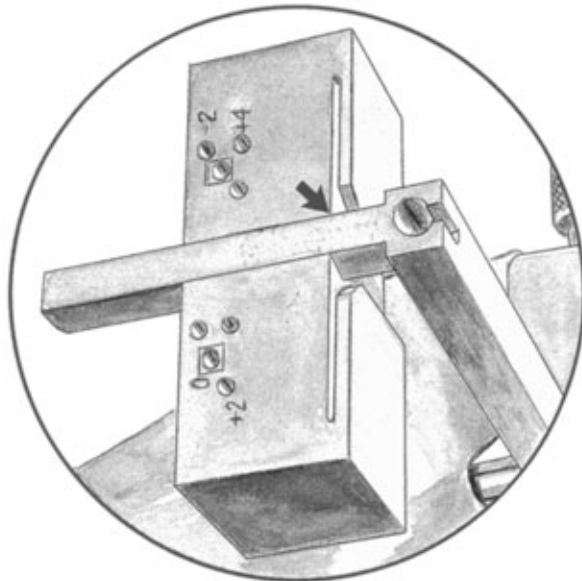
THE DISTAL FEMORAL CUTTING BLOCK

The cutting block is assembled onto the calibrated outrigger such that resection of the more prominent condyle, inclusive of residual cartilage, will correspond to the distal dimension of the femoral prosthesis. Where the femoral locating device rests on eburnated bone, resection is 2 mm less than the distal dimension of the femoral prosthesis to allow for absent cartilage and to avoid elevation of the joint line.

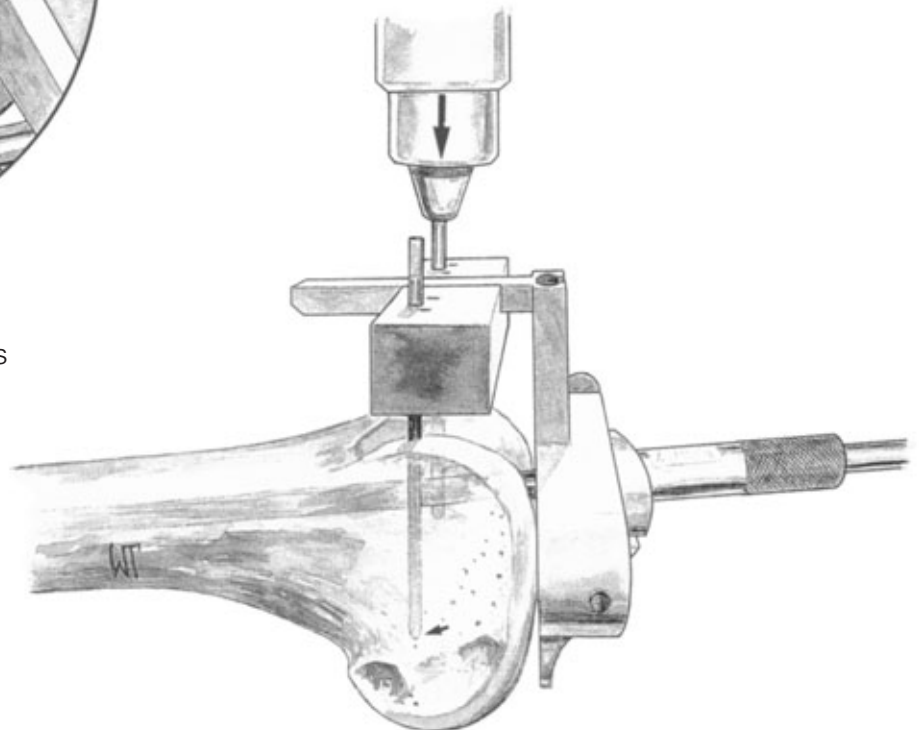Greater or lesser resection may be indicated to accommodate flexion contracture and hyperextension, respectively.

Alternatively, the cutting block is available in a slotted version. A 1.19 mm saw blade is recommended.

Either 1/8-inch drill bits or Steinmann pins are introduced through the holes designated zero and enclosed in □'s. They are advanced into the anterior cortex.

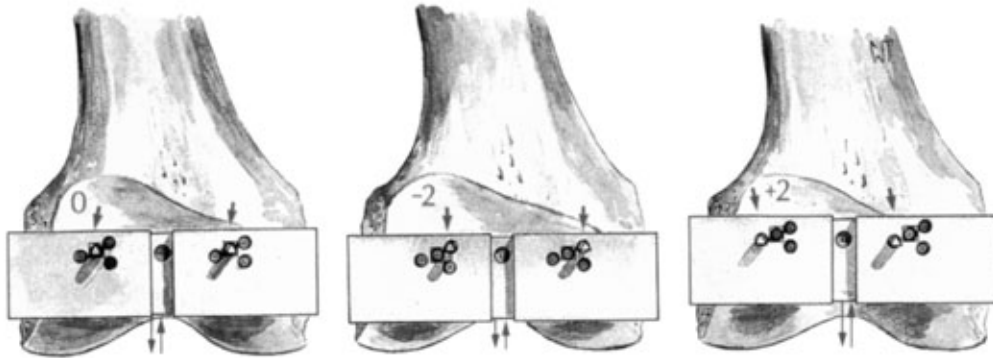It is easier to drill the lateral first.

55

THE DISTAL FEMORAL CUT

The locating device and intramedullary rod are disengaged from the cutting block, allowing the block to drop, on the pins, to the anterior cortex.

The holes on the block are designated –2, 0, +2 and +4, indicating in mm the amount of bone resection each will yield supplemental to that indicated on the calibrated outrigger.

The oscillating saw blade is positioned flush to the cutting surface of the block or, where applicable, through the slots. The condyles are resected and the surface checked for accuracy.

EVALUATING THE EXTENSION GAP

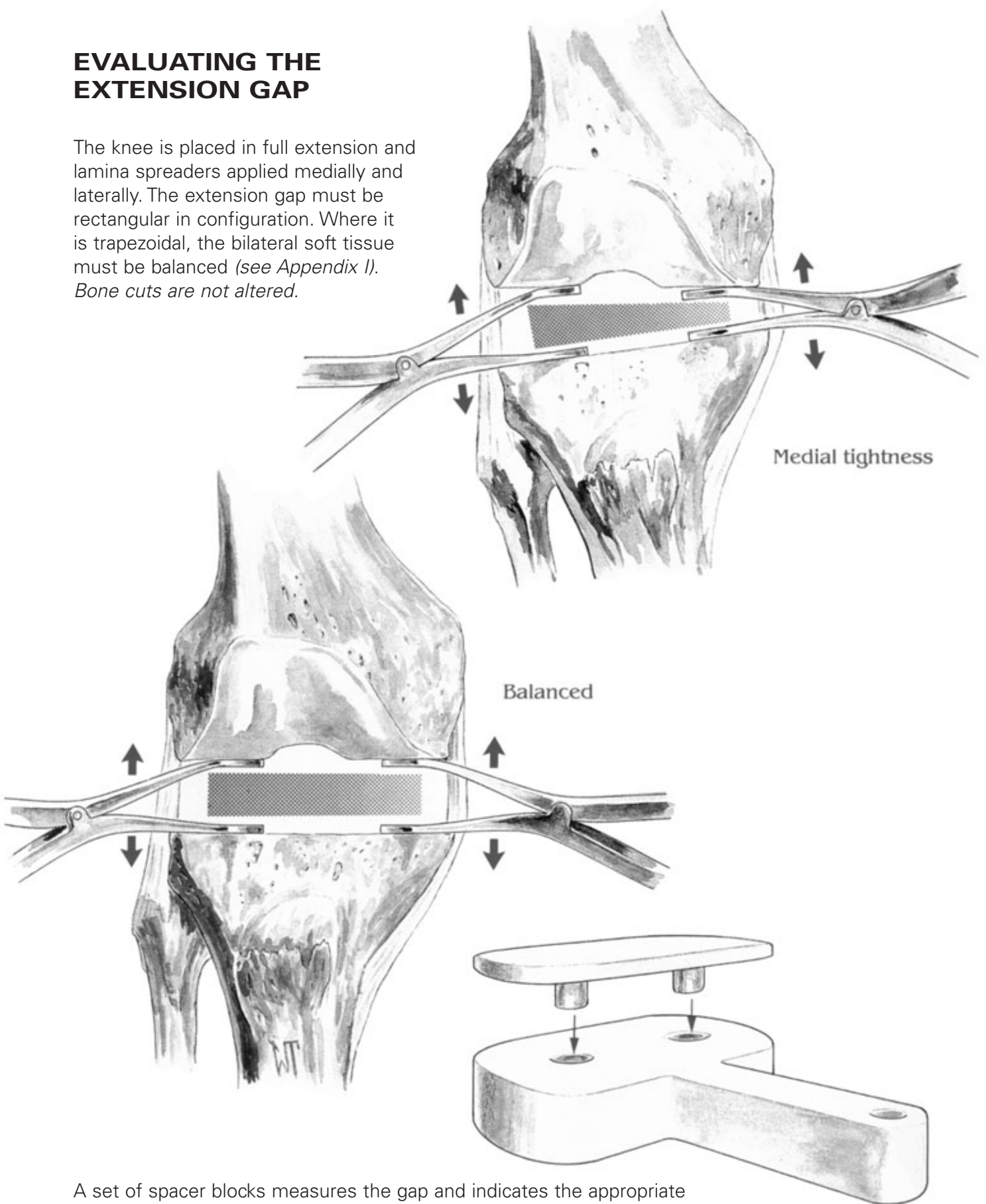The knee is placed in full extension and lamina spreaders applied medially and laterally. The extension gap must be rectangular in configuration. Where it is trapezoidal, the bilateral soft tissue must be balanced *(see Appendix I)*. *Bone cuts are not altered.*

Medial tightness

Balanced

A set of spacer blocks measures the gap and indicates the appropriate thickness of the tibial insert, subject to re-evaluation at trial reduction.

NB When measuring the extension gap, utilize the 1 mm shim.

SIZING THE FEMORAL COMPONENT
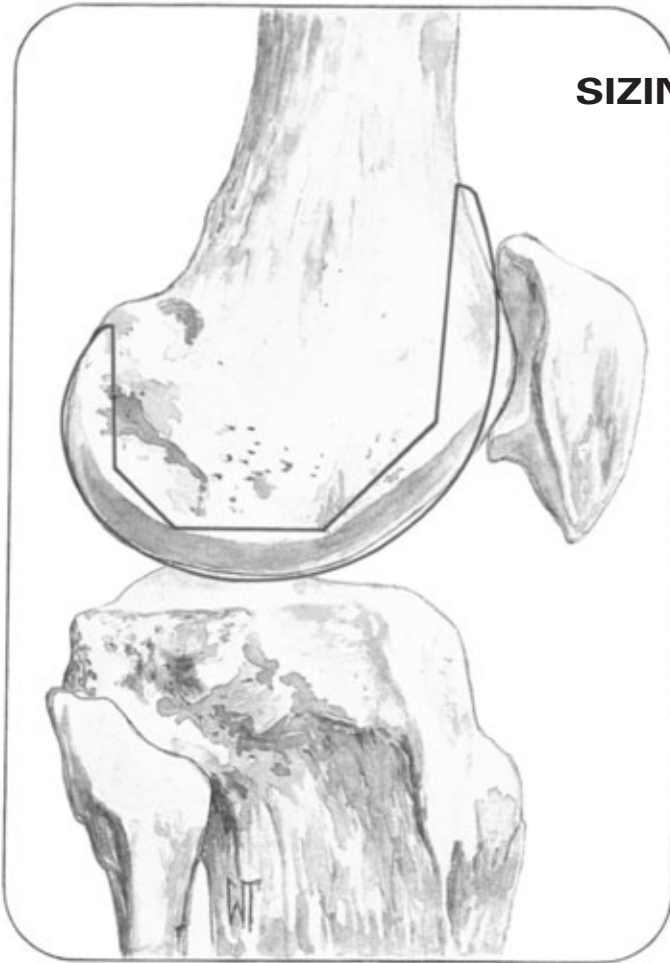
Careful preoperative planning, including the application of templates to lateral radiographs, is critical to the sizing of the femoral component. Priority is given to re-establishment of the A/P dimension, as this will restore normal kinematics and quadriceps function. Undersizing will create looseness in flexion and possible notching of the anterior femoral cortex. Oversizing will create tightness in flexion and increased tension in the quadriceps mechanism.

ASSEMBLING THE FEMORAL A/P CUTTING BLOCK

The appropriate rod is selected and assembled to the femoral A/P cutting block, the appropriate RIGHT/LEFT designation to the anterior. The pins are retracted.
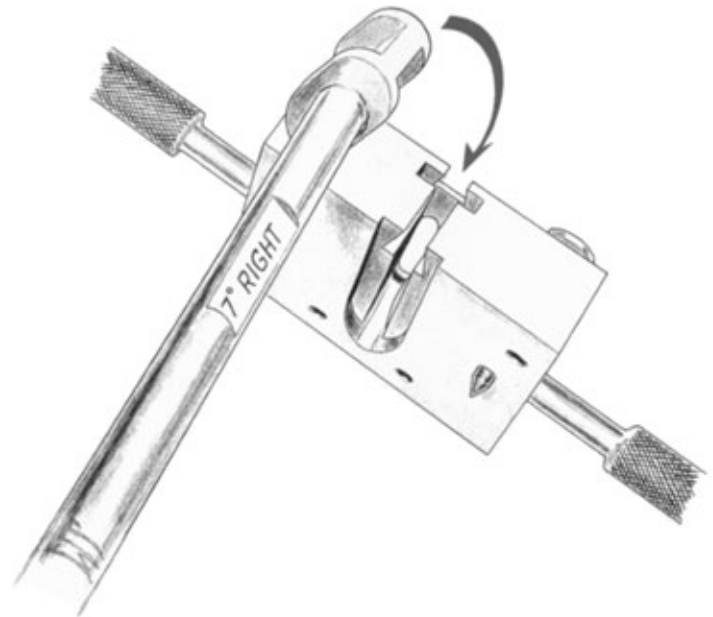
NB Alternatively, the femoral sizing guide is used to position and size the component (see pages 9 and 10). With positioning established, any appropriate A/P cutting block may be used.

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POSITIONING THE CUTTING BLOCK

The rod is introduced into the prepared intramedullary hole until the cutting block is seated flush to the cut distal surface.

The cylinder of the stylus assembly is fully seated in its receptacle on the anterior surface of the block such that it reads 0.
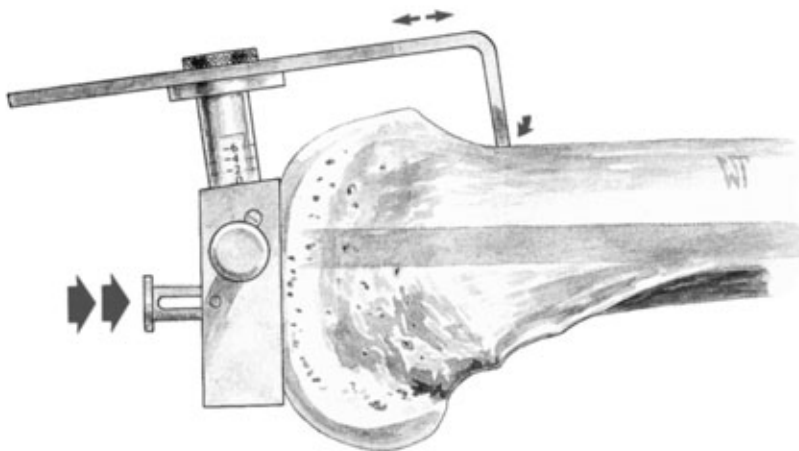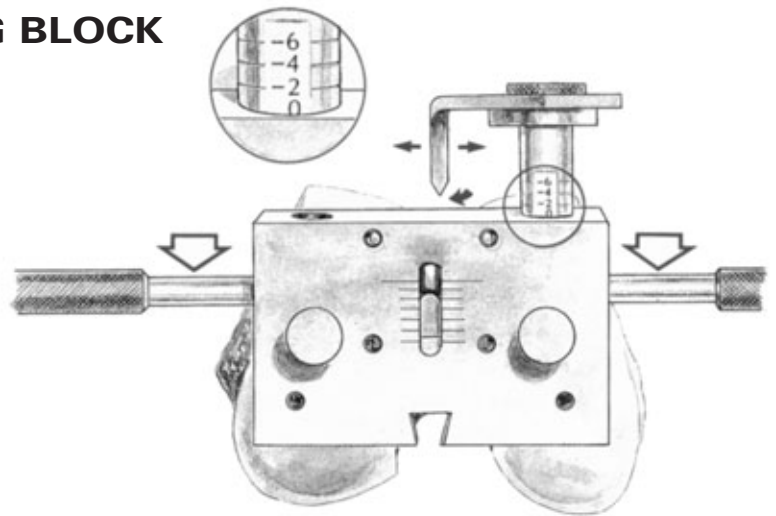
The cutting block is adjusted posteriorly until the stylus is in contact with the anterior femoral cortex.

ROTATIONAL ADJUSTMENT
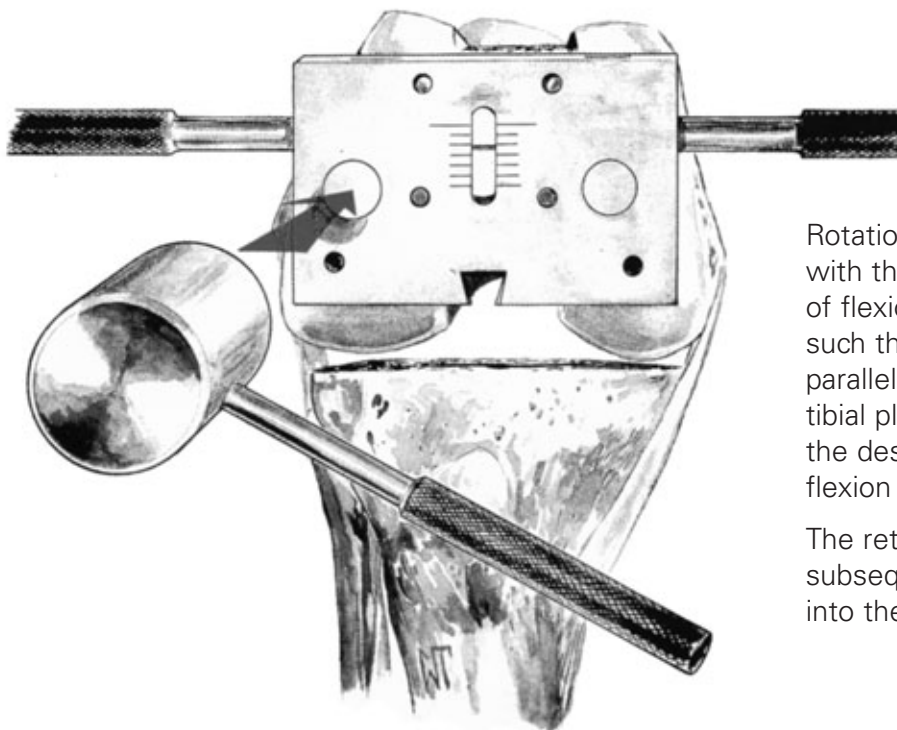
Rotation is determined with the knee in 90 degrees of flexion and the block positioned such that its posterior surface is parallel to the resected tibial plateau, creating the desired rectangular flexion gap.

The retractable pins are subsequently tapped into the distal femur.

59

EVALUATING THE FLEXION GAP

Lamina spreaders are positioned bilaterally between the resected proximal tibial surface and the posterior surface of the block. Tension is applied.
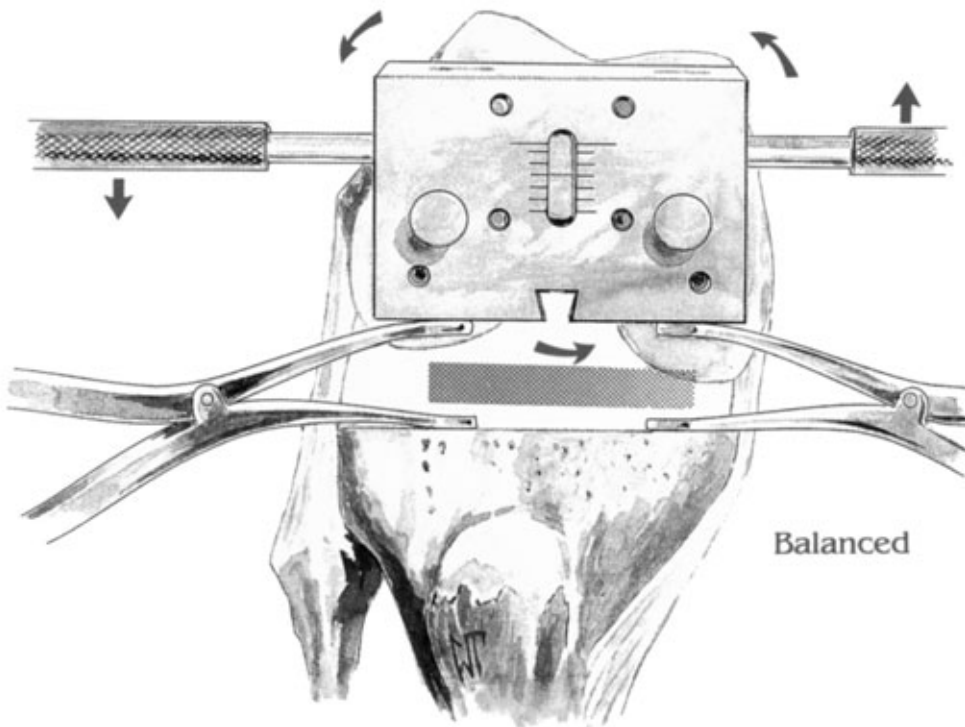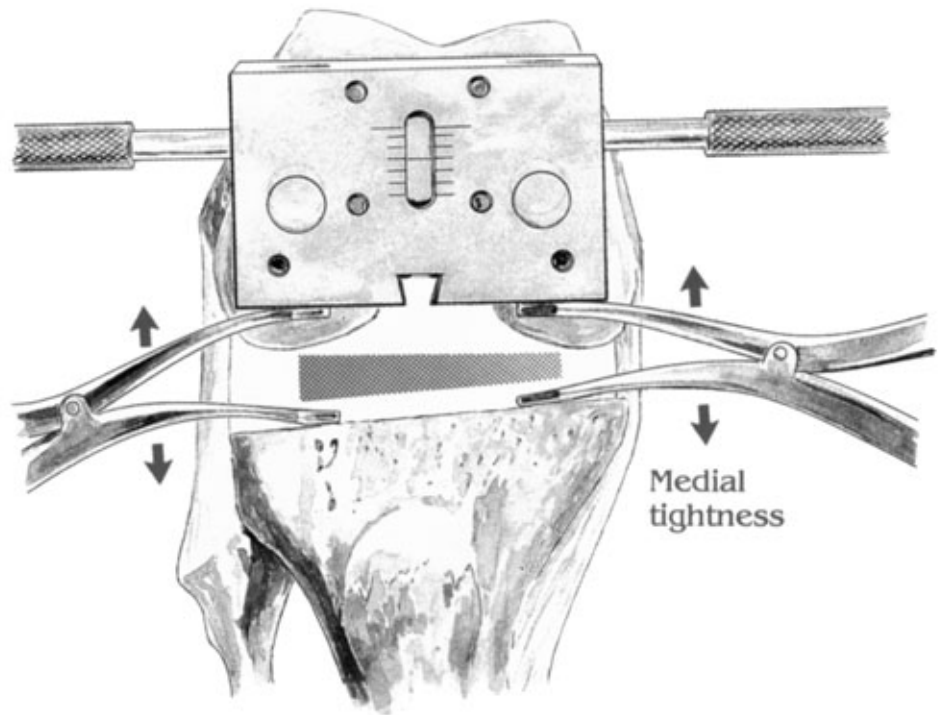
Medial tightness

Where there is medial tightness, the block is rotated externally to create the desired rectangular gap. This will yield a slightly greater amount of resected medial condyle, slightly less lateral. Internal rotation of the block is avoided as it will impair patellar tracking.

Balanced

NB *Further ligamentous release is not recommended at this stage.*

ANTERIOR AND POSTERIOR FEMORAL CUTS
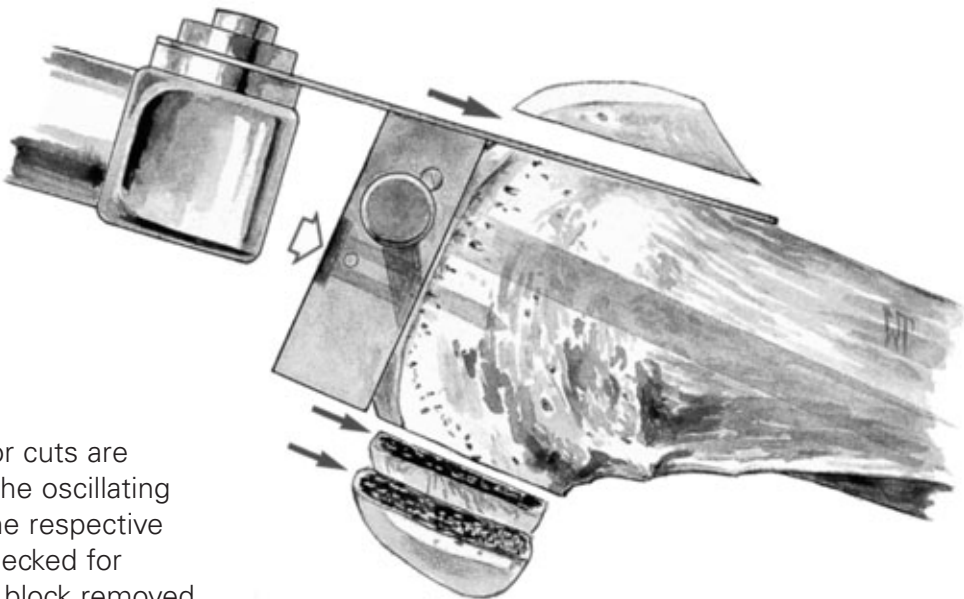
The anterior and posterior cuts are made with the blade of the oscillating saw held flush against the respective surfaces. The cuts are checked for accuracy and the cutting block removed.
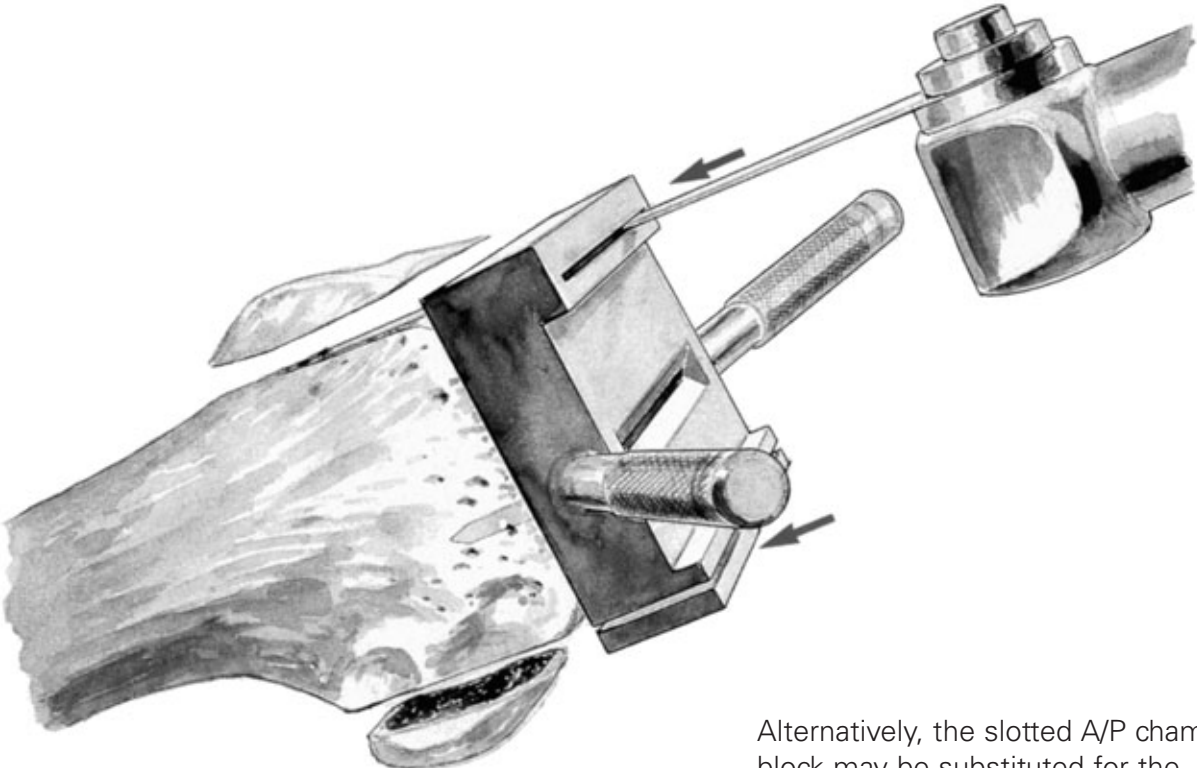
Alternatively, the slotted A/P chamfer block may be substituted for the cutting block, and positioned into the distal bilateral holes. A 1.19 mm saw blade is recommended.

MEASURING FLEXION GAP

Spacer blocks are used to measure the gap at 90 degrees of flexion. When using blocks to assess flexion and extension gaps, a 1 mm shim should be used for the extension gap and removed when assessing the flexion gap. This will compensate for the 1 mm difference between the distal and posterior resection levels.

Where further distal femoral resection is required to establish equivalent flexion and extension gaps, the Steinmann pins are returned to their original position in the anterior femoral cortex and the distal femoral cutting block repositioned using the holes designated +2 or +4, as indicated.

The long alignment rod should pass through the center of the talus and lie parallel to the lateral tibial axis.

THE FEMORAL NOTCH GUIDE

The appropriate femoral notch guide is applied to the distal femur, seated flush upon the cut anterior and distal surfaces. It is essentially centered, using the intercondylar notch for reference. Preferred positioning is closer to the lateral margin of the lateral condyle. Overhang is avoided.

The guide is secured with two Steinmann pins introduced through the holes designated with □'s. Where the posterior margins of the guide fail to align with the cut posterior condyles, the cuts are accordingly revised.
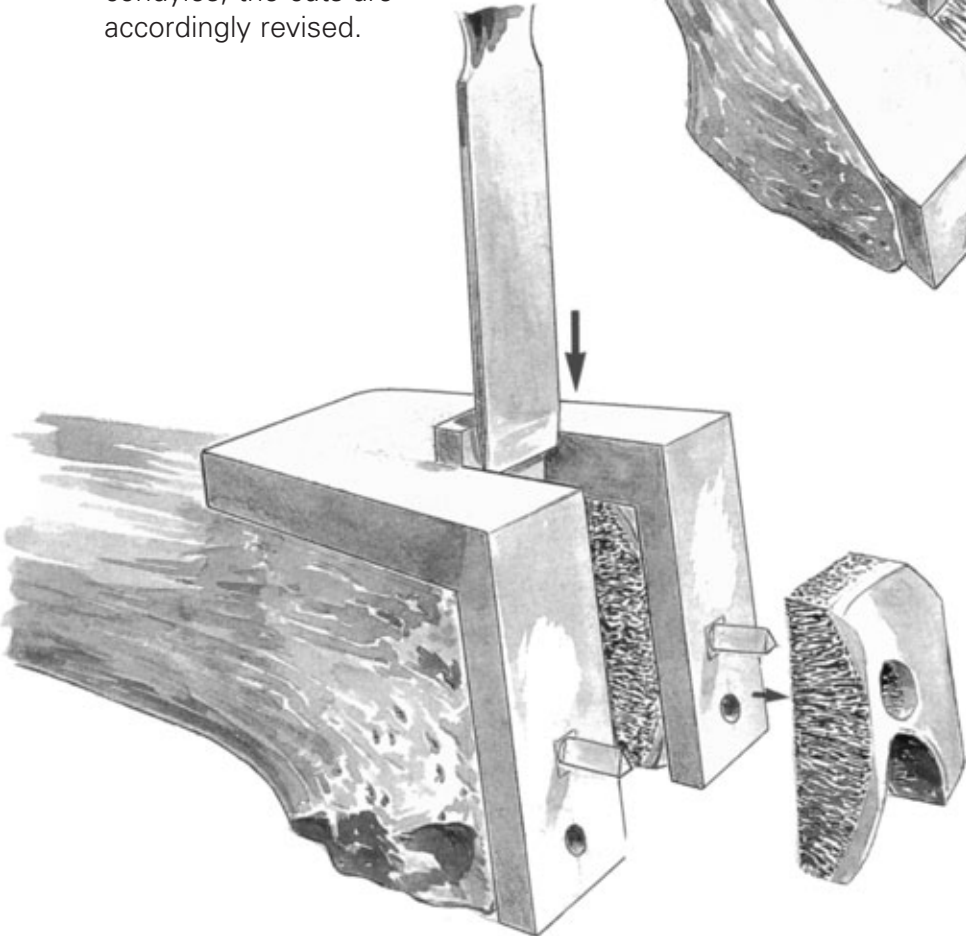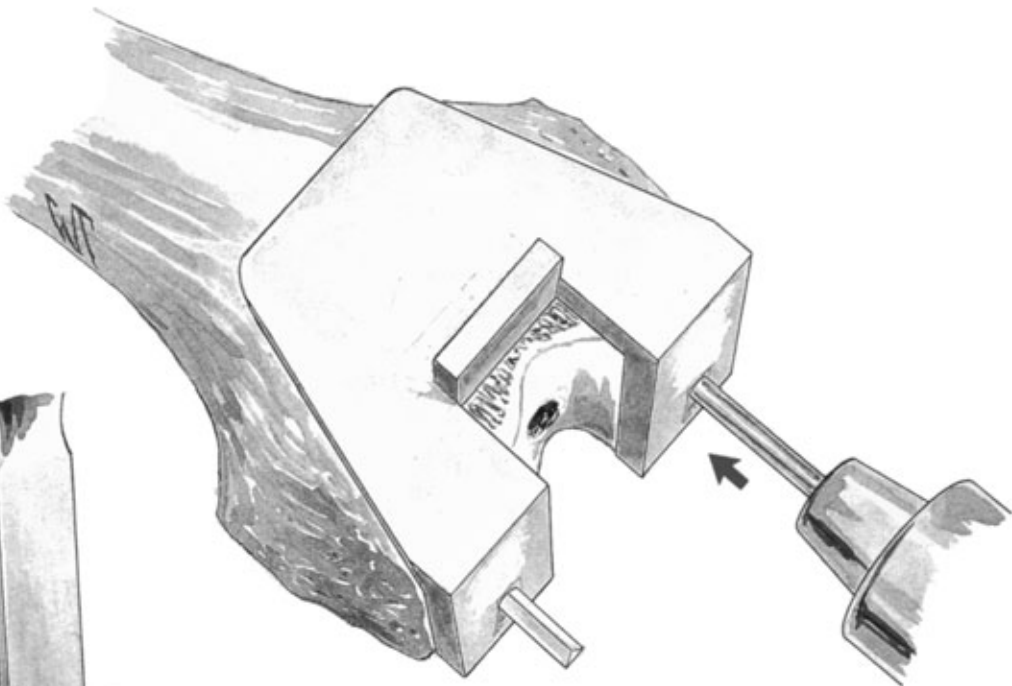
The notch is created with an oscillating saw and an osteotome.

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The appropriate chamfer block
is seated in the drill holes, the
chamfers performed and the
block removed.
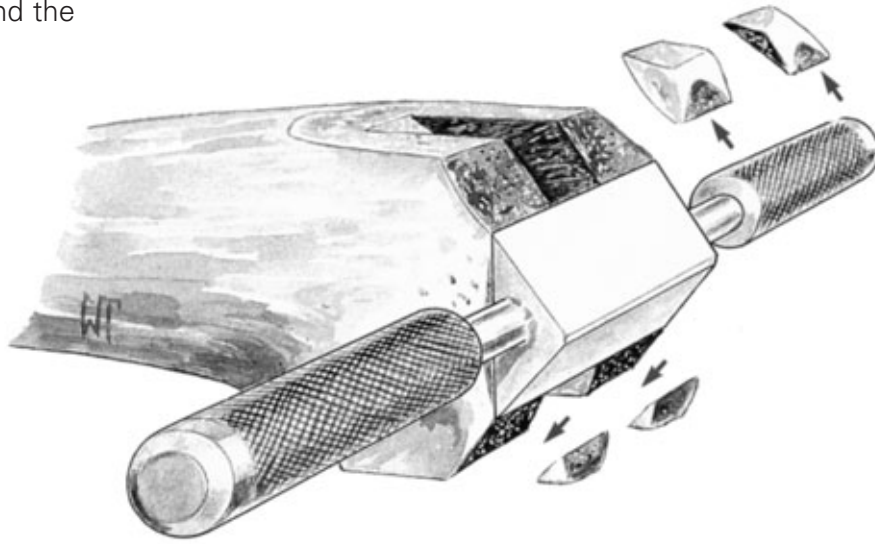
Alternatively, the femoral notch/chamfer guide may be employed for all of the
cuts. It is accordingly positioned as described above.
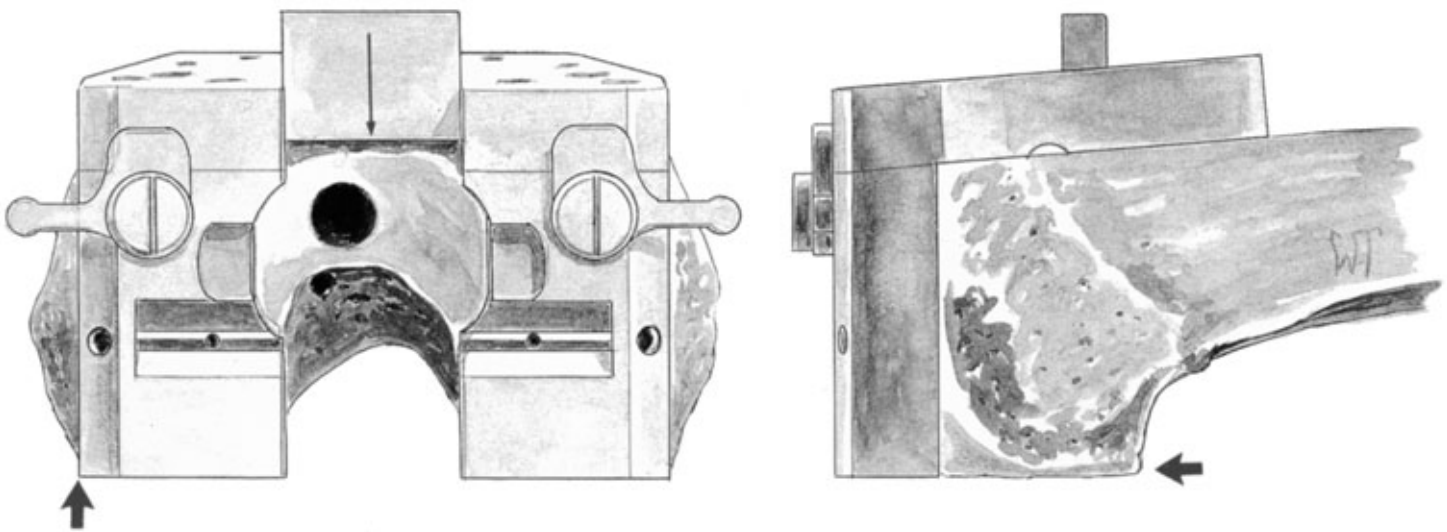
The guide is secured with Steinmann pins introduced through the distal bilateral holes. Where indicated, fixation is enhanced with additional pins introduced through the anterior holes.
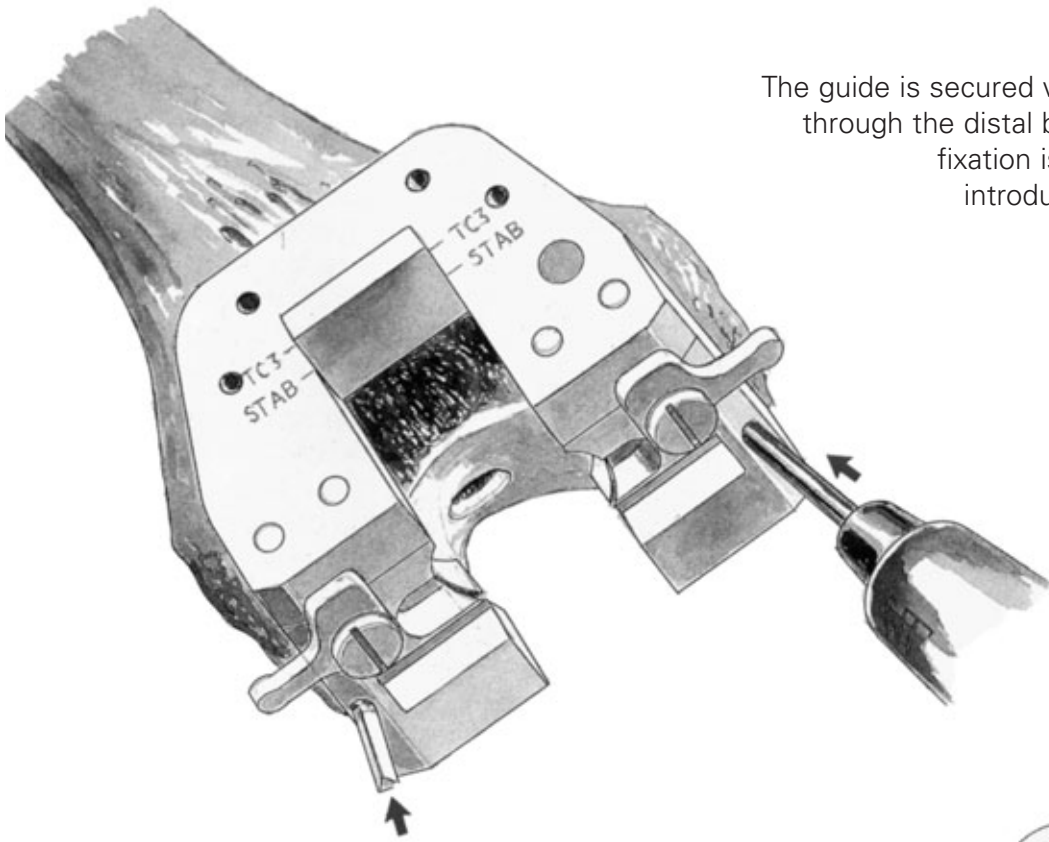
The notch is created with bilateral and superior transverse cuts, as described above.
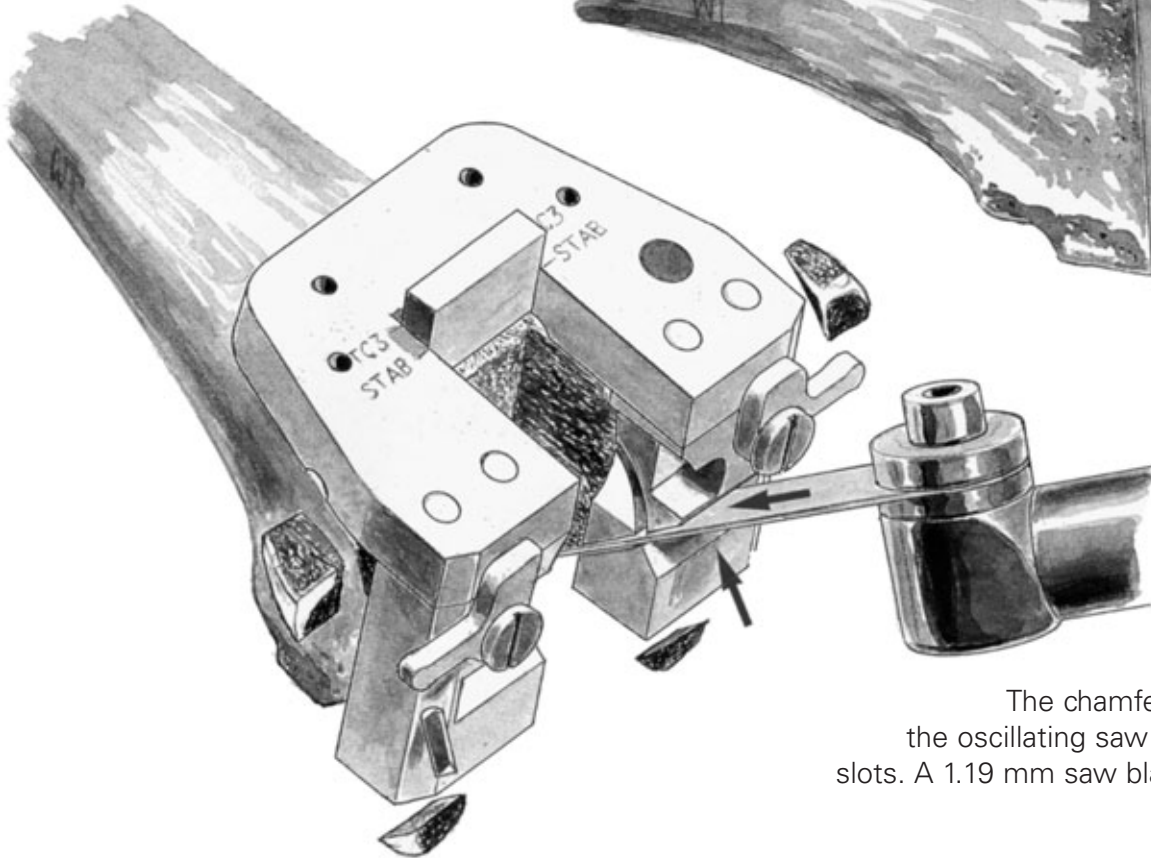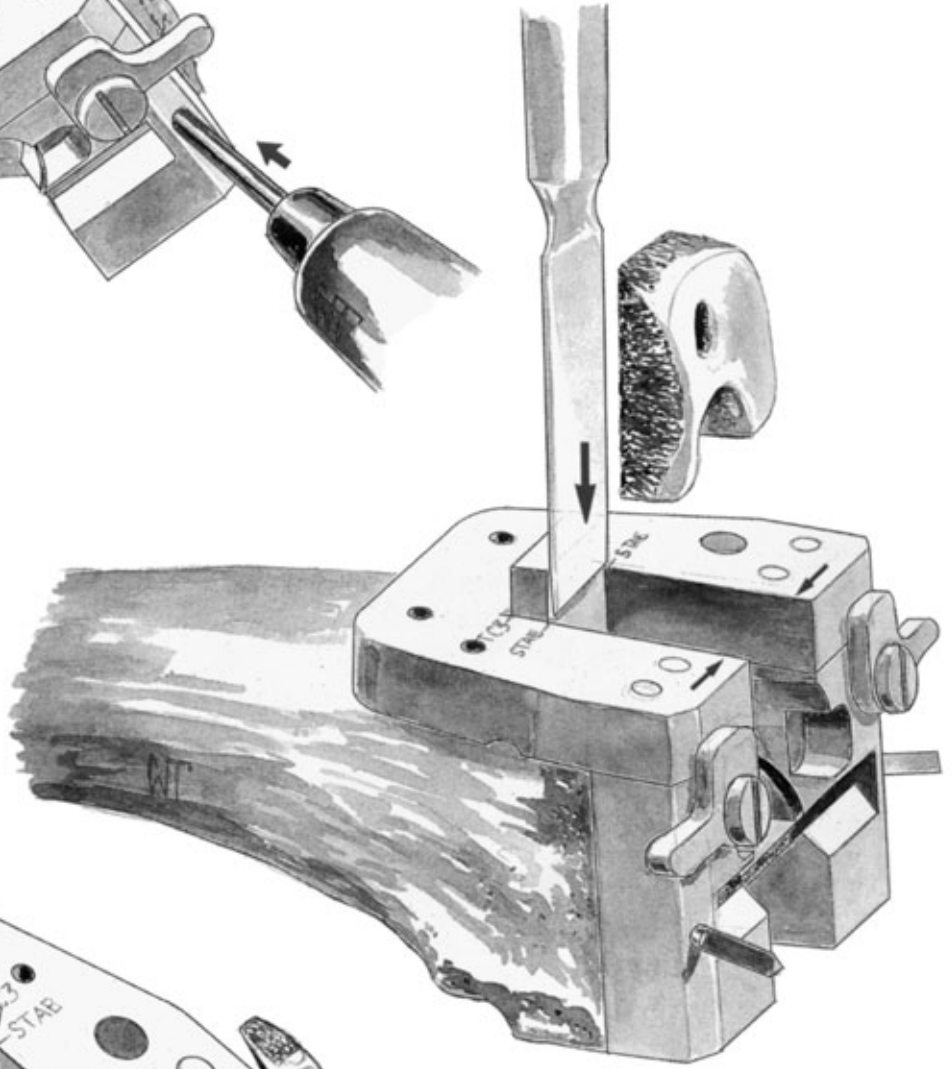
The chamfers are fashioned with the oscillating saw using the appropriate slots. A 1.19 mm saw blade is recommended.

PATELLAR RESURFACING

It is important that the sagittal dimension and accurate tracking be maintained and that adequate bone stock be preserved. Problems arise from inadequate or oblique resection resulting in greater thickness to the complex, asymmetric positioning of the implant, subsequent patellar tilt and implant wear.

It is important that sufficient soft-tissue be freed at the prepatellar bursa to position the calipers at the anterior cortex.

9mm

25mm

16mm

The greatest sagittal dimension is at the median ridge. The normal range is 20-30 mm. The dimension is established and an amount corresponding to the size of the selected implant subtracted. The remainder equals the target dimension following resection. Where the patella is small, a minimal residual dimension of 12 mm should be maintained.
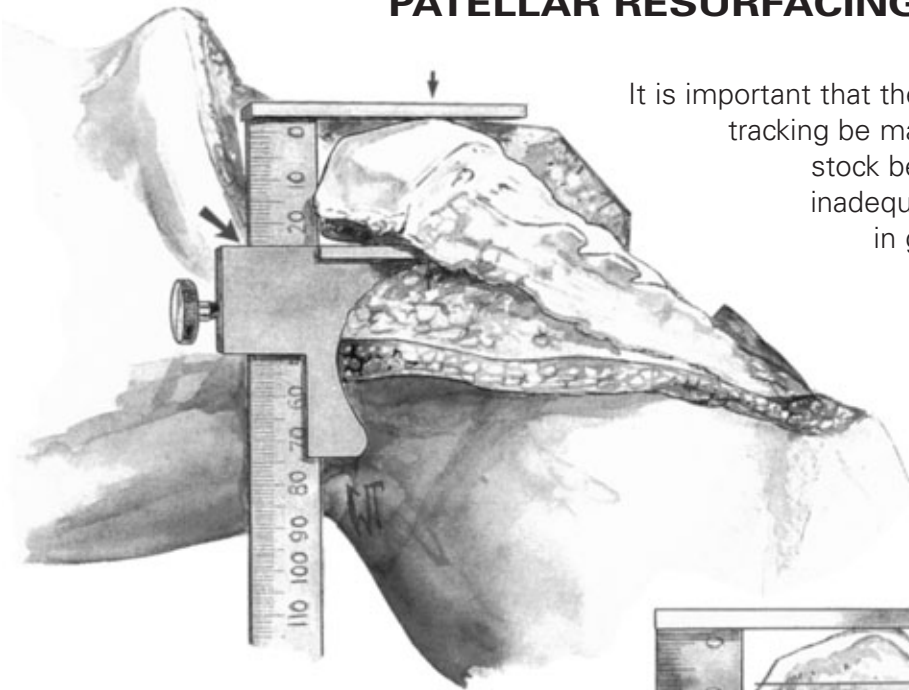
Example: From a patella 25 mm thick, 9 mm of articular surface is resected, yielding 16 mm of residual bone to accommodate the 38 mm implant.

The template is selected that most adequately covers the articular surface without overhang. The handle is positioned laterally. Where bone is deficient on the lateral side, the next smaller size is selected, but positioned slightly to the medial to enhance patellar tracking.

The amount of appropriate bone resection (indicated on the template) is noted.

38mm RESECT 9 mm

Where the P.F.C.® Σ patellar component size is 32 mm, resection is 8 mm.
Where it is 35 mm, resection is 8.5 mm.
Where it is 38 mm, resection is 9 mm.
Where it is 41 mm, resection is 11.5 mm.

THE PATELLAR CUTTING GUIDE

Synovial tissue is cleared to the level of the insertions of the quadriceps mechanism and the patellar ligament.

The prongs of the knurled fork are adjusted to the predetermined dimension of residual patella, as indicated on the calibrated column.

The leg is placed in extension, the cutting guide positioned with the prongs of the fork deep to the prepatellar bursa and against the anterior patellar cortex with the serrated jaws at the superior and inferior margins of the articular surface. The switch is placed to the LOCK position and the jaws closed to firmly engage the patella.

RESECTION AND DRILLING

Resection is performed with an oscillating saw, maintaining the blade flush to the cutting surface. The guide is subsequently removed and the residual dimension checked with calipers, laterally, medially, proximally and distally. All measurements should be equivalent. Asymmetry is addressed with the saw or a bone rasp.

Alternatively, the saw blade is inserted into the well of the cutting surface of either of the jaws. The insert is lifted and the blade thereby confined within the slot created, ensuring that the cut will remain flush to the cutting surface. A 1.19 mm saw blade is recommended.

The previously selected template is positioned onto the cut surface with the handle positioned laterally, such that two drill holes lie at the medial side, one at the lateral. The template is firmly engaged to the resected surface and the holes fashioned with the appropriate drill bit. Where a slightly undersized component is to be used, slight medial bias will facilitate tracking. Depth penetration is governed by the drill bit collar.

THE TRIAL TIBIAL COMPONENT

With the knee in maximal flexion, the tibia is subluxed anteriorly with the tibial retractor.

The tibial tray is selected that gives the greatest coverage of the prepared surface without overhang, anterior to the midcoronal plane. The appropriate color-coded trial is inserted into the tray.

NB See Appendix II for P.F.C. Keel Tray implantation.

THE TRIAL FEMORAL COMPONENT

The femoral trial is positioned on the prepared distal femur and the accuracy of the cuts evaluated.

Where the component tends to rotate posteriorly (rocking into flexure) the A/P cuts may require adjustment. Where there is lateral rocking, the depth of the notch is inadequate.

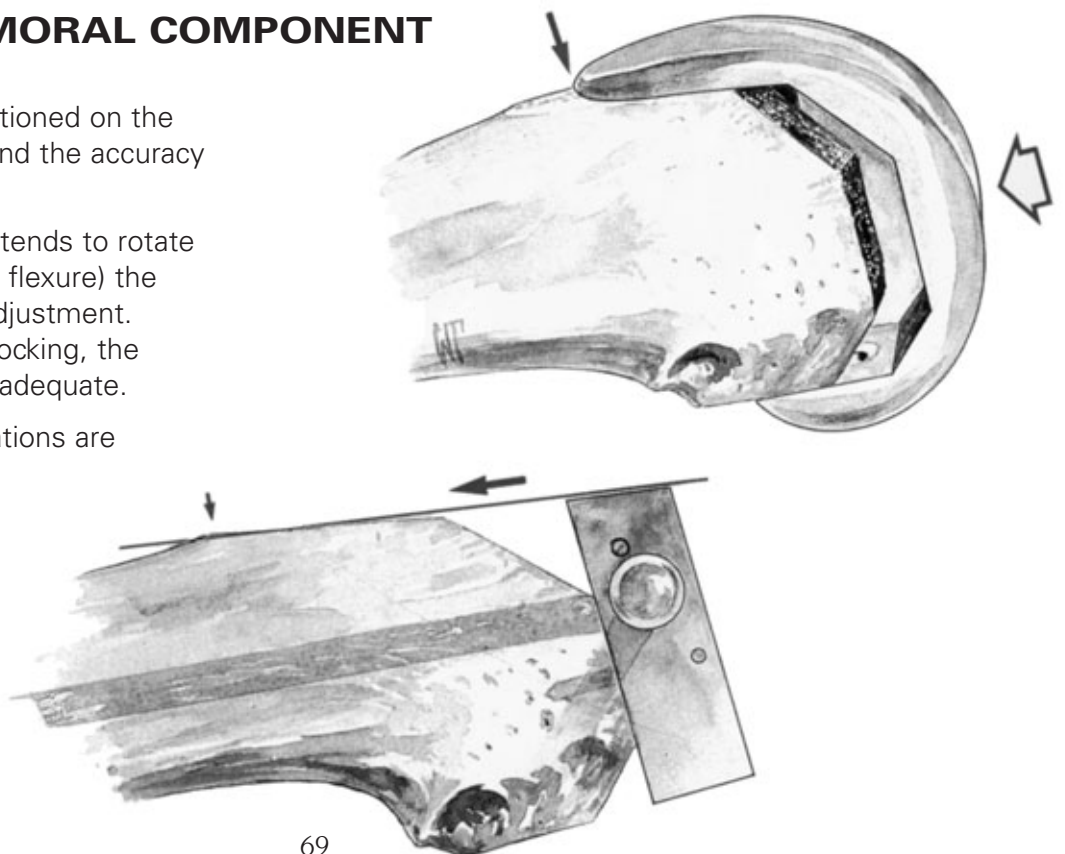All appropriate modifications are made at this time.

TRIAL REDUCTION

The knee is reduced and carried through a range of motion to evaluate stability. Where there is instability, the next greater size is substituted until the knee is stable, both in flexion and extension.

The patella should track normally, without outside assistance and with no tendency to tilt. Failing this, a lateral retinacular release is performed approximately 12 mm from the lateral margin of the patella.
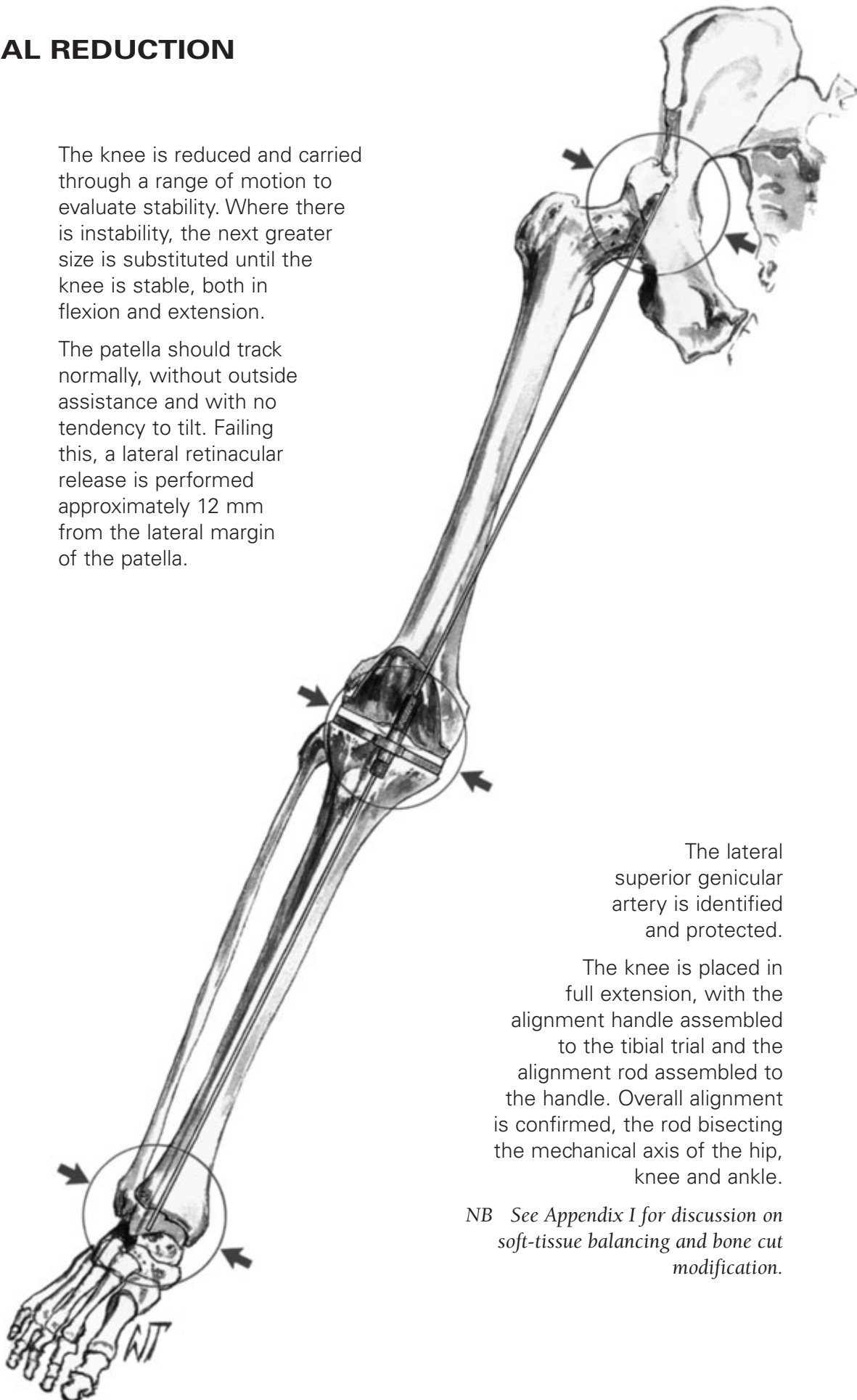
The lateral superior genicular artery is identified and protected.

The knee is placed in full extension, with the alignment handle assembled to the tibial trial and the alignment rod assembled to the handle. Overall alignment is confirmed, the rod bisecting the mechanical axis of the hip, knee and ankle.

NB   *See Appendix I for discussion on soft-tissue balancing and bone cut modification.*

PLATEAU PREPARATION

With the knee in full flexion and the tibia subluxed anteriorly, the trial tibial tray is assembled to the alignment handle and placed onto the resected tibial surface, positioned as close as possible to the posterior cortex, the lateral margin aligned with the lateral cortex. It is externally rotated slightly, such that the center of the handle is aligned with the medial third of the tibial tubercle. Internal rotation is avoided as it increases the Q-angle and compromises patellar tracking.

The tray is secured with two fixation pins inserted through the holes designated □.

NB See Appendix II for P.F.C. Keel Tray implantation.

THE TIBIAL DRILL

The tibial drill bushing is seated in the tray trial.

The tibial drill is advanced fully through the bushing into the cancellous bone.

Alternatively, where some portion of cancellous bone is to be retained to form a distal plug, drilling is stopped 10-15 mm above the bushing. The bone is subsequently impacted by the keel punch, plugging the medullary canal.

The drill and bushing are removed, the trial tray remains in place.

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THE TIBIAL KEEL PUNCH

The keel punch is positioned on the fixation pins and fully seated with a mallet, impacting the cancellous bone into the keel configuration.

A slap hammer is used to carefully disengage the keel punch with minimal disturbance to the site.

NB Where a Modular Plus Wedge is indicated, see Appendix III.

IMPLANTING THE COMPONENTS

THE TIBIAL TRAY

Where unilateral tibial deficiency has produced eburnation, the area is penetrated with multiple holes 3-4 mm in depth.

The site is thoroughly cleansed with pulsatile lavage. Methyl methacrylate at 3-5 minutes setting time (the consistency of toothpaste) is applied to the prepared tibial surface and forced into the trabeculae with digital pressure to attain 3-5 mm penetration. It is subsequently applied to the undersurface of the component.
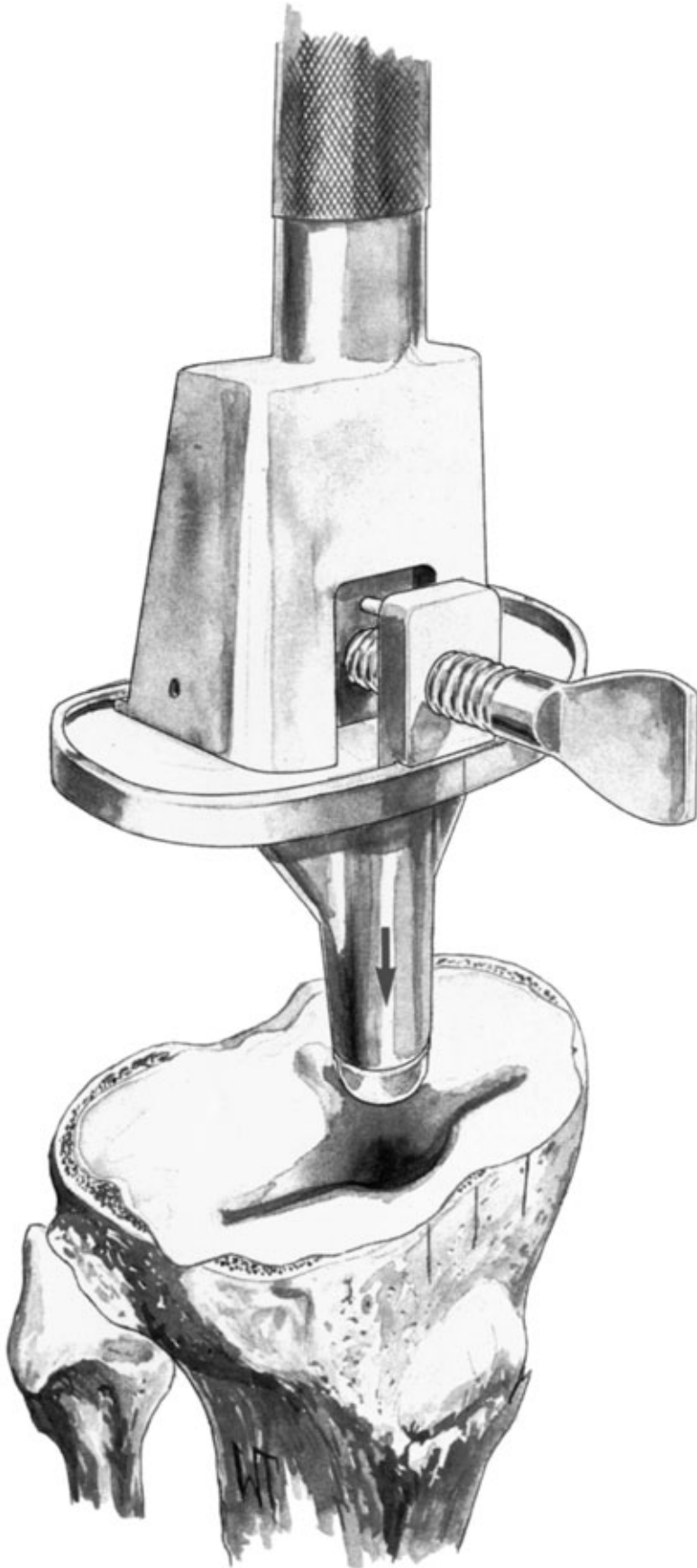
The tray is assembled to the universal tibial impactor and carefully inserted, *avoiding malrotation.* When fully seated, several mallet blows are delivered to the top of the impactor. The tray is held in position for approximately 2 minutes and the impactor disengaged.
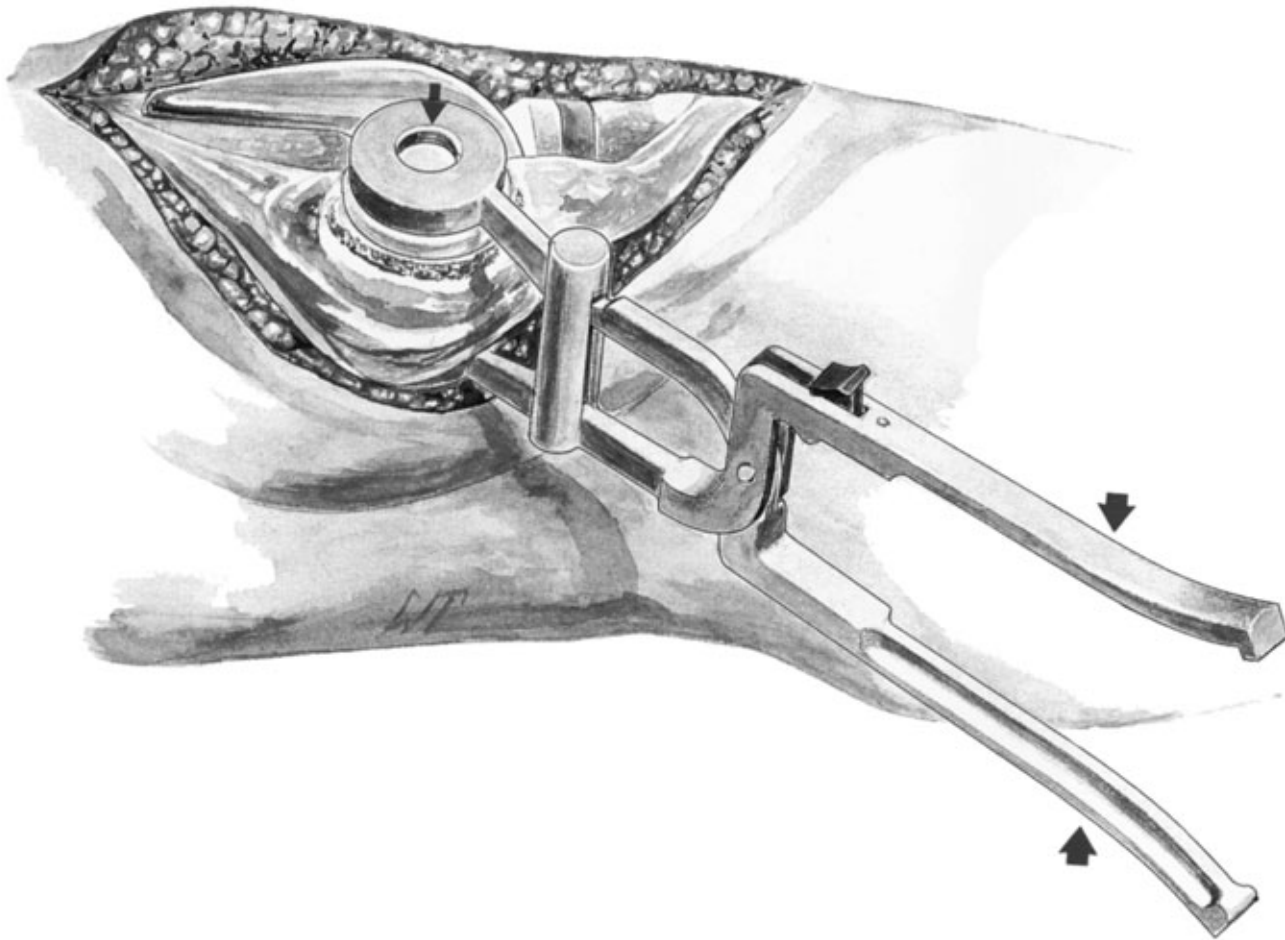
A trial insert is positioned in the tray, a trial component on the prepared femur. The knee is placed in full extension to maintain pressure at the bone/ tray interface until the cement has polymerized. The knee is subsequently placed in flexion and all extruded cement cleared with an osteotome.

THE FEMORAL COMPONENT

The femoral trial is removed, the tibial trial insert remains in place. The medullary canal is plugged with cancellous bone seated flush to the cut surface. The site is thoroughly cleansed with pulsatile lavage.

Methyl methacrylate at 3-5 minutes setting time is applied to all cut surfaces and pressed into the cancellous bone at the anterior, anterior chamfer and distal surfaces and to the component at the posterior chamfer and posterior condylar recesses. Care is taken to avoid the articular surface of the implant. As the component is implanted, care is taken that the leading edges be advanced in equal measure and maintained parallel to the cut distal surface.

The component is fully seated with the femoral impactor and all extruded cement is cleared. The knee is brought into full extension to produce maximal pressure on the bone/femoral component interface. Pressure is maintained until the cement has polymerized. The knee is subsequently placed in flexion and all extruded cement cleared with an osteotome.

THE PATELLAR COMPONENT

The patellar implant may be cemented at the surgeon's convenience with either of the other components. The cut surface is thoroughly cleansed with pulsatile lavage. Cement is applied to the surface and the component inserted.


The patellar clamp is designed to fully seat and stabilize the implant as the cement polymerizes. It is positioned with the silicon O-ring centered over the articular surface of the implant and the metal backing plate against the anterior cortex, *avoiding skin entrapment*. When snug, the handles are closed and held by the ratchet until polymerization is complete. Excessive compression is avoided, as it can fracture osteopenic bone. All extruded cement is removed with a curette.

THE TIBIAL INSERT

The tourniquet is released and all bleeding points coagulated.

The knee is placed in flexion. The trial insert is removed and the permanent insert introduced into the implanted tibial tray, seated posteriorly with its anterior margin resting on the lip of the tray.
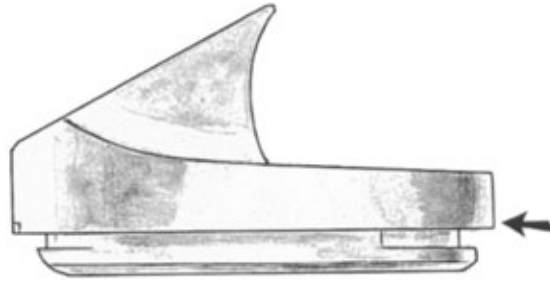
The anterior margin is tapped with a nylon mallet, deflecting it past the anterior lip into its permanent position. Seating is confirmed by circumferential inspection.
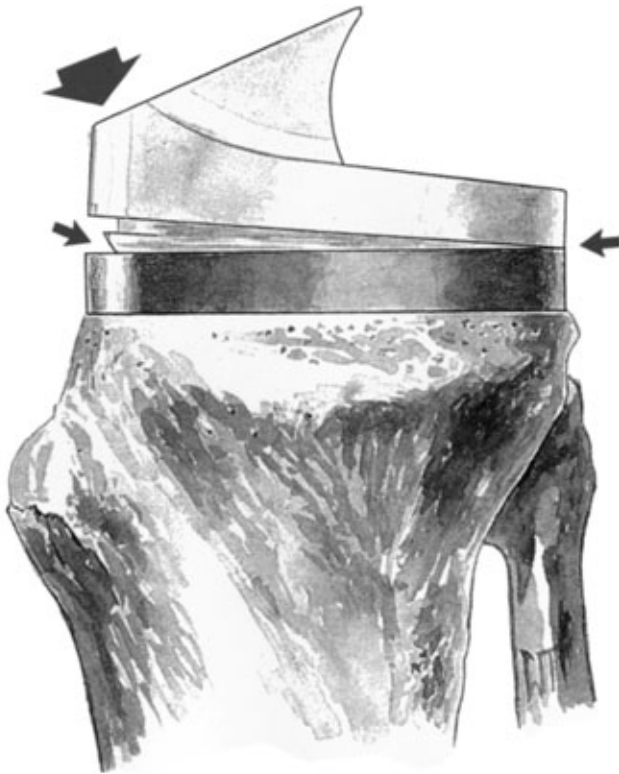
CLOSURE

The field is thoroughly irrigated with antibiotic solution. A closed-wound suction drain is placed in the suprapatellar pouch and brought out through the lateral retinaculum. The fat pad, quadriceps mechanism, patellar tendon and medial retinaculum are reapproximated with interrupted sutures.

The knee is put through a range of motion from full flexion to full extension to confirm patellar tracking and capsular integrity. Subcutaneous tissue is reapproximated and the skin closed with sutures or staples. Final range of motion is noted for postoperative rehabilitation. A compressive dressing is applied, removed after 24 hours and physical therapy initiated.

LIGAMENTOUS BALANCE IN TOTAL KNEE ARTHROPLASTY

The suggested sequence of ligamentous release to correct varus or valgus deformity and quadriceps-mechanism imbalance is described. There is no general agreement on the order, there is on the principles.

• Preliminary soft-tissue release is performed at the start of surgery, based upon preoperative evaluation.

• Balance is established by eliminating soft-tissue contractures, not by modifying the bone cuts.

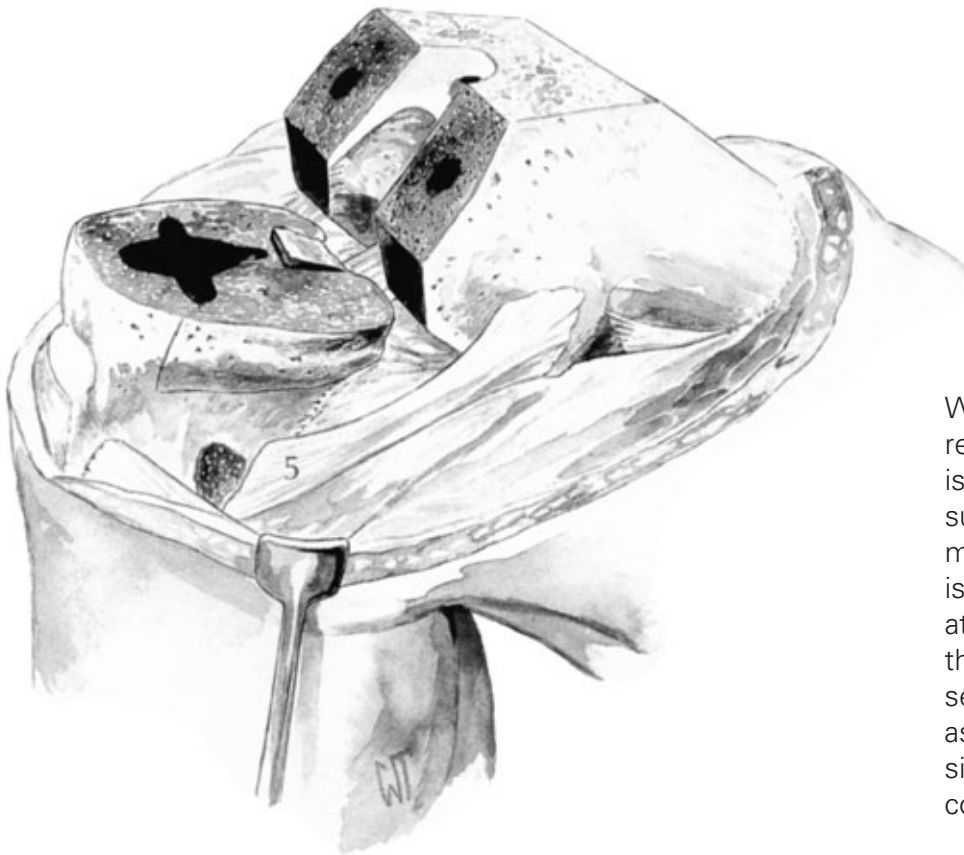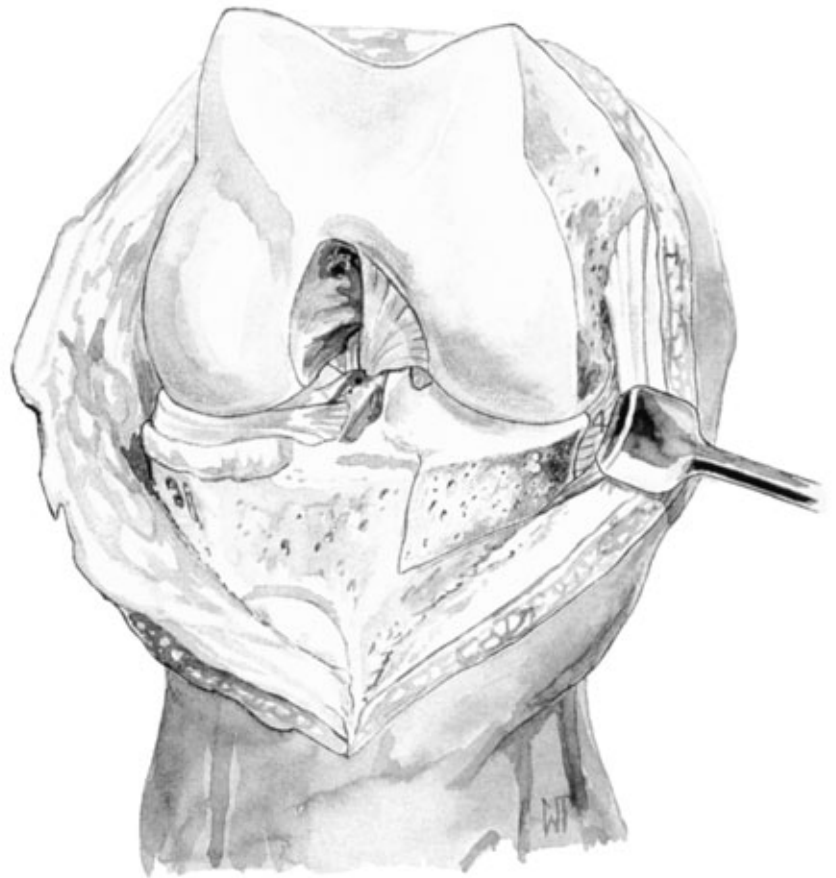• Final correction is established at trial reduction.

MEDIAL LIGAMENTOUS RELEASE FOR FIXED VARUS DEFORMITY
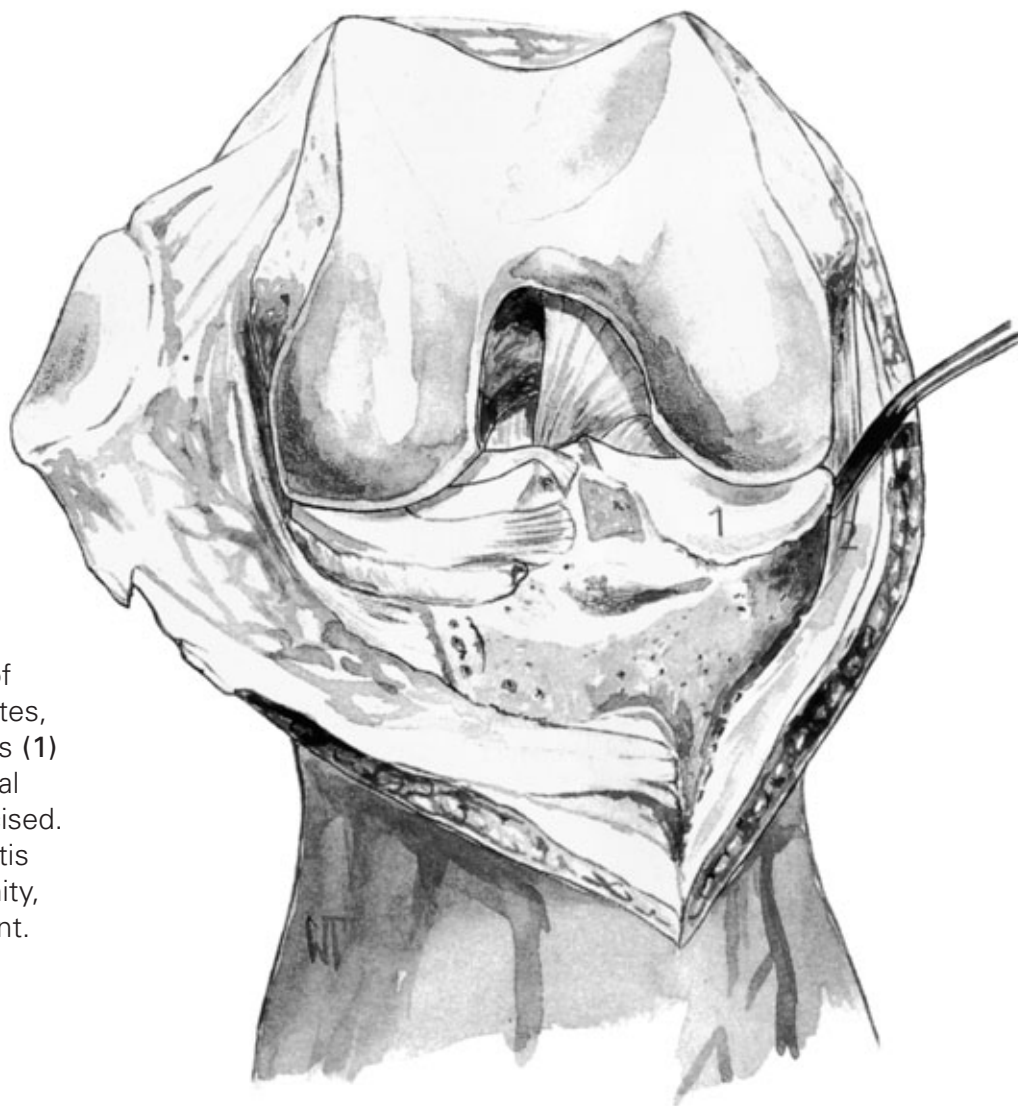
Following removal of peripheral osteophytes, the medial meniscus **(1)** and the meniscotibial ligament **(2)** are excised. In rheumatoid arthritis and minimal deformity, this is often sufficient.

Where further release is
indicated, the posterior
expansion of the deep
medial collateral ligament
is released from its tibial
attachment **(3)** using a
curved osteotome.

Where still further
release is indicated, the
medial tibia is denuded
subperiosteally **(4)**.

Where, following trial
reduction, further release
is indicated, the
superficial portion of the
medial collateral ligament
is released from its tibial
attachment **(5)**. Generally,
this is indicated only in
severe deformity
associated with
significant flexion
contracture.

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LATERAL LIGAMENTOUS RELEASE FOR FIXED VALGUS DEFORMITY

Following removal of peripheral osteophytes, initial release comprises lateral meniscectomy (1) and release of the iliotibial band from its tibial insertion (2).

A lateral quadriceps retinacular release is indicated where there is poor patellar tracking at trial reduction.
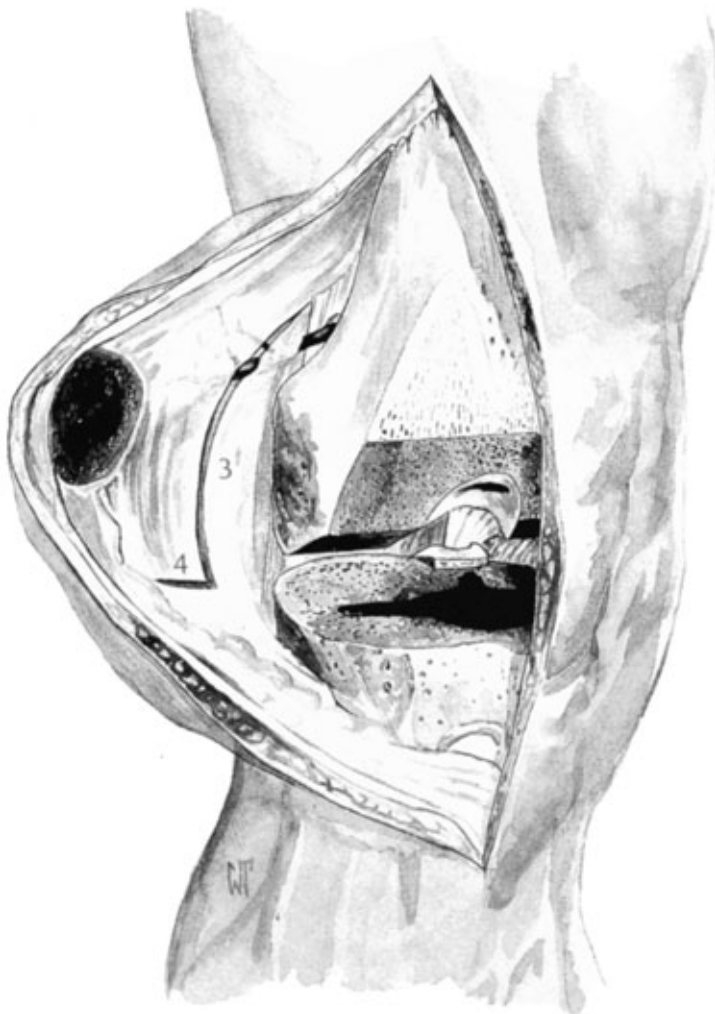
Lateral retinacular release is performed on the internal surface in the longitudinal plane. Care is taken that the lateral superior genicular artery be protected; it is isolated at the intermuscular septum as it penetrates the retinaculum superficially, retracted proximally as the retinacular incision is carried to the level of the jointline, distally, as the incision is extended superiorly to the intermuscular septum (3).

Where indicated, further release is affected by extending the distal terminus of the incision transversely to the lateral margin of the patellar tendon (4).

Where still further release is indicated, the lateral collateral ligament and popliteus tendon are released from the femoral epicondyle and repositioned posteriorly **(5)**.

Where further release is indicated, the posterior cruciate ligament is evaluated and, where necessary, sacrificed **(6)**.

*NB Priority of steps 5 and 6 are a matter of preference.*

Where balance requires still further release, dissection is extended posteriorly, freeing the intermuscular septum **(7)** and the lateral head of the *gastrocnemius* **(8)**.

Care is taken that the posterolateral neurovascular structures be preserved and that the insertion of the *biceps femoris*, which overlies the common peroneal nerve, remain intact.

BALANCING THE POSTERIOR CRUCIATE LIGAMENT

In cruciate-retaining total knee replacement, there are three indicators for PCL tightness identified at trial reduction: limited flexion with excessive femoral rollback, anterior lift-off of the tibial tray and palpable ligamentous tension in flexion.
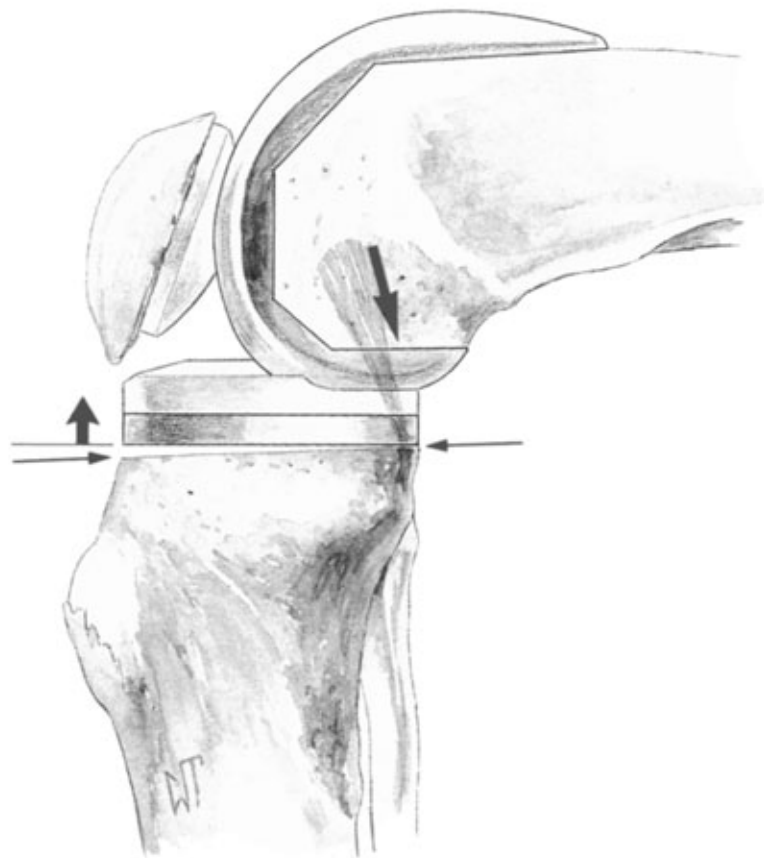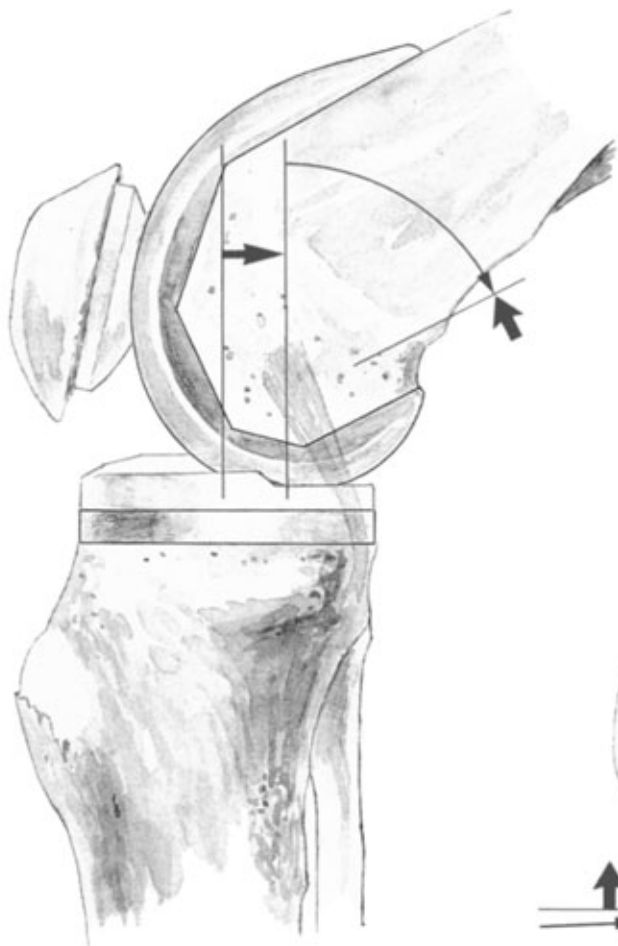
Possible causes include residual posterior/posteromedial osteophytes and loose bodies such as meniscal segments. It is essential during initial exposure that all peripheral posterior osteophytes be cleared, that the menisci be completely removed and that the attachments of the PCL be defined.

Problems commonly arise from failure to clear the posterior horns of the menisci, including the posterior meniscofemoral ligament, and failure to identify synovial adhesions.

Where the surgeon elects to increase the posterior tibial slope, it should not exceed a total of 7 degrees, as excessive posterior slope will complicate ligamentous balance in flexion and extension. It is preferable, therefore, that the PCL be recessed.
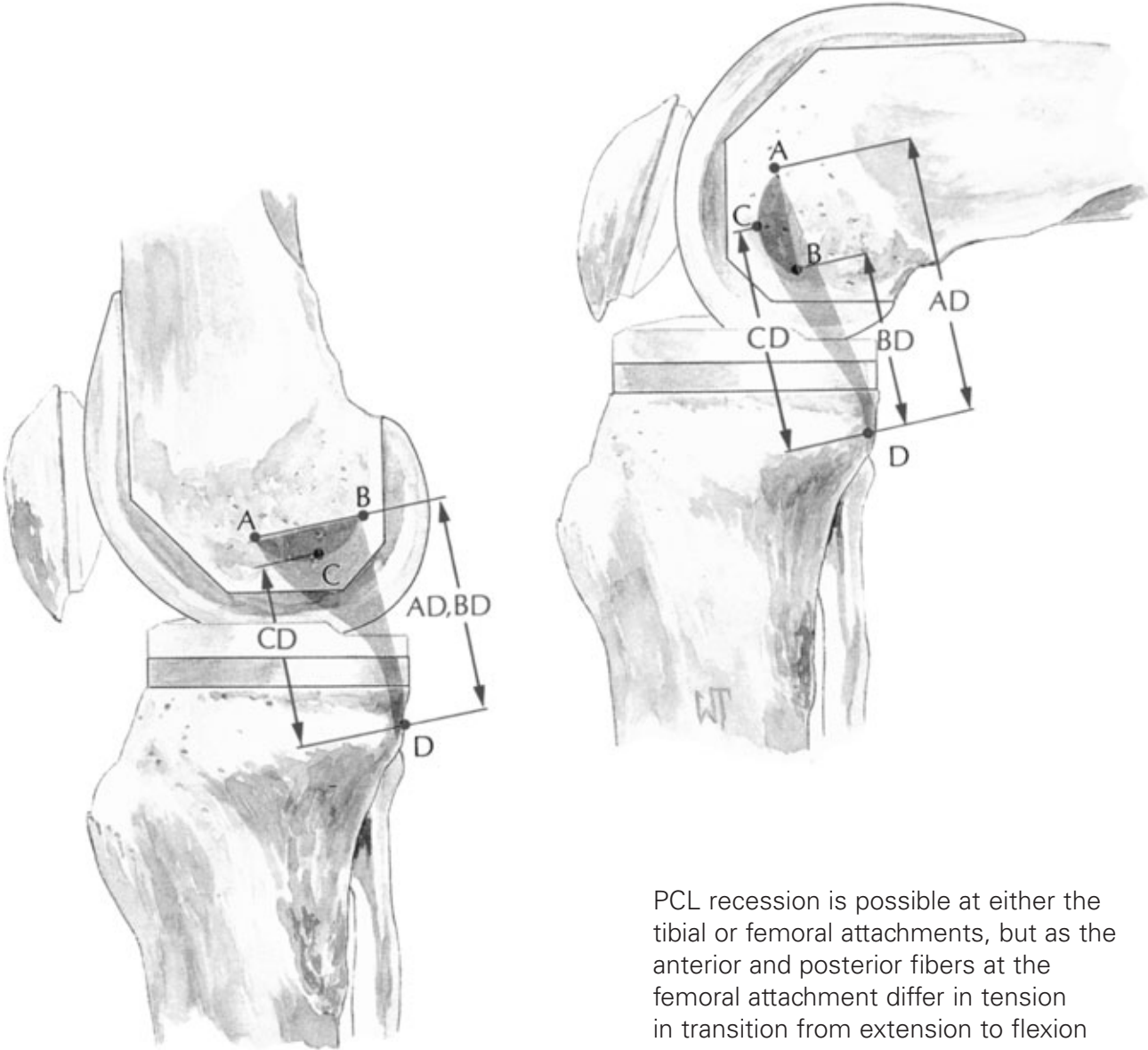
PCL recession is possible at either the tibial or femoral attachments, but as the anterior and posterior fibers at the femoral attachment differ in tension in transition from extension to flexion and as compromising this attachment increases the likelihood of evulsion, preliminary recession at the tibial attachment is recommended.

The tibial attachment is elevated subperiosteally along the entire proximal margin such that the ligament is allowed to recede incrementally until flexion tension in trial reduction is satisfactory with normal patellar tracking.
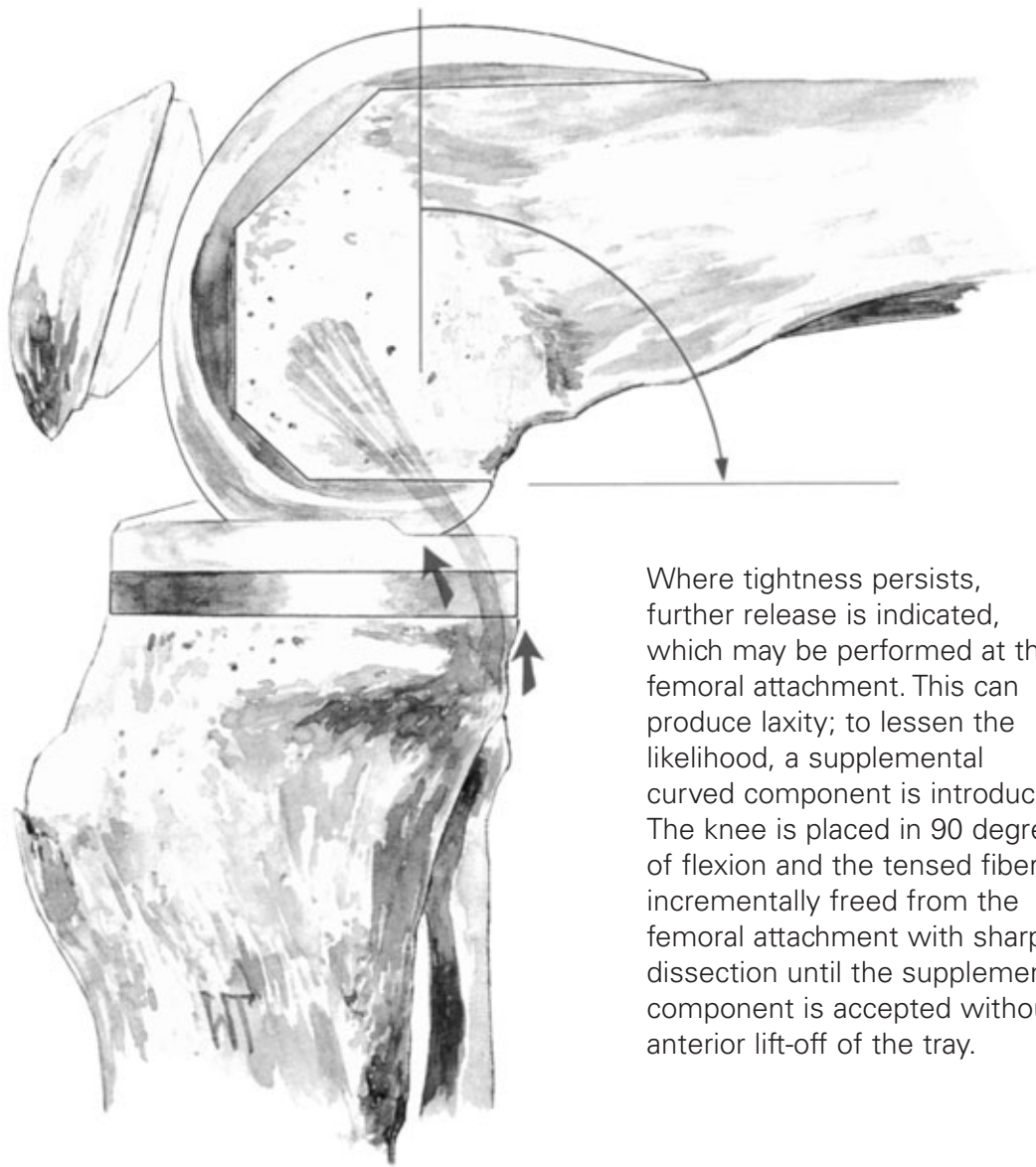
Where tightness persists, further release is indicated, which may be performed at the femoral attachment. This can produce laxity; to lessen the likelihood, a supplemental curved component is introduced. The knee is placed in 90 degrees of flexion and the tensed fibers incrementally freed from the femoral attachment with sharp dissection until the supplemental component is accepted without anterior lift-off of the tray.

NB Residual posterior osteophytes or undetected bone fragments can impinge upon the components and promote lift-off.

BALANCING FLEXION AND EXTENSION GAPS

Where the joint line is maintained, flexion and extension gaps are usually found to be balanced at trial reduction, but where there is preoperative deformity and contracture, imbalance may be present.

RESIDUAL FLEXION CONTRACTURE

Where there is restriction in extension but not in flexion, additional bone is removed from the distal femur. This affects the extension gap but not the flexion. Where contracture persists, following appropriate retinacular release and removal of posterior osteophytes and scar tissue, depending on severity, removal of an additional 2-4 mm of distal femur is indicated.
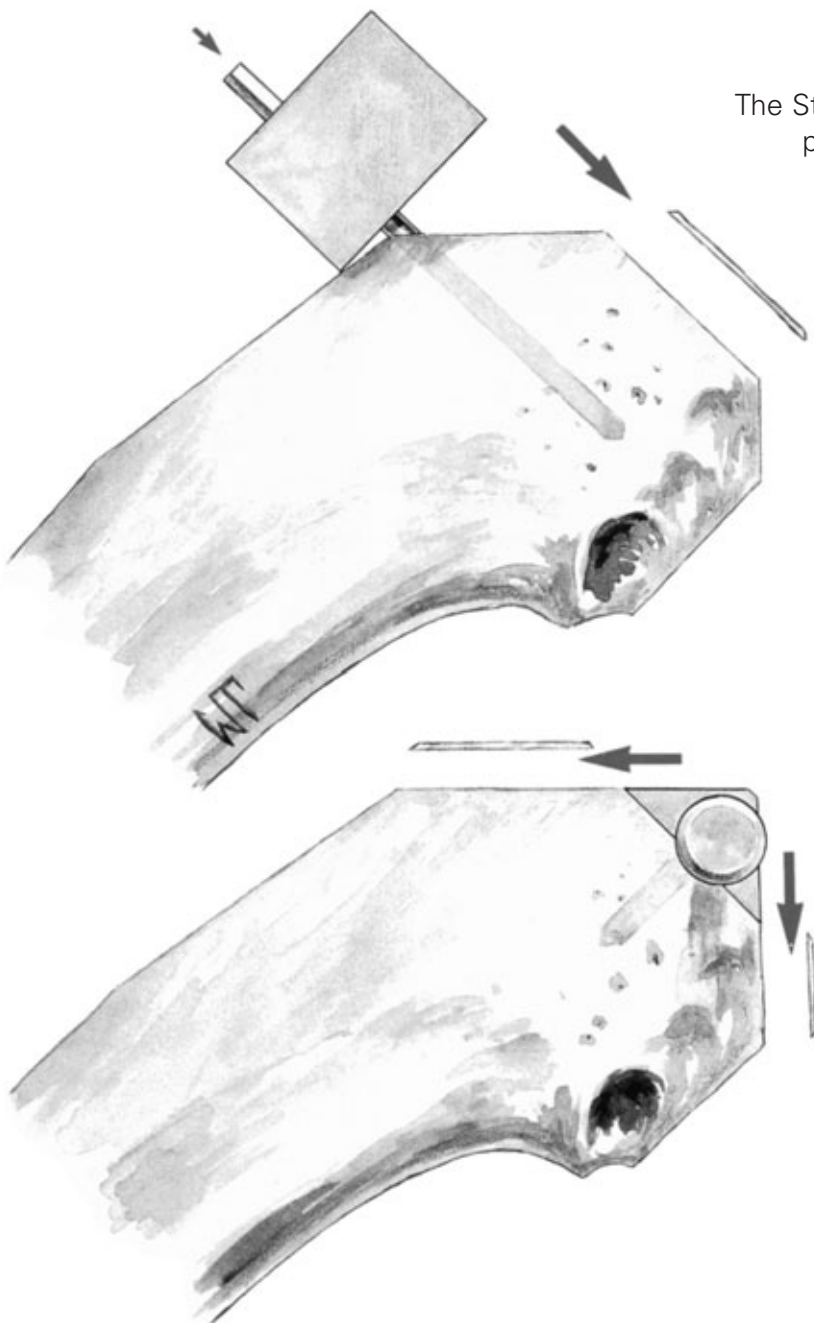

The Steinmann pins are returned to their original position in the anterior femur and the distal femoral cutting block returned to the pins using the holes designated +2 or +4 as the degree of contracture indicates. The distal cut is accordingly revised.
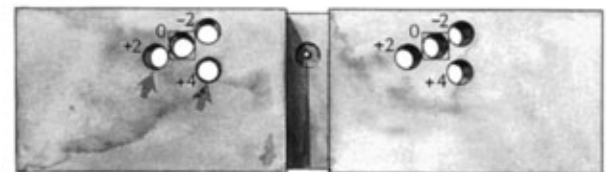

Chamfers are subsequently revised to maintain the correct configuration, anterior and posterior cuts are not. This affects ligamentous tension in extension but not in flexion.

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RESIDUAL TIGHTNESS IN FLEXION AND EXTENSION

A thinner tibial insert or additional tibial resection is indicated, as either will affect flexion and extension gaps. Where resection is selected, it is recommended that 2 mm of proximal tibia be removed. The Steinmann pins are returned to their drill holes in the anterior tibial cortex and the cutting block repositioned on the pins, using the holes designed +2. The cut is accordingly revised.
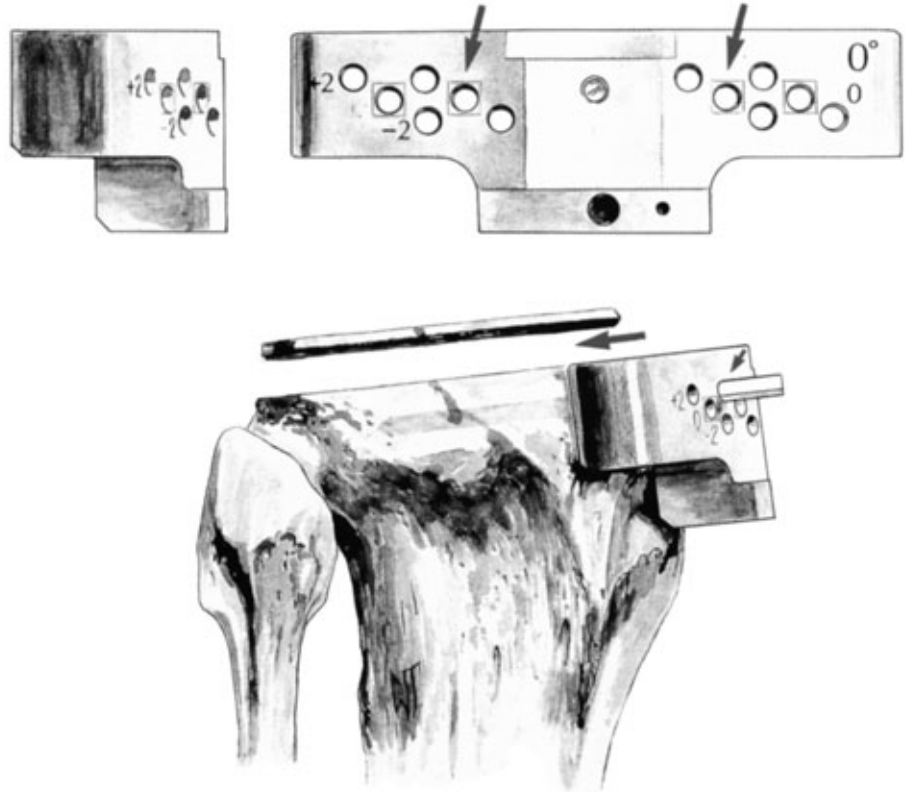
RESIDUAL TIGHTNESS IN FLEXION ONLY
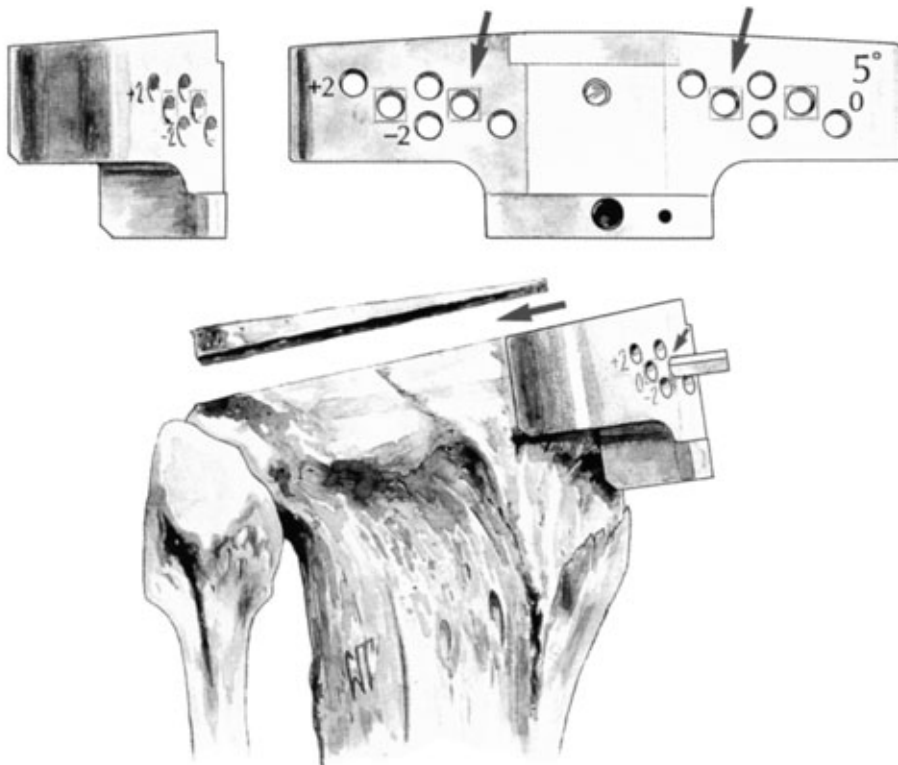
Where such is the case, excessive PCL tension is indicated. Release is effected as described above. Residual posterior osteophytes, soft tissue and loose bodies may be factors and must be addressed. Where tension persists following appropriate correction, 5 degrees of additional posterior slope may be indicated. The pins are returned to the anterior cortex and the 5-degree cutting block positioned using the holes designated 0. This final slope should not exceed 7 degrees.

Alternatively, tightness in flexion may be addressed by downsizing the femoral component, provided that anterior femoral notching is avoided. The pins are returned to the distal femoral surface, the designated cutting block repositioned and the cuts revised. As additional posterior condyle is resected, flexion gap is increased.

*NB For discussion of soft-tissue balancing, see above.*

IMPLANTATION OF THE P.F.C. TIBIAL KEEL TRAY
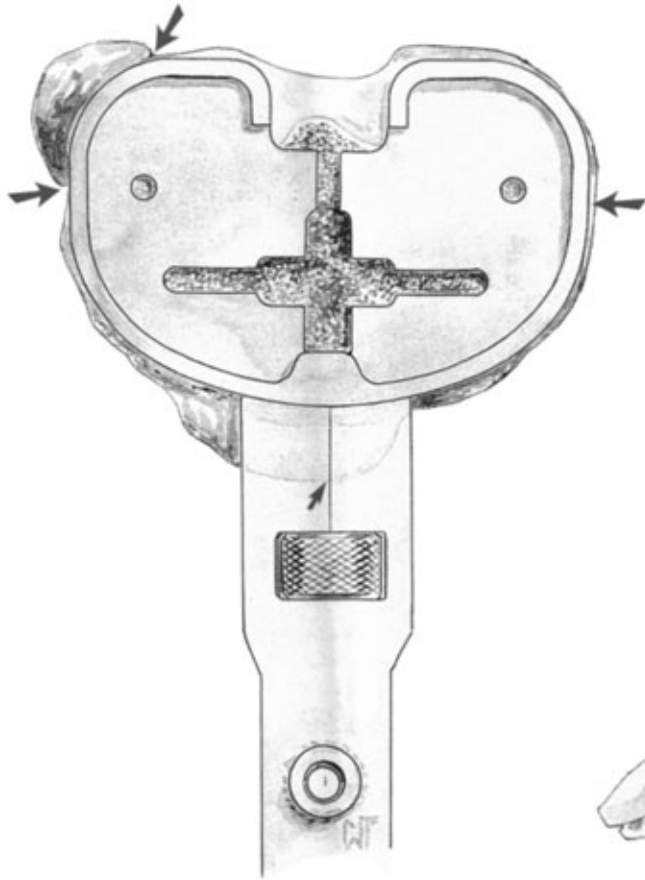
The knee is placed in maximal flexion and the tibia subluxed anteriorly with the tibial retractor.

The trial tibial keel tray is selected which provides the greatest coverage of the prepared surface but precludes overhang.

The tray is assembled to the alignment handle and placed onto the resected tibial surface. The appropriate color-coded trial is selected to be subsequently inserted into the tray.
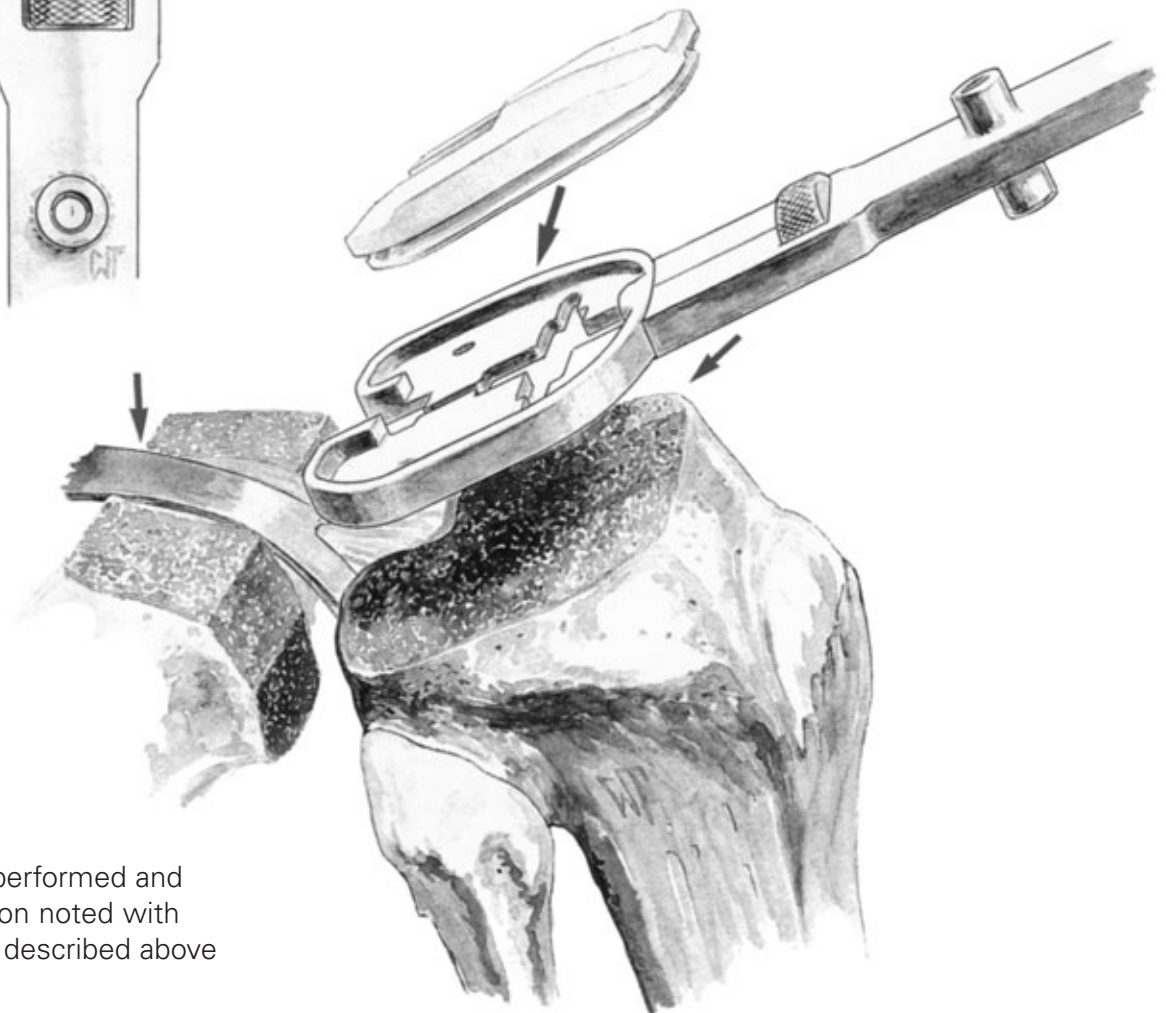

Trial reduction is performed and rotational correction noted with electrocautery as described above *(see page 31).*

Where required, the tray
is secured with two fixation
pins introduced through the
bilateral holes.
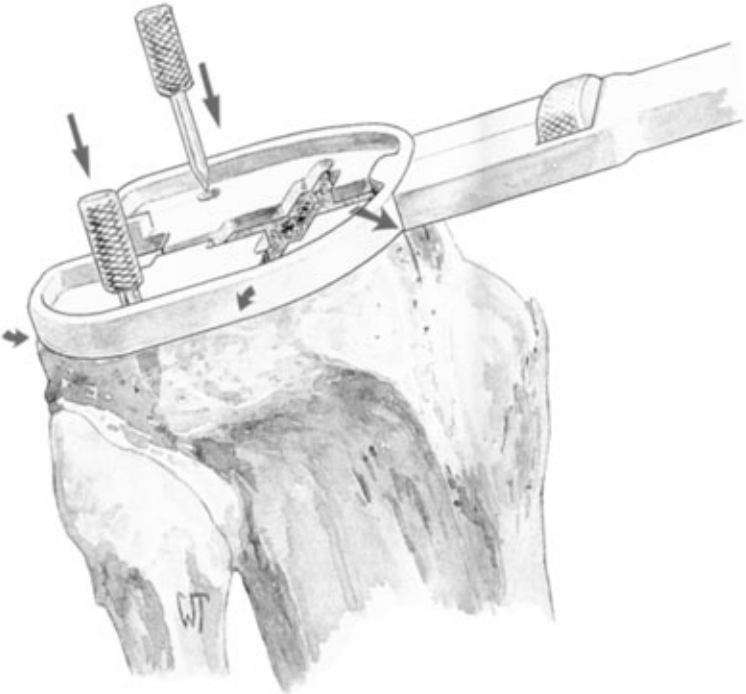
With positioning and alignment confirmed,
the cementless-tray stem punch is
appropriately positioned at the tray and
the cancellous bone impacted into the
cementless-stem configuration with
several blows from a mallet.
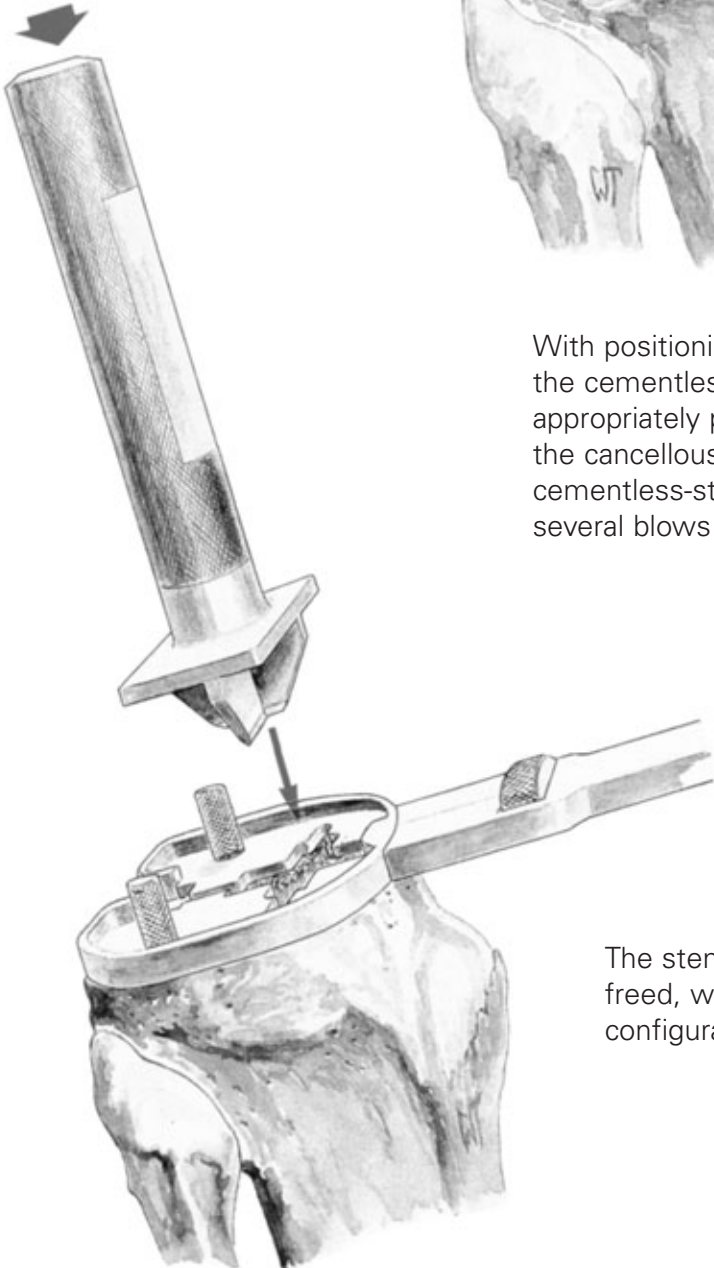
The stem punch is subsequently
freed, with care that the punch
configuration be preserved.

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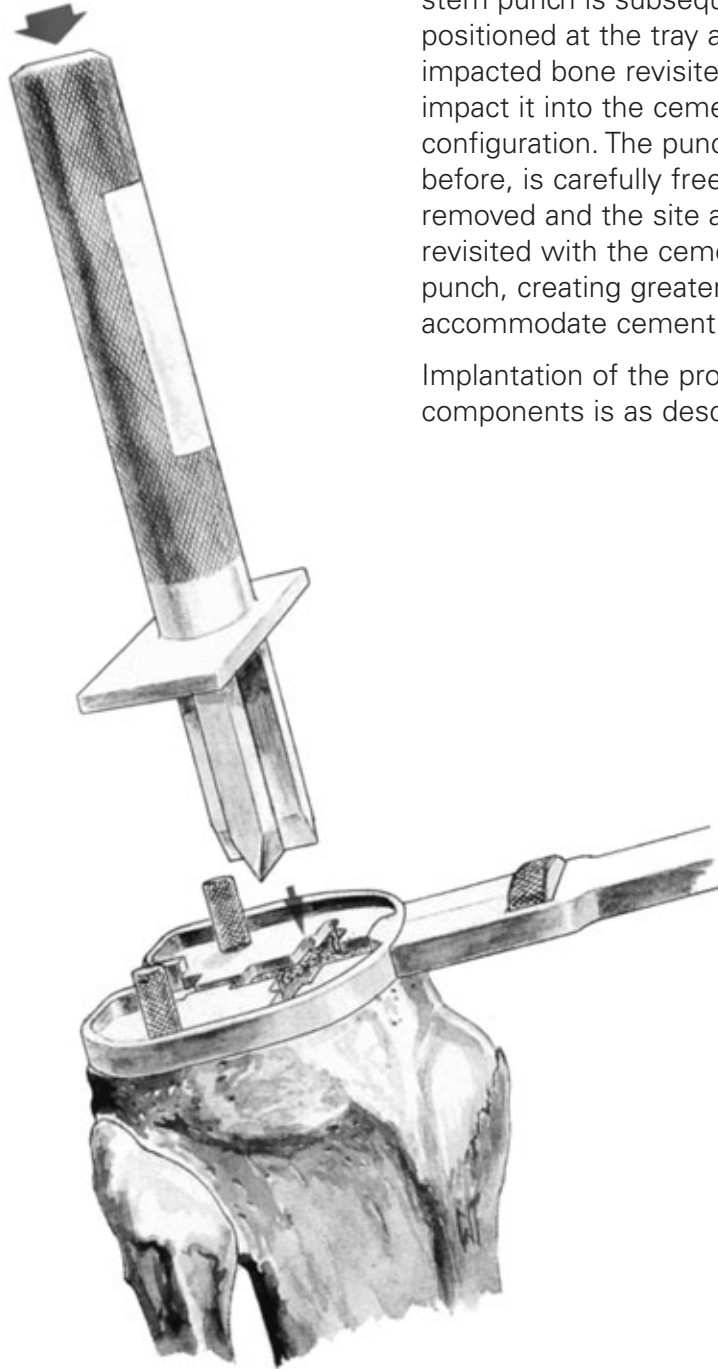
Where the cemented tray is to be implanted, the cemented-tray stem punch is subsequently positioned at the tray and the impacted bone revisited to further impact it into the cemented-tray configuration. The punch, as before, is carefully freed, the tray removed and the site again revisited with the cemented-tray punch, creating greater depth to accommodate cement.

Implantation of the prosthetic components is as described above.

The entire site is thoroughly cleansed with pulsatile lavage. Methyl methacrylate cement is prepared and applied by syringe or digital pressure in its low viscous state to ensure maximal penetration into the trabecular bone.

The tibial tray is assembled to the universal tibial impactor and carefully inserted, *avoiding malrotation.* When fully seated, several mallet blows are delivered to the top of the impactor. The impactor is subsequently disengaged from the implanted tray and removed.
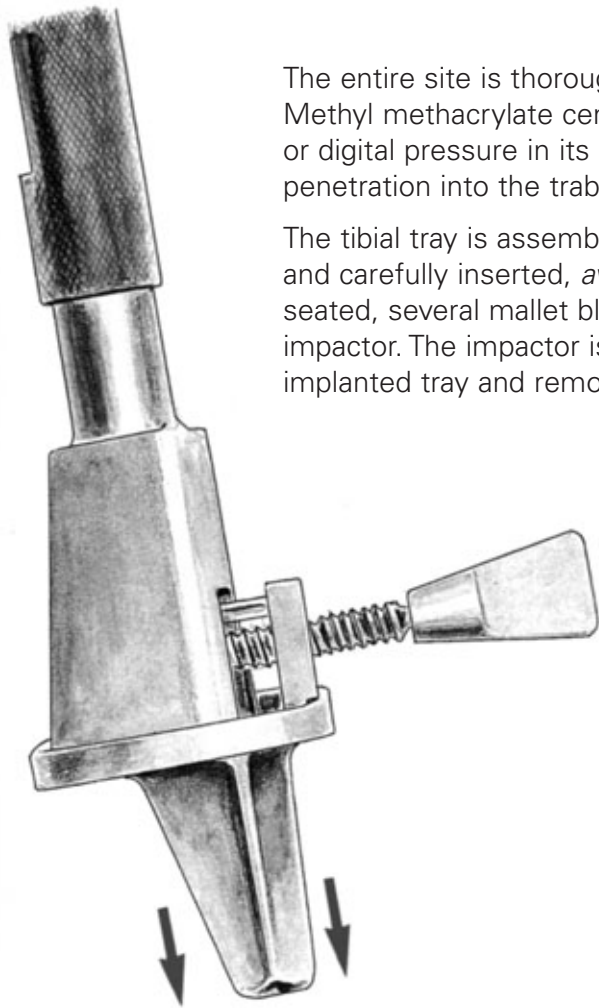
As the cement polymerizes, a trial insert is placed in the tray, a trial component on the prepared femur. The knee is placed in full extension to maintain pressure at the bone/tray interface. Slight valgus stress is maintained to ensure that the tray not tilt into varus. All extruded cement is carefully removed with special attention to the posterior compartment.

The trial insert is removed, the permanent insert introduced into the tray and seated posteriorly with its anterior margin resting on the lip. The anterior margin is tapped with a nylon mallet, deflecting it past the lip and into position. Seating is confirmed by circumferential inspection.
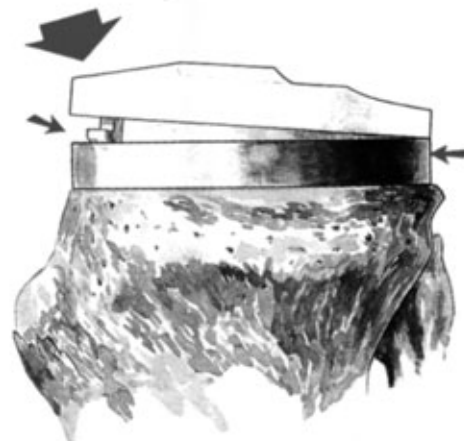
## MODULAR PLUS WEDGE AUGMENTATION

Where wedge augmentation is indicated, the following steps are in order:

Following rotational correction at trial reduction, the trial insert is removed, the tray repositioned and secured with the short fixation pins. The Modular Plus tibial-wedge drill guide is subsequently coupled to the tray.
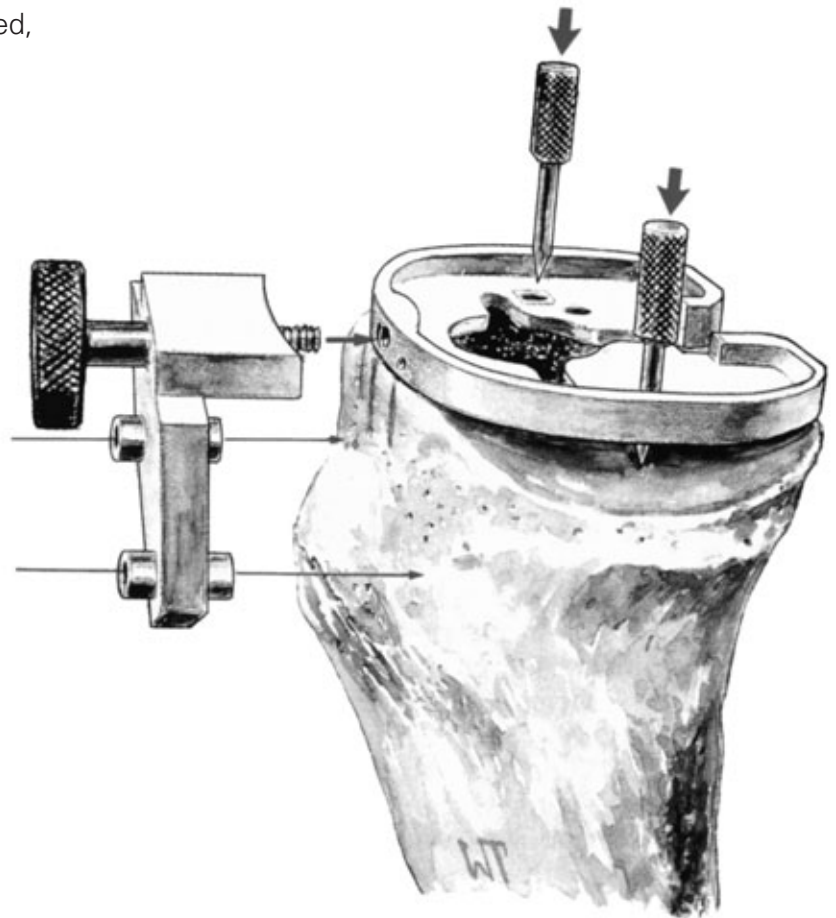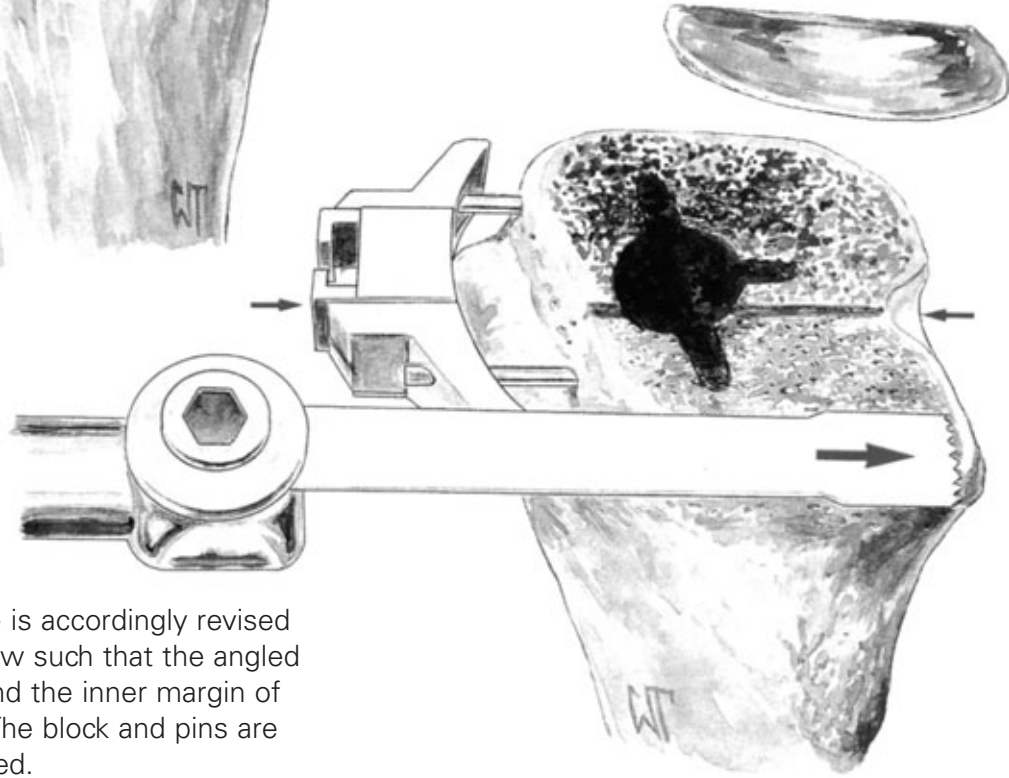
Steinmann pins are introduced through the holes in the drill guide. The guide, fixation pins and the tibial tray are subsequently removed, the Steinmann pins remain in place.
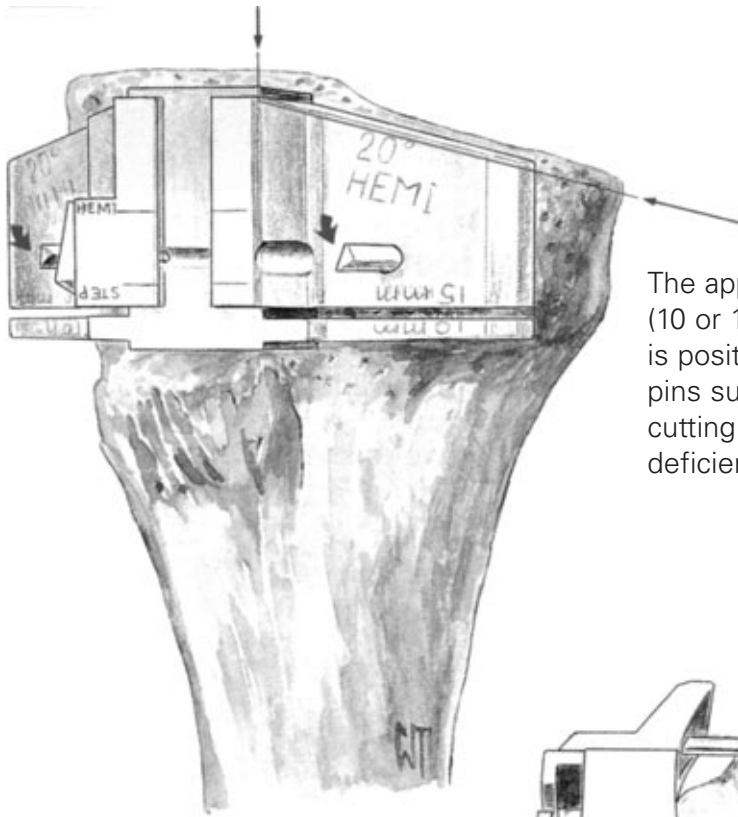
The appropriate cutting block
(10 or 15 mm STEP, 10 or 20-degrees HEMI)
is positioned on the Steinmann
pins such that the designated
cutting surface align with the
deficient condyle.

The deficient surface is accordingly revised
with an oscillating saw such that the angled
cut not extend beyond the inner margin of
the cutting surface. The block and pins are
subsequently removed.
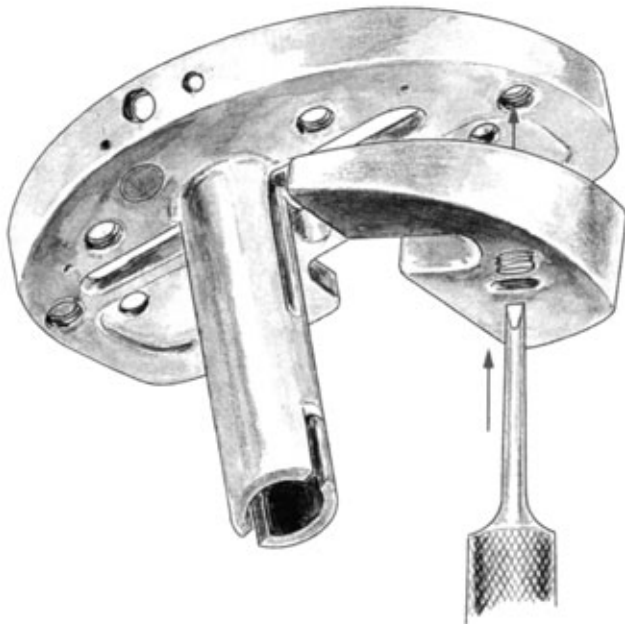
The appropriate trial
wedge is assembled
to the trial tray and
validated in trial
reduction.

THE EXTERNAL ALIGNMENT SYSTEM

In patients with femoral deformity or with total hip replacement, the intramedullary alignment system is not appropriate. The short intramedullary rod coupled to the femoral locating device, the 0 bushing, tower and alignment rod are employed. The femoral head is identified preoperatively.
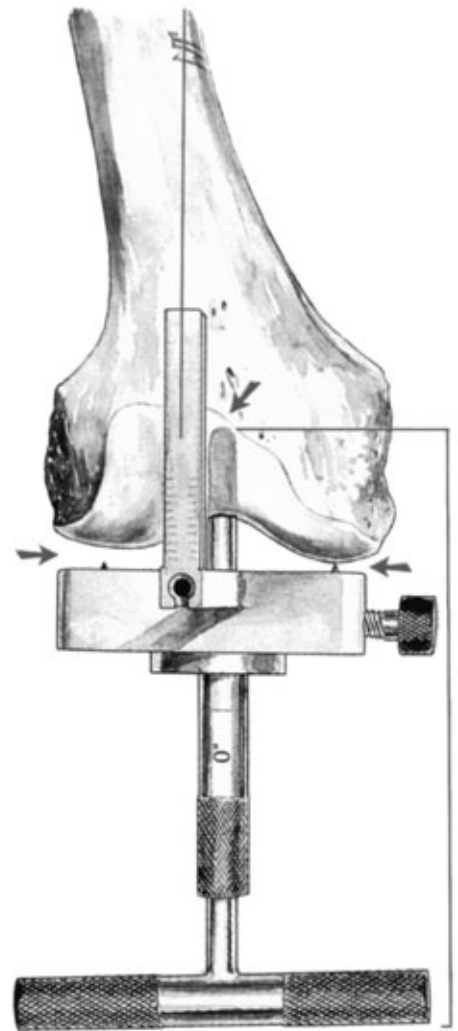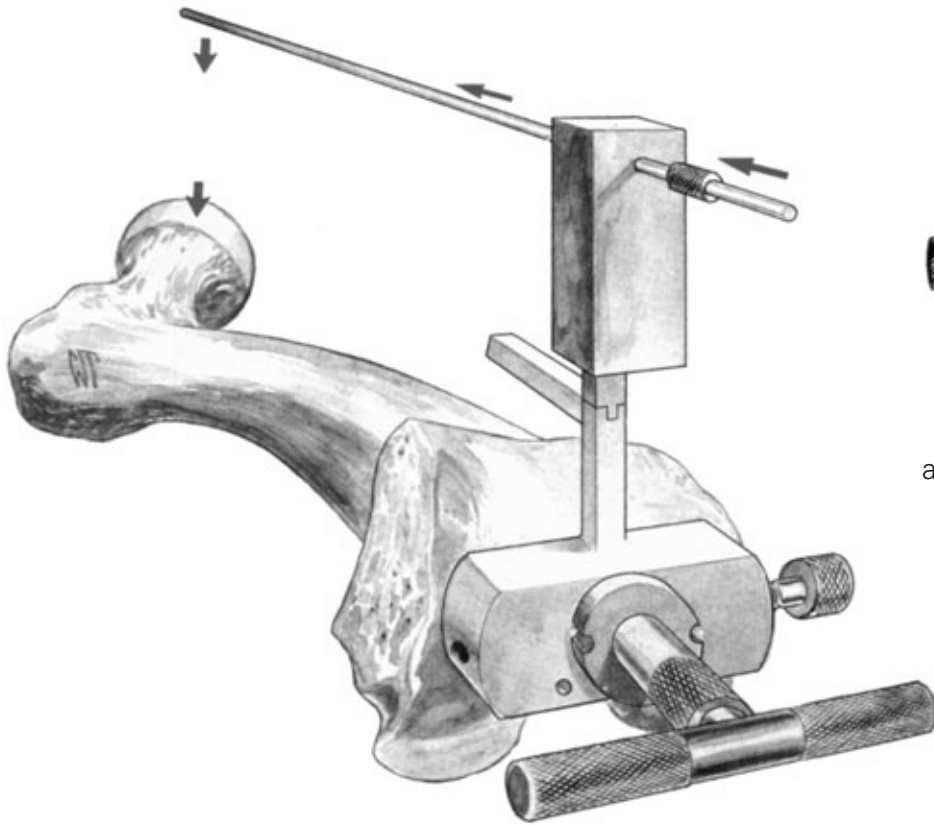
The medullary canal is entered as described above. The 0-degree bushing is assembled to the femoral locating device, the rod introduced through the locating device into the medullary canal.

The tower is assembled to the locating device, the alignment rod introduced through the hole and advanced to the hip such that the alignment rod is centered over the femoral head. Resection is as described above.

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NOTES

CAUTION: Federal Law (USA) restricts these devices to sale by or on the order of a physician.

For more information about DePuy products, visit our web site at **www.jnjgateway.com.**

DePuy Orthopaedics, Inc.
700 Orthopaedic Drive
Warsaw, IN 46580
USA
Tel: +1 (800) 366 8143
Fax: +1 (574) 267 7196

DePuy International Ltd
St Anthony's Road
Leeds LS11 8DT
England
Tel: +44 (113) 270 0461
Fax: +44 (113) 272 4101