

Aesculap® OrthoPilot®

OrthoPilot® KneeSuite - TKR Surgical technique
Total Knee Revision e.motion® and Columbus®



Aesculap Orthopaedics

OrthoPilot® TKR – Total Knee Revision

¹ Jenny JY, Clemens U, Kohler S, et al.: Consistency of implantation of a total knee arthroplasty with a non-image-based navigation system: a case-control study of 235 cases compared with 235 conventionally implanted prostheses. *J Arthroplasty* 2005;20(7):832-9.

² Jenny JY, Miehke RK, Giurea A: Learning curve in navigated total knee replacement. A multi-centre study comparing experienced and beginner centres. *Knee* 2008;15(2):80-4.

³ Thielemann FW, Clemens U, Hadjicostas PT: Computer-assisted surgery in revision total knee arthroplasty: early experience with 46 patients. *Orthopedics* 2007;30(10 Suppl):S132-5.

⁴ Sheng PY, Konttinen L, Lehto M, et al.: Revision total knee arthroplasty: 1990 through 2002. A review of the Finnish arthroplasty registry. *J Bone Joint Surg Am.* 2006 Jul;88(7):1425-30.



OrthoPilot®

The OrthoPilot® system assists in the precise implantation of knee and hip endoprotheses.¹ Perfect integration in the surgical workflow as well as minimal prolongation of operation time were essential criteria in the development of the OrthoPilot® system.² At the same time, we focussed on a navigation system that is non-traumatic for the patient. From the beginning, a method was developed that dispenses with CTs and MRIs and the X-ray exposure or expenses that these entail, and requires the least possible amount of extra operation time.

- CT Scan not required
- Ergonomic instruments precisely aligned to the surgery
- User-friendly navigational flow integrates itself easily into the operation
- Proven precision of implant alignment
- Intraoperative documentation with OrthoPilot®
- Numerous international studies confirm significantly better alignment
- Routinely used in over 600 hospitals
- Over 300 OrthoPilot® publications worldwide e.g.,³

The failure rate of knee revisions after 10 years is 22 %, ⁴ and while failures are due to a wide range of reasons, common reasons are:

- Shift, mainly in the form of joint line proximalisation, resulting in patella baja
- Faulty axis alignment
- Malrotation of the implants
- Imbalance of extension gap in relation to flexion gap

With OrthoPilot® TKR, a unique navigation software especially designed for knee revision, and which addresses these problems, is available for the first time. Results show that with OrthoPilot® TKR, precise axis alignment as well as optimised joint line reconstruction and rotational alignment of the femur component can be achieved,³ while taking into account the ligament situation by simulation of the expected extension and flexion gaps for good knee stability. A longer life span and thus a reduction in the failure rate of knee revisions is expected.

OrthoPilot® TKR – Total Knee Revision

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OrthoPilot® TKR – Total Knee Revision

1 | Instrument overview

Femur-RB revision, C-hook



large	NE191R
small	NE163R

Tibia-RB revision



NE192R

Straight pointer



FS604

Femoral orientation block



e.motion® NE440R

Columbus® NE324T

T-handle for revision and navigation adapter



T-handle for revision	NE198R
Navigation adapter	NE199R

Tibial revision sawing guide



e.motion®, right	NE196R
e.motion®, left	NE197R
Columbus®, right	NQ651R
Columbus®, left	NQ650R

Tibial cut control plate



NP617R
NP617RM

Revision spreader with spreader forceps



Revision spreader	NE750R
Spreader forceps	NP609R

OrthoPilot® TKR – Total Knee Revision

1 | Instrument overview

Distal femoral revision sawing guide



e.motion® NE200R

Columbus® NQ704R

4 in 1 revision sawing block with 2 fixing clips



e.motion® F2 – F8 NE722R-NE728R

Columbus® F2 – F8 NQ721R-NQ728R

Active transmitters



3 x FS601

Passive transmitters



Yellow FS633

Blue FS634

Red FS635

2 | Preoperative X-ray image-based planning



The OrthoPilot® system and the revision software can be used in all cases of bicondylar implant failure (non-septic and firmly in position) where an implant replacement with a revision prosthesis is indicated. Bone quality and hip joint flexibility should be adequate.

Note:

The corresponding notes in the respective surgical technique descriptions, instructions for use and package inserts, in particular in the instructions for use for the OrthoPilot® application software TKR TA012791, must be observed.

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3 | Preoperative planning



Aesculap considers it necessary to carry out adequate preoperative planning on the basis of the following X-ray images:

- Whole leg image in standing position
- Knee joint in AP projection
- Knee joint in lateral projection
- Tangential image of the patella

optional:

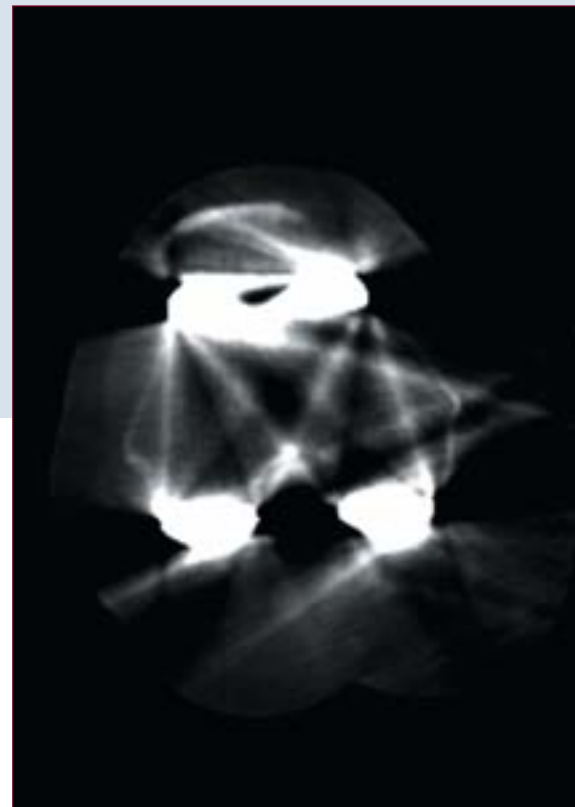
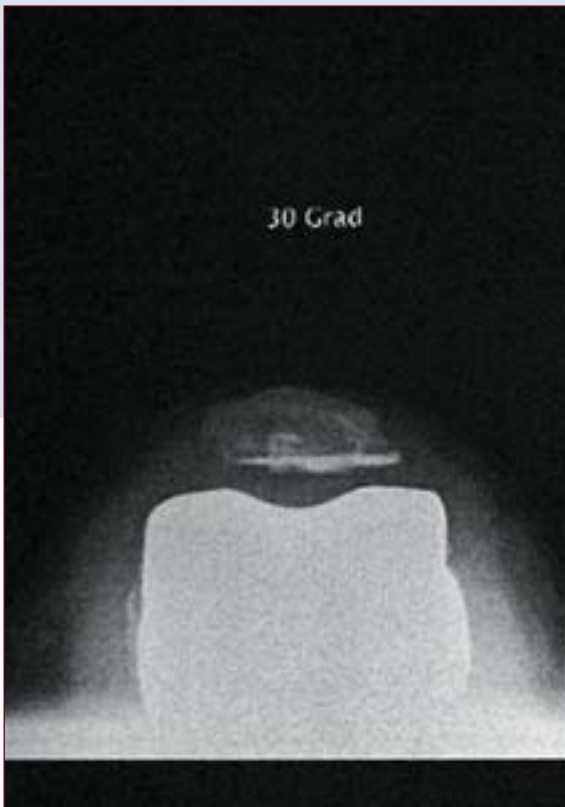
- X-ray images before primary implantation
- X-ray images of the opposite side
- CT image of the primary implant

Selected information which can be obtained on the basis of the X-ray images:

- Axis deviation
- Implant alignment, joint gap, ML implant size
- Slope, joint gap in flexion, AP implant size
- Rotational position, patella position

optional:

- Joint line planning (fibula tip, epicondyles, etc.)
- Joint line planning (fibula tip, epicondyles, etc.)
- Rotational position (epicondyles)



Analysis of the reason for revision is essential when carrying out preoperative planning, as a repetition of the errors which possibly led to primary implant failure should by all means be avoided. In addition to the standard radiological examinations, the surgeon should take the following points into consideration before performing revision surgery:

- Soft tissue situation
- Functionality of the extensor mechanism
- Removal of the primary prosthesis
- Bone preservation
- Restoration of good axis orientation
- Functional stability
- Restoration of the joint line

Anatomic landmarks such as the fibula head or the trans-epicondylar line serve as orientation marks when determining the height of the joint line.

The surgeon can obtain the following information when analysing the X-ray images with the help of the X-ray templates of the Aesculap prosthesis systems Columbus® and e.motion®:

- Angle between anatomic and mechanical femur axis
- Resection heights
- Implant sizes
- Tibial and femoral entry points for intramedullary alignment
- Tibial augments and/or femur wedges required

OrthoPilot® TKR – Total Knee Revision

4 | Patient preparation

Positioning and sterile draping of the patient is carried out according to the standard procedures which are also applied in the conventional technique. Aesculap recommends using a leg holder, which facilitates leg control during the various phases of the operation.

In order to record the points to be registered and to carry out all the necessary bone cuts, it is necessary to change the leg position several times. The leg holder enables the knee position to be varied between full extension and full flexion.

TIP

To facilitate mobilisation of the quadriceps, the knee should be brought to 100° flexion prior to activating the tourniquet.

If a pad is used, make sure that it does not hinder full circulation of the hip joint required for registering the femoral head centre.



5 | OrthoPilot® set-up and transmitter position

5.1 OrthoPilot® positioning

When positioning the OrthoPilot®, ensure that the physician has an unobstructed view of the screen at all times, that the device is positioned on the side opposite the leg to be operated on, and that the camera is ideally at a distance of approx. 2 m (1.8 – 2.2 m) from the transmitters.

In many cases, it has proven beneficial to position the camera at shoulder height on the opposite side of the patient and aligned at approx. 45° to the OP field.

TIP

Point the laser pointer integrated in the handle of the camera (does not apply to FS010) at the knee joint to be operated on while the leg is in approx. 90° flexion. The camera alignment can be adjusted at any stage of the operation, except during determination of the hip centre.

5.2 Femoral transmitters

The following applies in general: the transmitters should be positioned in such a way that they are visible to the camera during the entire operation.

After opening the knee joint, the C-hook NE191R or NE163R is attached in the femoral incision approx. 10 cm proximal from the joint line. For this purpose, the screw of the femoral C-hook is tightened with a manual screw driver. The C-hook should be at a right angle to the femur axis. One of the two transmitter adapters should point towards the femoral head. On the anterior side, it has proven beneficial to place the C-hook on the lateral edge of the cortex.

TIP

The tip of the pointer with a length of approx. 10 cm can be used as a basis for orientation.

5.3 Tibial transmitters

The tibial TKR Rigid Body NE192R is placed on the front edge of the tibia from the medial side either in the incision or through a separate approx. 2 cm long incision further distal on the tibia. After pre-drilling using the 3.2 mm drill NP615R from the navigation instrument



set NP610, NP611, NQ594 or NQ596, and after preliminary preparation using the thread cutter NE292R, the rigid body is fixed with the special monocortical screw. This screw is also tightened with a manual screw driver. The first few turns, in particular, should be carried out under pressure. The transmitter adapter should point in a medial direction, at right angles to the tibia axis.

TIP

The active (FS601, red port) or passive (FS635) transmitter marked red is attached to the femoral rigid body (C-hook) adapter; the active (FS601, blue port) or passive (FS634) transmitter marked blue is attached to the tibial TKR rigid body adapter. The active (FS601, yellow port) or, yellow passive (FS633) transmitter is attached to the respective instruments required at each stage.

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6 | Entering patient-related information

Entering hospital-related data

Name of the surgeon
Name of the hospital/department

Entering patient data

First name
Surname
Date of birth
Gender

Side

left
right

Instrument type

e.motion®_revision_passive
e.motion®_revision_active
Columbus®_revision_passive
Columbus®_revision_active

Planning of the desired post-OP joint line using X-ray images

The joint line can be planned starting either from the femur or from the tibia.

The following options can be selected for planning from the femoral side:

- Femur-related joint line
- Non femur-related joint line

The following options can be selected for planning from the tibial side:

- Tibia-related joint line
- Non tibia-related joint line

The distances in millimetres between reference points which can be freely selected and the planned post-operative joint line of the femur or tibia are entered directly from the X-ray image, while taking into account the respective magnification factor.

In every case, it should be indicated whether the joint line is to be distalised or proximalised by selecting "=>Distal" or "=>Proximal".

Joint line planning either from the femoral or the tibial side is mandatory.

7 | Determination of the joint centres

7.1 Registration of the knee centre

An approximate knee centre point is palpated with the tip of the pointer distally in the centre of the trochlea with the implant in position. For this, the pointer FS604 is connected to the yellow transmitter FS633 (passive) or FS601 (active, yellow port), depending on the transmitter technology used.

TIP

To facilitate palpation, it is recommended to hold the leg in a flexion position. The point at which the medullary channel is opened can be recorded.



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7 | Determination of the joint centres

7.2 Registration of the hip joint centre

The start screen for recording the hip joint centre is displayed.

As soon as the leg is held still, an arrow pointing upwards is displayed, and data collection can begin with movement of the femur in the direction of 12 o'clock.

TIP

The circular movement described may be clockwise or counter-clockwise, depending on the physician's preference.

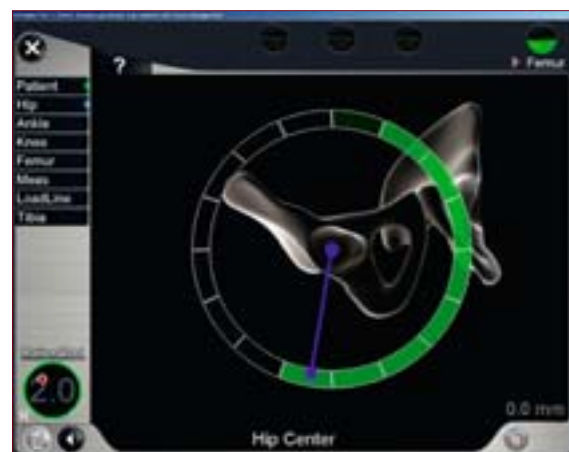
The femur is moved in such a way that the blue point moves over the fields arranged in the circle. As soon as sufficient measurement data for precise determination of the femoral head centre have been recorded, the program automatically jumps to the next step.

Irregular or excessively broad movement can trigger messages indicating inadequate data or excessive scope of movement, and the movement must then be repeated.

TIP

Special attention should be paid to:

- Visibility of the femoral transmitter during the entire movement cycle
- Unrestricted freedom of circular movement (no obstruction by holding and fixing equipment)
- Avoiding transmission of force via the femur to the pelvis
- Avoiding any pelvic movement (this is the surgeon's responsibility; if this cannot be avoided, determination as per 7.3 must be performed)
- Avoidance of a hip flexion angle $> 45^\circ$



7.3 Optional determination of the hip joint centre with pelvic reference

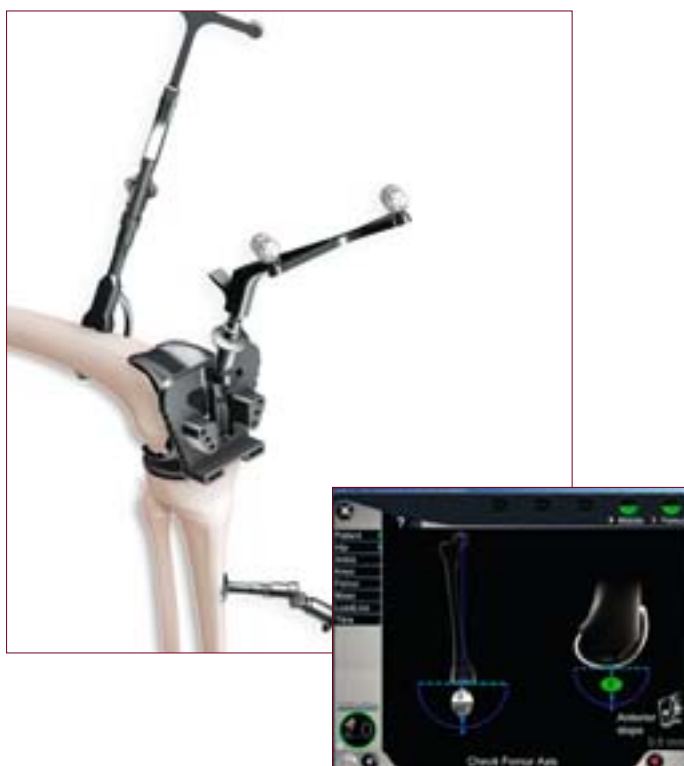
Recording the femoral head centre, which requires a reference transmitter to be attached firmly to the iliac crest, can be started by prolonged activation of the right pedal. This mode is displayed by a separate representation on the screen with the subtitle "Hip joint centre (pelvic ref)".

Large movements of the hip joint must be carried out until the information displayed indicates that sufficient data have been recorded. As soon as sufficient data have been recorded, the program automatically moves on to the next step.



7.4 Plausibility check of the mechanical lateral distal femoral angle (mLDFA)

By applying the orientation block NE440R (e.motion®) or NE324T (Columbus®) at the distal femoral condyles in 0° slope to the mechanical femoral axis, the abnormal varus/valgus position and the mLDFA for the plausibility check are displayed. If this angle seems implausible to the surgeon based on his or her preoperative X-ray planning, determination of the hip joint centre must be repeated (if necessary with the pelvic pin, see Chapter 7.3).



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7 | Determination of the joint centres

7.5 Determination of the ankle joint centre

In this program step, the movement of the transmitter at the foot is tracked in relation to the transmitter at the tibia, and thus the centre of the ankle joint is determined.

The transmitter is fixed to the metatarsal area via the footplate NM769R intended for that purpose and using the elastic strap NM743. The sterile fixing is effected supracutaneously on the sterile draping. After attaching the footplate, the transmitter is attached, which should point toward the camera.

By pressing the right pedal, data collection is started. As soon as sufficient measured data have been recorded, the software automatically moves on to the next program step.

TIP

In order to coordinate the actual movement with the display on the screen, it is best to start the movement in the middle of the flexion/extension range of the ankle joint. If the maximum physiological and anatomical range of movement was repeatedly covered, the user can also call up the next step (by pressing the right pedal).

In cases of an arthrodesis, this step can also be skipped. In this case, the ankle joint centre is determined exclusively on the basis of palpation of the malleoli and the anterior ankle joint point.



7.6 Determination of the knee joint centre

In this program step, the movement of the transmitter at the femur is tracked in relation to the transmitter at the tibia, and the centre of the knee joint is thus determined.

The message "knee center" is displayed on the screen. By pressing the right pedal, determination of the knee joint centre is started. Flexion and extension movements are next carried out with the leg. For this, the leg should be grasped with one hand under the heel.

In order to coordinate the actual movement with the display on the screen, it is recommended to start the movement with the knee in approximately 90° flexion position. Rotation of the tibia is not mandatory. Nevertheless, rotation at 90° flexion may be carried out to increase accuracy as soon as two arrows are displayed on the screen. Filled arrows indicate that the data were recorded. As soon as sufficient measurement data have been recorded, the software automatically moves on to the next program step. If the maximum range of movement was repeatedly covered (even without inward or outward rotation), the next step can optionally be called up by the user by pressing the right pedal.



7.7 Determination of the proximal tibial centre

In this step, the centre of the proximal tibia is recorded at the polyethylene surface of the implant which is in position using the pointer FS604. For this procedure, the entry point of the intramedullary channel is:

- at the centre of the medial-lateral diametral line of the tibial head,
- at the transition from the first to the second third of the anterior/posterior diametral line of the tibial head, as measured from the anterior edge.



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8 | Joint line planning

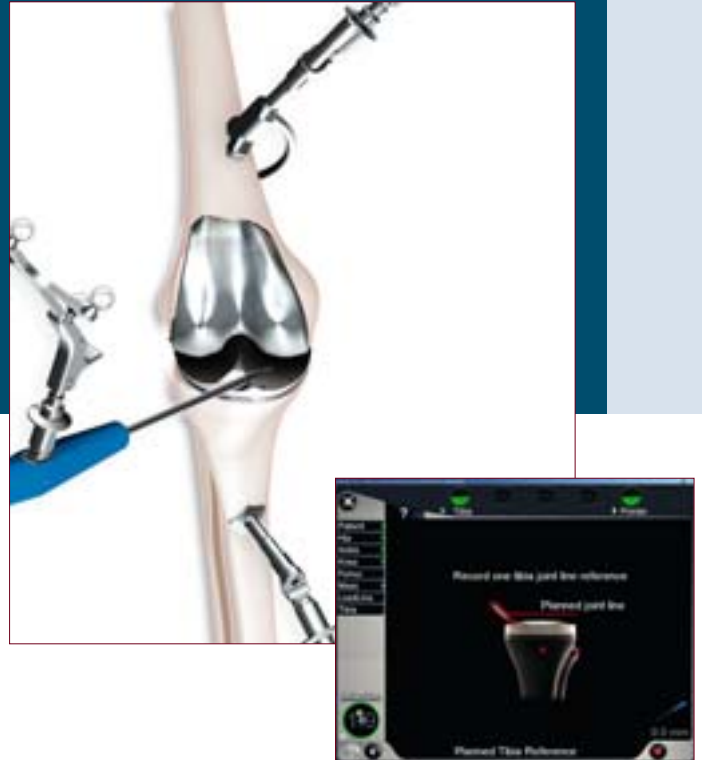
8.1 Planning the tibial joint line

In this step, the reference point for planning the joint line which was selected in preoperative X-ray planning is recorded from the tibial perspective.

Examples of possible reference points:

- Fibula head
- PE inlay
- Implant/bone interface

If no tibia-related joint line planning was performed, the message "not required" appears on the screen, and the step can be skipped by pressing the right pedal.



8.2 Planning the femoral joint line

In this step, a reference point for planning the joint line is recorded from the femoral perspective. Examples of reference points that can also be easily located on the X-ray image prior to surgery:

- Epicondyles
- Implant/bone interface
- Distal condyles of the implant which is in position

If no femur-related joint line planning was performed, the message "not required" appears on the screen, and the step can be skipped by pressing the right pedal.

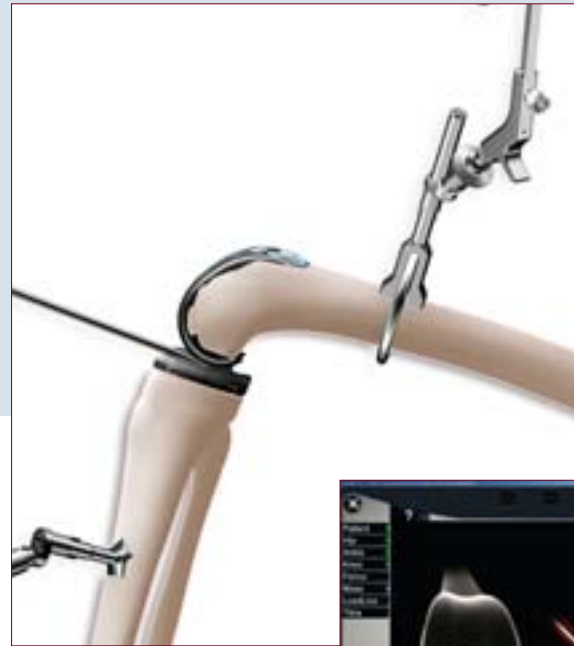


9 | Posterior condylar line and anterior cortical point

9.1 Recording the medial and lateral posterior condyle

The tip of the pointer is placed at the middle of the posterior medial condyle of the primary prosthesis. The point selected is the one lying furthest posterior, i.e. the one with the greatest distance from the anterior femoral cortex.

The recording on the lateral side is made in the same manner.



9.2 Recording the anterior cortical point

This point is required for determining the size of the femoral component ("continuous" display). It is located at the place where the anterior shield of the implant in position ends proximally. In cases of "notching" of the implant in position, a point located somewhat higher on the bone should be selected in order to avoid renewed "notching". In the medio-lateral direction, the most anterior point should be palpated.

The proposal for the size of the femoral component is calculated on the basis of the distance between this point and the posterior condyle. This point is furthermore used later on to determine whether there is a danger of sawing into the anterior cortex.



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10 | Recording the epicondylar line

Next, the epicondylar line is recorded via recording of the medial and lateral epicondyle. In a later program step, the user can decide whether to use the epicondylar line or the connecting line between the posterior condyles palpated on the primary implant as reference line for rotational alignment or correction of the femoral component of the revision implant.

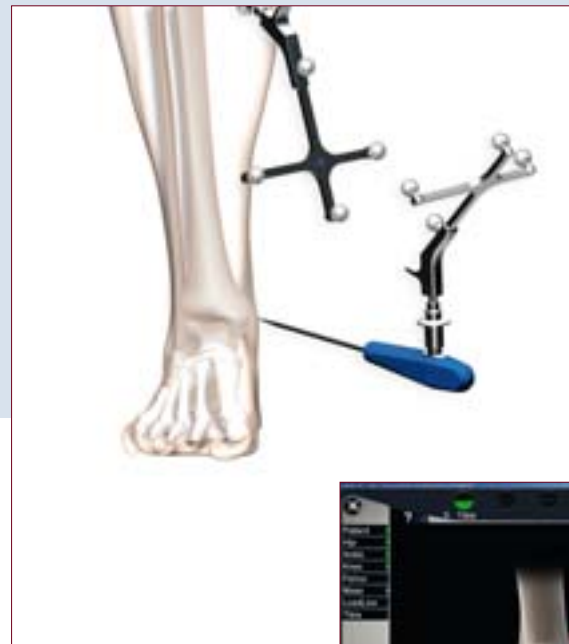
The tip of the pointer is placed first on the medial, then on the lateral epicondyle. The recording is made in each instance by pressing the right pedal.



11 | Ankle joint palpations

11.1 Medial and lateral malleolus

The pointer is placed at the centre of the medial malleolus and the respective point is recorded using the right pedal. The recording on the lateral side is made in the same manner.



11.2 Anterior ankle joint point

For the recording, the pointer is placed at the anterior edge of the distal tibia as close as possible to the ankle joint gap. The following step is displayed: "Anterior ankle joint point". This palpation point should lie on the central tibial axis immediately adjoining the ankle joint centre. It should be palpated there (as indicated by the red point) and not in the middle between the two malleoli.

TIP

The second metatarsus/second ray or the extensor hallucis longus tendon can be used as a reference here.



OrthoPilot® TKR – Total Knee Revision

12 | Leg axis, condyle recording and rotation determination

12.1 Representation of the mechanical leg axis

In the following step, the registered axis situation is displayed in coronal and in sagittal view. The axis situation is displayed dynamically while the relationship between the mechanical tibial axis and the mechanical femoral axis is calculated on a moment by moment basis. The system thus enables dynamic goniometry of the knee joint, including specification of the current axis deviation or flexion position within the scope of movement.

TIP

This step can be used as a plausibility check of the abnormal axis position in various flexion positions of the leg, and also permits preliminary conclusions to be drawn regarding the ligament situation by applying varus and valgus stress.



12.2 Condyle recording

The distal and posterior condyles of the primary implant are recorded with the help of the femoral orientation block NE440R (e.motion®) or NE324T (Columbus®) (with foot plates NE441RM/NE442RM), which must be in contact with both the distal and the posterior condyle surfaces. The alignment in the sagittal plane is displayed on the right half of the screen. Data should be recorded when the block is in approx. 0° slope in relation to the mechanical femur axis in the sagittal plane. For additional information, the alignment angle in degrees of the epicondylar line recorded with the pointer in relation to the posterior condyles of the primary implant is indicated.

TIP

If inward rotation of the primary implant was detected by means of a pre-operative CT image, the epicondylar line consequently appears to be rotated outward in the display in relation to the implant which is rotated inward. If this value is not plausible, renewed palpation of the epicondyles is recommended.

Before recording the condyles, the tibial implant, or at least the polyethylene inlay should be removed.

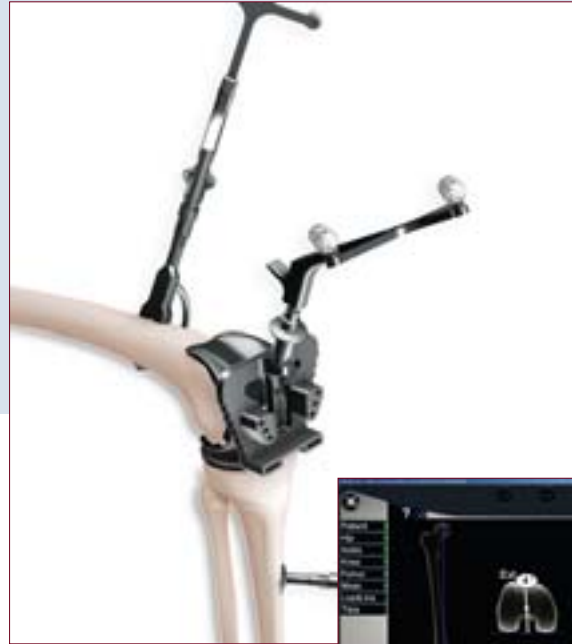


12.3 Setting femoral rotation

The new rotational position of the femoral revision prosthesis is adjusted using the orientation block NE440R (e.motion®) or NE324T (Columbus®) without foot plates. This rotational value is decisive for calculation and display of anterior notching, since the femoral prosthesis cannot be freely positioned in AP direction, its position being determined by the stem position +/- 2 mm offset option for e.motion® and +/- 4 mm for Columbus®. This value is adopted in the femoral planning screen, but can also be readjusted there later on.

TIP

Ideally, rotational correction, should such be required when changing from the primary to the revision prosthesis, is determined beforehand with the help of the epicondyles using a CT image.



Note:

For the femur first technique, see Chapter 23: Femur first technique

OrthoPilot® TKR – Total Knee Revision

13 | Recording the tibial bone situation

13.1 Recording the medial and lateral tibial bone situation

The tip of the pointer is placed on the medial tibial plateau. Then the lateral tibial plateau is recorded. For palpation, it is recommended to use significant landmarks, such as one of the lowest points of the more severely damaged side and one of the highest points of the less severely damaged side. In a later step, the position or incision height of the tibial incision block is shown as determined by these two palpations.



13.2 Recording the tibial medullary channel

The deviation of the tibial medullary channel in relation to the mechanical axis in terms of varus/valgus angle and tibial slope can be both recorded and also modified/corrected to a minor extent via the navigation adapter NE199R equipped with the yellow transmitter (FS601 active, or FS633 passive) and attached to the revision T-handle NE198R.

This step can be skipped by prolonged pressing of the right foot pedal, and resection of the tibia can be navigated directly without reference to intramedullary alignment.



14 | Tibial plateau resection

After gradual introduction of intramedullary reamers from the e.motion® or Columbus® instrument set, the revision T-handle NE198R with navigation adapter NE199R is removed. This is continued until the desired length and diameter is reached under continuous navigation control with respect to varus/valgus angle and slope. The 0° tibial connection sleeve NE190R can then be attached to the stem.

Depending on which leg, left or right, is being operated on, the yellow transmitter is either attached directly to the tibial cutting guide – for e.motion®: NE196R for the right leg, NE197R for the left leg – or, for Columbus®, to the adapter NE162R which is attached to either of the cutting guide NQ651R (right leg) or NQ650R (left leg). The connecting element NE171R is used to establish connection through the respective sawing slit with the 0° tibial sleeve attached to the reamer.

Due to the connection to the intramedullary reamer which is fixed in position, the varus/valgus angle and the tibial slope can no longer be modified. The precise resection height in relation to the bony reference points palpated on the tibia medially and laterally can be determined by moving the cutting guide in a proximal or distal direction.

The tibial cutting guide is initially fixed from the anterior side using two headless screw pins, after which the connecting element to the reamer and the reamer itself are removed. The cutting guide can now still be relocated via the available pin holes, e.g. for a staggered cut if this is required.

If the tibial medullary channel recording step was skipped by prolonged pressing of the pedal, the tibial cutting guide with the yellow transmitter attached can be freely navigated to the desired varus/valgus and slope value in relation to the mechanical axis, irrespective of the alignment of the tibial diaphysis or the medullary channel. The height of the tibial resection can be navigated to the points previously recorded.



At the centre of the upper border of the screen, the PE inlay best suited on the basis of given resection planning for achieving the planned joint line for a possible joint line planned from the tibial side is indicated. In addition, the deviation from the planned joint line on the basis of given cutting template alignment and the PE inlay indicated appears centrally in the middle of the screen.

When the desired resection height has been set, the cutting guide is additionally fixed medially and laterally via oblique headed pins, and the resection can then be performed.

TIP

In order to avoid contamination of the marker spheres on the transmitters, it is advisable to either remove the transmitters or to cover them appropriately until resection has been completed.

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15 | Determining the size and reassessing the tibial resection

15.1 Implant size determination

At this stage, after tibial resection, it is advisable to determine the size of the femur and of the tibial plateau using appropriate instruments (trial plateaus for the tibia and femoral orientation block for the femur). If necessary, the femur size must be corrected via the plus and minus symbols with the help of prolonged pressing the pedal on the right or left as appropriate. In the Aesculap knee system e.motion®, femur-tibia combinations in which the tibial plateau is more than one size smaller than the femoral implant should be avoided.



15.2 Reassessing the tibial resection

The tibial control plate NP617R or NP617RM with attached yellow transmitter serves to reassess and record the tibial resection.

The screen displays the actual alignment and position of the resection surface in relation to the mechanical axis in terms of varus/valgus angle and tibial slope.

The data recorded here using the right pedal are used for further calculations, and it is therefore imperative to record this value afresh if resection of the tibia is repeated.

If augmentation of the tibia is intended, either medially or laterally or even bilaterally, it is mandatory during this step to lay the appropriate trial augmentations from the e.motion® or Columbus® instrument set underneath the control plate before performing the measurement.

If joint line planning from the tibial side was performed, the PE inlay accordingly best suited for achieving the planned joint line is indicated at the centre of the upper part of the screen. As central information, the deviation from the planned joint line appears in the centre of the screen.



16 | Recording the femoral bone situation

The objective of the following steps is to use the pointer to record the distal and posterior condylar defects for augmentation planning later on. The data are recorded in the following sequence:

- Posterior condyle, medial
- Posterior condyle, lateral
- Distal condyle, medial
- Distal condyle, lateral



The values displayed for the two distal palpations are the distances in millimetres from the respective bone palpations to the planned femoral joint line. This distance must be filled out by the implant (distal implant thickness) together with appropriate augments.



OrthoPilot® TKR – Total Knee Revision

17 | Measuring the joint gap in extension and flexion

17.1 Measuring the joint gap in extension

Before measuring the flexion/extension gap, osteophytes which could influence ligament tension and capsular tension must be removed. With the leg extended as far as possible (0°–10°), the distractor NE750R is introduced between the tibial resection and the distal femur condyles and is forced apart with identical force medially and laterally using the spreader forceps NP609R. The plates of the distractor must lie flat on the tibial resection surface in order to ensure precise measurement.

The OrthoPilot® screen indicates the medial and lateral gap distances in millimetres and the mechanical leg axis in degrees, revealing possible ligament release, as well as the flexion position of the leg.

After recording the data by pressing the right pedal, the distractor is released and the leg moved into a 90° flexion position.

TIP

Since the gap distances represent the distance from the recorded tibial resection surface to the respective bone points recorded distally on the medial and lateral distal condyle, a preparation plateau can be placed underneath on the tibial side. This prevents possible sinking of the distractor plates into the cancellous bone. If application of the distractor on the femoral side should prove difficult, a femoral trial prosthesis could be attached here, and distraction could thus be carried out against the femoral trial prosthesis.

The gap distances indicated on the OrthoPilot® screen remain unaffected, regardless of whether the distraction procedure is carried out with or without tibial preparation plateau and/or trial femur.

17.2 Measurement of the joint gap in flexion

With the leg in 90° +/- 5° flexion, the distractor is again forced apart medially and laterally with identical force using the spreader forceps, and the gap situation is thus recorded.



18 | Recording the femoral diaphysis

At this stage of the surgical procedure, the alignment of the femoral medullary channel is determined, just as for the tibia, by means of reamers of different diameters, i.e. the angle between mechanical axis and femoral diaphysis is indicated. This value in turn indicates which angled stem should ideally be selected in order to avoid ending up with a femoral distal varus or valgus cut.

Corrections can also, to a minor extent, be achieved here in the course of femoral shaft preparation of the diaphysis via the different reamers which are always introduced under navigation control.

TIP

The target value is either 5°, 6° or 7°, since angled stems are available in the implant systems Columbus® (5° and 7° for cement-free, 6° for cemented) and e.motion® (5° and 7° for both cement-free and cemented, not 6°) for these angles.



OrthoPilot® TKR – Total Knee Revision

19 | Femoral planning

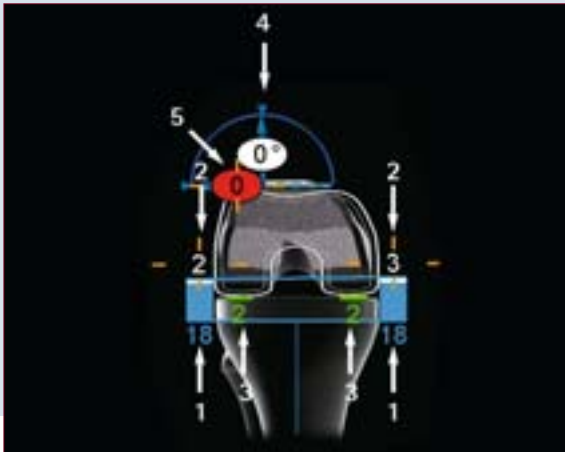


TIP

Yellow values in the cutting height display signify that cutting is performed above the respective reference points recorded at the distal and posterior condyles, i.e. no bone tissue is actually resected. The yellow value can also be taken to signify the distance from the palpated bony reference point of the respective condyle to the rear surface of the femoral implant which must be filled up with cement or with augments.

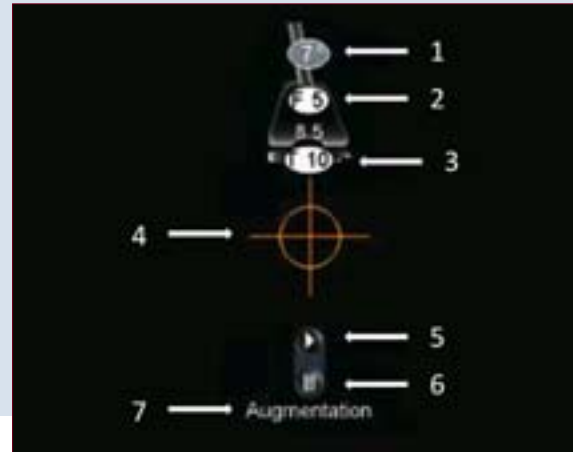
19.1 In extension

- 1 Measured extension gap, here 20 mm laterally and 20 mm medially, indicated by the blue columns and the blue numbers.
- 2 Distal femoral cutting height, here 1 and -1 mm respectively from the lateral and medial sides, indicated by white columns and white numbers or yellow columns and yellow numbers respectively. Yellow signifies a negative cut in relation to the palpated bony defects. Genuine bone cuts are represented by white numbers and white columns.
- 3 Remaining extension gap of 2 mm laterally and 1 mm medially after planned installation of implant components, indicated by the green columns and the green numbers. As soon as the remaining gap distances become negative, they are represented by yellow columns and yellow numbers. A negative/yellow gap distance in clinical terms signifies distension of the soft tissue (e.g. ligaments).
- 4 Varus/valgus display, here 1°, indicated by the arc inside the femur and the number in the elliptic field.
- 5 The value displayed in the rectangle with rounded corners indicates the deviation in mm from the **planned** joint line. If the number is not zero, the information is supplemented by the term proximal for proximalisation of the **planned** joint line, and distal for distalisation of the planned joint line.
- 6 Valgus value of 1° in the grey ellipse as reminder of the stem position from the reamer navigation.



19.2 In flexion

- 1 Measured flexion gap, here 18 mm laterally and 18 mm medially, indicated by the blue columns and the blue numbers.
- 2 Posterior femoral cutting height, here 2 mm laterally and 3 mm medially, indicated by the white columns and the white figures.
- 3 Remaining flexion gaps of 2 mm laterally and 2 mm medially after planned installation of implant components, indicated by the green columns and the green numbers, or by yellow columns and yellow numbers if the remaining extension gap becomes negative. A negative gap distance in clinical terms signifies distension of the soft tissue (e.g. ligaments).
- 4 Rotation, here 0°, indicated by the arc in the femur and the number in the elliptic field. Indicated as number of degrees in relation to the recorded posterior condyles of the primary implant.
- 5 Anterior cutting height (notching), here 0 mm, in relation to the point palpated anterior (position of the anterior femoral shield in relation to this measured point). This value turns red as soon as the femoral shield would come to lie below this palpated point.



19.3 Display and control elements (centre)

- 1 Stem reminder from the reamer navigation step in the grey ellipse, here 7°.
- 2 Femoral implant of size 5 with distal implant thickness of 8.5 mm for e.motion®.
- 3 Total height of the tibial component (metal plate with PE inlay), here 10 mm.
- 4 Orange cross line with circle. This cross line represents a virtual pointer (virtual mouse).
- 5 White arrow tip: if the white arrow tip is selected, the system can be switched to the next step by briefly activating the right foot pedal. This can also be achieved once planning has been completed by prolonged activation of the foot pedal.
- 6 Recycle bin: if the recycle bin is selected, all modified values are reset to the values originally calculated by the software by briefly activating the right foot pedal. This step should be carried out if completely new planning is desired.
- 7 Switching to femoral augmentation planning and back again.

OrthoPilot® TKR – Total Knee Revision

20 | Augmentation planning and distal femur cut



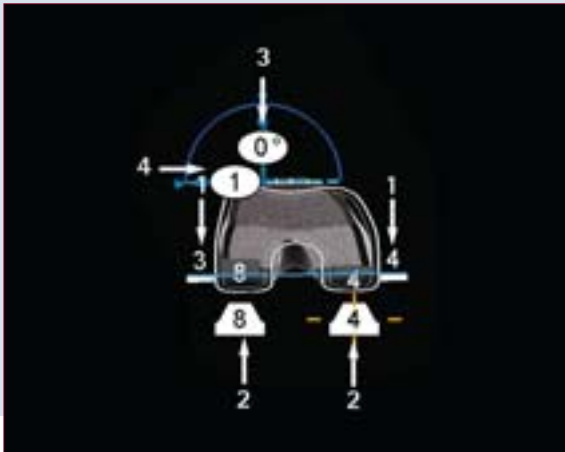
20.1 Control

Augmentation planning is accessed via the "Augmentation" button. Yellow columns and numbers represent negative bone cuts, i.e. resection is carried out distal to the defect point, which can indicate that an augment needs to be used.



20.2 In extension

- 1 Lateral and medial resection height at the distal femur, here 1 mm laterally and -1 mm medially.
- 2 Selected augments for the medial and lateral condyle distally.
- 3 Change with respect **to the planned** joint line, here 0 mm, displayed in the white rectangle.



20.3 In flexion

- 1 Lateral and medial resection height at the posterior femoral condyles, here 3 mm laterally and 4 mm medially.
- 2 Selected augments for the medial and lateral condyle posterior.
- 3 Rotational position of the femoral prosthesis, here 0° external rotation, displayed in the white ellipse. In relation to the recorded posterior condyles of the primary implant.
- 4 Anterior cutting height (notching), here 0 mm, in relation to the point palpated anterior (position of the anterior femoral shield in relation to this measured point). This value turns red as soon as the femoral shield would come to lie below this palpated point.



20.4 Display and control elements (centre)

- 1 Stem reminder from the reamer navigation step in the grey ellipse, here 7°.
- 2 Size 5 femoral implant.
- 3 Total height of the tibial component (metal plate with PE inlay), here 10 mm.
- 4 Orange cross line with circle. This cross line represents a virtual pointer (virtual mouse).
- 5 White arrow tip: if the white arrow tip is selected, the system can be switched to the next step by briefly activating the right foot pedal. This can also be achieved once planning has been completed by prolonged activation of the foot pedal.
- 6 Recycle bin: if the recycle bin is selected, all modified values are reset to the values originally calculated by the software by briefly activating the right foot pedal. This step should be carried out if completely new planning is desired.
- 7 Switching to femoral planning and back again.

OrthoPilot® TKR – Total Knee Revision

21 | Distal femur resection, control and rotational alignment

21.1 Distal femur resection

The 5°, 6° or 7° femoral angled sleeve most fitting for the situation is attached to the reamer from the step "Recording the femoral diaphysis", which was last selected and is still inserted in the femur. The distal femur resection block NE200R (e.motion®) or NQ704R (Columbus®) is fitted with the yellow transmitter (FS633 passive or FS601 active). With the help of the connecting element NE171R, the cutting guide is connected via the sawing slot to the 5°, 6° or 7° femoral sleeve attached to the reamer.

Due to the connection to the intramedullary reamer which is fixed in position, the varus/valgus angle and the slope can no longer be modified. The precise resection height in relation to the bony reference points palpated on the distal femoral condyles medially and laterally is determined by moving the cutting guide in a proximal or distal direction.

The target values are those which were selected during femoral planning. If these values are reached in terms of varus/valgus angle, resection height, joint line and slope, the colour of the ellipses in which the values are displayed changes to green.

If the step "Recording the femoral diaphysis" was skipped by prolonged pressing of the pedal, the distal femoral cutting guide with the yellow-marked transmitter attached can be freely navigated to the desired varus/valgus and slope value in relation to the mechanical axis. The alignment of the femoral diaphysis and the medullary channel are not taken into account in this procedure. The height of the femoral resection can be navigated to the points previously recorded. Possible deviations from the joint line planned in the femoral planning screen on the basis of given cutting guide alignment appear in the centre of the screen. These appear green when the planned values are reached.

TIP

In order to avoid contamination of the marker spheres on the transmitters, it is advisable to either remove the transmitters or to cover them appropriately until resection has been completed.



The femoral cutting guide is initially fixed from the anterior side using two headless screw pins, after which the connecting element to the reamer and the reamer itself are removed. The cutting guide can now still be relocated via the available pin holes.

When the desired resection height has been set, the cutting guide is additionally fixed medially and laterally via oblique headed pins, and the resection can then be carried out.

TIP

The cutting guide slot labelled "0" is decisive for regular resection, and the 4 or 8 mm sawing slot (e.motion®) or the 5, 10 or 15 mm sawing slot (Columbus®) must be selected in cases where augments are needed. For 12 mm augments in e.motion®, the cutting guide can be shifted proximally by a further 4 mm via the existing holes.



21.2 Reassessing the distal resection

After reassessing the distal femur resection using the 4-in-1 cutting guide NE722R-NE728R (e.motion®) or NQ721R-NQ728R (Columbus®), rotational adjustment and AP positioning is carried out in accordance with prior planning. In order to record accurate values, the respective trial augment must be placed underneath the 4-in-1 cutting guide for measurement in cases where distal augments have been prepared.



OrthoPilot® TKR – Total Knee Revision

21 | Distal femur resection, control and rotational alignment

21.3 Setting the rotational alignment

In addition to showing the rotation in relation to the recorded distal condyles of the implant in position, the screen also displays the rotational position in relation to the recorded epicondyles. Furthermore, the AP position in relation to the anterior cortical point as well as the posterior cutting height with indication of the planned augments and the resultant remaining gap distances in flexion are displayed.

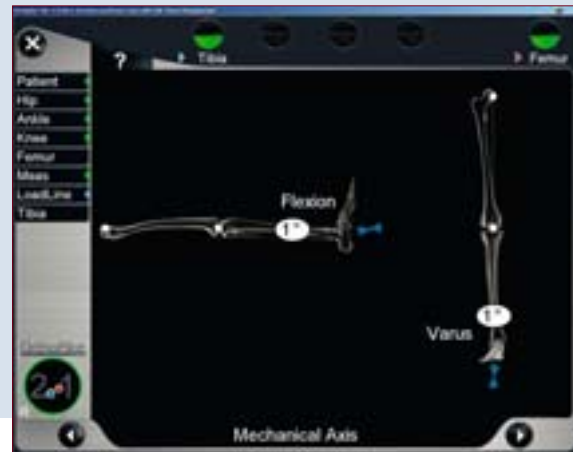
After the desired position has been reached, the 4-in-1 sawing guide is fixed distally in the bone with two pins. The reamer can be removed via the 4-in-1 block, provided its diameter does not exceed 16 mm. For larger diameters, the cutting guide must be removed for removal of the reamer and must subsequently be refitted onto the two pins. The cutting guide is thereupon additionally fixed from the medial and lateral sides using oblique pins. After removal of the distal pins, the cuts can be performed in the sequence anterior, posterior, followed by the oblique cuts. The cutting display for the posterior cut refers to the sawing slot marked 0. Only if posterior augmentation is planned should the sawing slot marked 4 or 8 mm (e.motion®), or 5, 10 or 15 mm (Columbus®) be selected. For 12 mm augmentations at the posterior condyles in e.motion®, a special sawing guide from the manual instrument set must be used, which is applied and affixed to the anterior cut surface after the anterior cut and the two oblique cuts have been performed.

After completing resection, implantation can now be performed, at first with trial implants and then with the final implants. Instrumentation and implant assembly is implemented as described in the manual surgical technique instructions e.motion® PS/Revision O30601 or Columbus® Revision O37701, respectively.



22 | Mechanical axis

The mechanical axis achieved postoperatively (varus-valgus angle), as well as the maximum possible extension of the leg can already be checked using trial implants, and at the end using the final implant. A documented result of the operation is thus provided, which can if desired be attached to the patient file.



OrthoPilot® TKR – Total Knee Revision

23| Femur first technique

Note:

Please follow all steps up to and including Chapter 12.3.

23.1 Recording the femoral diaphysis

At this stage of the surgical procedure, the alignment of the femoral diaphysis is determined, just as for the tibia, by means of reamers of different diameters, i.e. the angle between mechanical axis and femoral diaphysis is indicated. This value in turn indicates which angled stem should ideally be selected in order to avoid ending up with a femoral distal varus or valgus cut. Corrections can, to a minor extent, be achieved here as well in the course of femoral shaft preparation of the diaphysis via the different reamers, which are always introduced under navigation control.

TIP

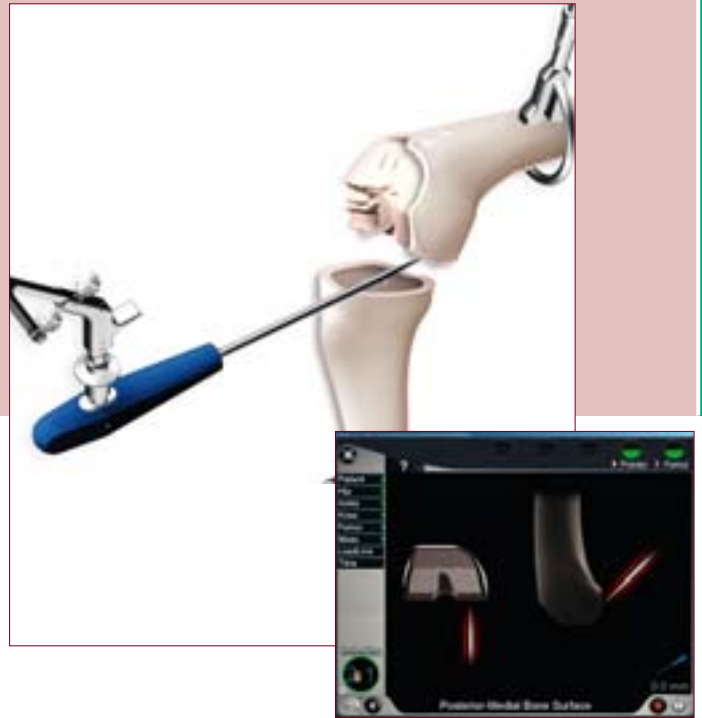
The target value is either 5°, 6° or 7°, since angled stems are available for these angles in the implant systems Columbus® (5° and 7° for cement-free, 6° for cemented) and e.motion® (5° and 7° for both cement-free and cemented, not 6°).



23.2 Recording the femoral bone situation

The objective of the following steps is to use the pointer to record the distal and posterior condylar defects for augmentation planning later on. The data are recorded in the following sequence:

- Posterior condyle, medial
- Posterior condyle, lateral
- Distal condyle, medial
- Distal condyle, lateral



The values displayed for the two distal palpations are the distances in millimetres from the respective bone palpations to the planned femoral joint line. This distance must be filled out by the implant (distal implant thickness) together with appropriate augments.



OrthoPilot® TKR – Total Knee Revision

23| Femur first technique

23.3 Distal femur resection

The 5°, 6° or 7° femoral angled sleeve most fitting for the situation is attached to the reamer from the step "Recording the femoral diaphysis", which was last selected and is still inserted in the femur. The distal femur resection block NE200R (e.motion®) or NQ704R (Columbus®) is fitted with the yellow transmitter (FS633 passive or FS601 active). With the help of the connecting element NE171R, the cutting guide is connected via the sawing slot to the 5°, 6° or 7° femoral sleeve attached to the reamer.

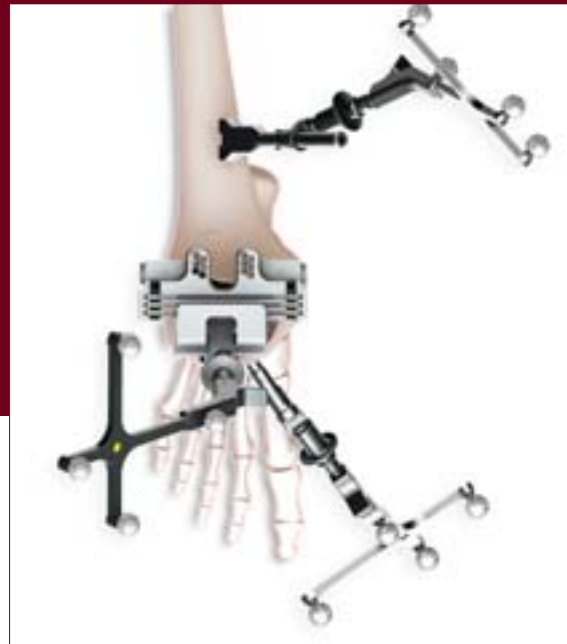
Due to the connection to the intramedullary reamer which is fixed in position, the varus/valgus angle and the slope can no longer be modified. The precise resection height in relation to the bony reference points palpated on the distal femoral condyles medially and laterally is determined by moving the cutting guide in a proximal or distal direction.

The target values are those which were selected during femoral planning. If these values are reached in terms of varus/valgus angle, resection height, joint line and slope, the colour of the ellipses in which the values are displayed changes to green.

If the step "Recording the femoral diaphysis" was skipped by prolonged pressing of the pedal, the distal femoral cutting guide with the yellow-marked transmitter attached can be freely navigated to the desired varus/valgus and slope value in relation to the mechanical axis. The alignment of the femoral diaphysis and the medullary channel are not taken into account in this procedure. The height of the femoral resection can be navigated to the points previously recorded. Possible deviations from the joint line planned in the femoral planning screen on the basis of given cutting block alignment appear in the centre of the screen. These appear green when the planned values are reached.

TIP

In order to avoid contamination of the marker spheres on the transmitters, it is advisable to either remove the transmitters or to cover them appropriately until resection has been completed.



The femoral cutting guide is initially fixed from the anterior side using two headless screw pins, after which the connecting element to the reamer and the reamer itself are removed. The cutting guide can now still be relocated via the available pin holes.

When the desired resection height has been set, the cutting guide is additionally fixed medially and laterally via oblique headed pins, and the resection can then be carried out.

TIP

The sawing slot labelled "0" is decisive for regular resection, and the 4 or 8 mm sawing slot (e.motion®) or the 5, 10 or 15 mm sawing slot (Columbus®) must be selected in cases where augments are needed. For 12 mm augmentation in e.motion®, the cutting guide can be shifted proximally by a further 4 mm via the existing holes.



23.4 Reassessing the distal resection

After reassessing the distal femur resection using the 4-in-1 cutting guide NE722R - NE728R (e.motion®) or NQ721R - NQ728R (Columbus®), rotational adjustment and AP positioning is carried out in accordance with prior planning. In order to record accurate values, the respective trial augment must be placed underneath the 4-in-1 cutting guide for measurement in cases where distal augments have been prepared.



OrthoPilot® TKR – Total Knee Revision

23| Femur first technique

23.5 Setting the rotational alignment

In addition to showing the rotation in relation to the recorded distal condyles of the implant in position, the screen also displays the rotational position in relation to the recorded epicondyles. Furthermore, the AP position in relation to the anterior cortical point as well as the posterior cutting height with indication of the planned augments and the resultant remaining gap distances in flexion are displayed.

After the desired position has been reached, the 4-in-1 sawing guide is fixed distally in the bone with two pins. The reamer can be removed via the 4-in-1 block, provided its diameter does not exceed 16 mm. For larger diameters, the cutting guide must be removed for removal of the reamer and must subsequently be refitted onto the two pins. The cutting guide is thereupon additionally fixed from the medial and lateral sides using oblique pins. After removal of the distal pins, the cuts can be performed in the sequence anterior, posterior, followed by the oblique cuts. The cutting display for the posterior cut refers to the sawing slot marked 0. Only if posterior augmentation is planned should the sawing slot marked 4 or 8 mm (e.motion®), or 5, 10 or 15 mm (Columbus®) be selected. For 12 mm augmentations at the posterior condyles in e.motion®, a special sawing guide from the manual instrument set must be used, which is applied and affixed to the anterior cut surface after the anterior cut and the two oblique cuts have been performed.

After completing resection, implantation can now be performed, at first with trial implants and then with the final implants. Instrumentation and implant assembly is implemented as described in the manual surgical technique instructions e.motion® PS/Revision O30601 or Columbus® Revision O37701, respectively.



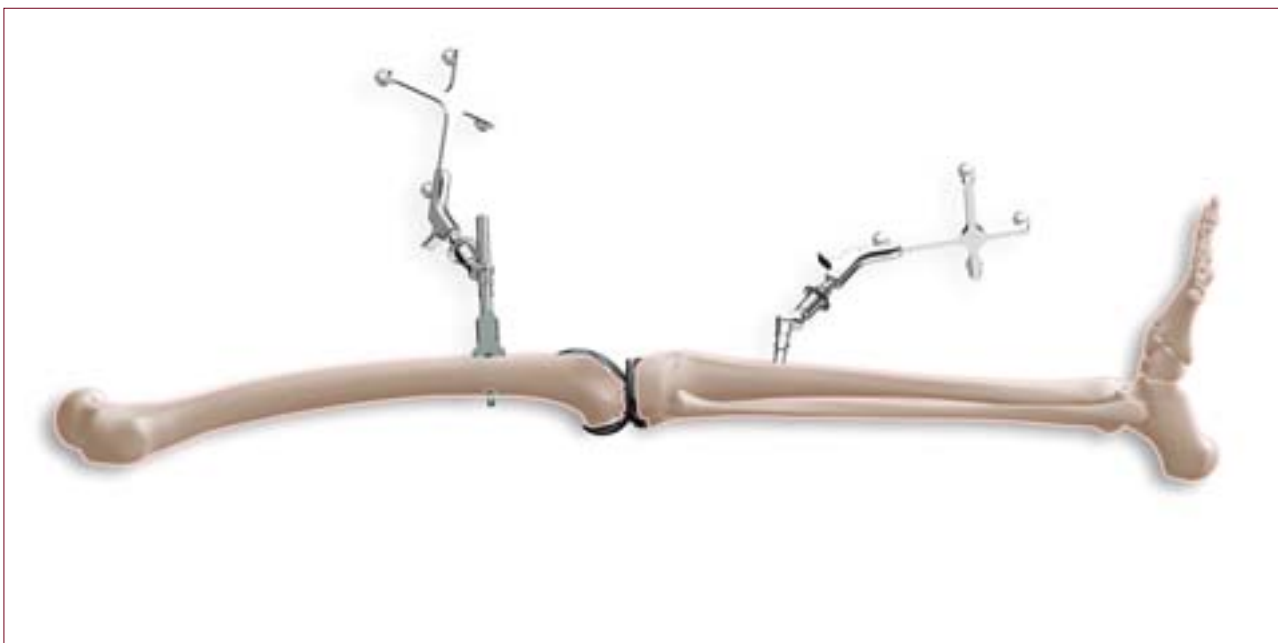
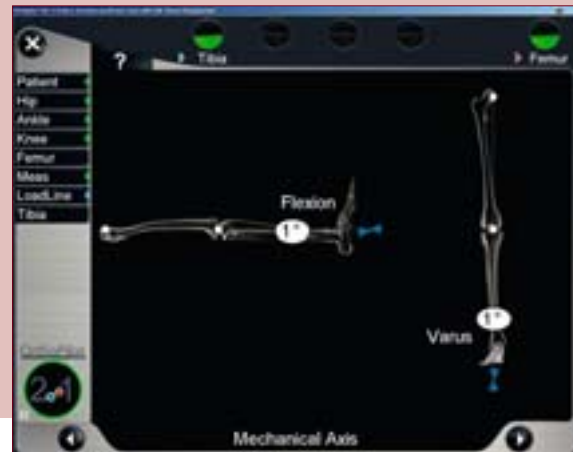
Note:

After preparation of the femur, the procedure is continued by following the steps described in Chapters 13–15. The subsection 15.1 does not apply to the femur first technique, as the size of the femoral component was already determined beforehand.

The final display and reassessment of the postoperative mechanical axis is analogous to Chapter 22 of the tibia first technique.

24 | Mechanical axis

The mechanical axis achieved postoperatively (varus-valgus angle), as well as the maximum possible extension of the leg can already be checked using trial implants, and at the end using the final implant. A documented result of the operation is thus provided, which can if desired be attached to the patient file.



OrthoPilot® TKR – Total Knee Revision

25 | OrthoPilot® TKR e.motion® instrument set overview

25.1 Active transmitter technology



OrthoPilot® TKA peripheral instruments, active		
NP600		
3	FS601	Infrared transmitter
1	NP601P	Storage
1	JF213R	Perforated sieve tray
1	NP615R	Drill, Ø 3.2 mm
3	NP619R	Screw sleeve with adapter
1	NP618R	Screw driver with hex connection, Ø 3.5 mm
1	KH398R	Screw length measuring device
1	NP616R	Insertion aid, Ø 3.2 mm
2	NP620R	Bicortical screws, 30 mm
2	NP621R	Bicortical screws, 35 mm
2	NP622R	Bicortical screws, 40 mm
2	NP623R	Bicortical screws, 45 mm
2	NP624R	Bicortical screws, 50 mm
2	NP625R	Bicortical screws, 55 mm

OrthoPilot® TKA implantation instruments		
NP602		
1	NP617R	Tibial cut control plate
1	NM769R	Footplate
1	NP608R	Universal alignment system
1	FS604	Active pointer
1	NP603P	Storage
1	JF213R	Perforated sieve tray
1	NP597R	Tibial sawing guide, left
1	NP596R	Tibial sawing guide, right
1	NP598R	Distal sawing guide
2	NM743	Elastic holding strap

OrthoPilot® TKR navigated e.motion® instruments		
NE194		
1	NE191801	RB adapter
1	NE192R	Tibia-RB rev. adapter
1	NE199R	T-handle adapter
1	NE198R	T-handle
1	NE193R	Storage
1	NE171R	Sawing guide adapter
1	NE191R	Femur-RB C-hook
1	NE190R	Connection sleeve, 0°
1	NE200R	Femoral sawing guide e.motion® rev.

25.2 Passive transmitter technology



OrthoPilot® TKA peripheral instruments, active

NP168		
1	FS633	Rigid body, yellow
1	FS634	Rigid body, blue
1	FS635	Rigid body, red
1	NP168P	Storage
1	JF213R	Perforated sieve tray
1	NP616R	Insertion aid, Ø 3.2 mm
3	NP619R	Screw sleeve with adapter
1	NP615R	Drill, Ø 3.2 mm
1	NP281R	Screw length measuring device
1	NP618R	Hex connection, Ø 3.5 mm
2	NP620R	Bicortical screws, 30 mm
2	NP621R	Bicortical screws, 35 mm
2	NP622R	Bicortical screws, 40 mm
2	NP623R	Bicortical screws, 45 mm
2	NP624R	Bicortical screws, 50 mm
2	NP625R	Bicortical screws, 55 mm

OrthoPilot® TKA implantation instruments

NP602		
1	NP617R	Tibial cut control plate
1	NM769R	Footplate
1	NP608R	Universal alignment system
1	FS604	Active pointer
1	NP603P	Storage
1	JF213R	Perforated sieve tray
1	NP597R	Tibial sawing guide, left
1	NP596R	Tibial sawing guide, right
1	NP598R	Distal sawing guide
2	NM743	Elastic holding strap

OrthoPilot® TKR navigated e.motion® instruments

NE194		
1	NE191801	RB adapter
1	NE192R	Tibia-RB rev. adapter
1	NE199R	T-handle adapter
1	NE198R	T-handle
1	NE193R	Storage
1	NE171R	Sawing guide adapter
1	NE191R	Femur-RB C-hook
1	NE190R	Connection sleeve, 0°
1	NE200R	Femoral sawing guide e.motion® rev.

25.3 OrthoPilot® TKR e.motion® software

Software module

OrthoPilot® TKR e.motion® FS212

OrthoPilot® TKR – Total Knee Revision

26 | OrthoPilot® TKR Columbus® instrument set overview

26.1 Active transmitter technology



Columbus® PS/REV active navig. instr. supplement

NQ596

1	NE191R	Revision femur rigid body adapter
1	NE163R	Revision femur rigid body adapter, small
1	NE191801	Rigid body attachment, complete
1	NE192R	Revision tibia rigid body adapter
1	NE192R	Revision navigation adapter F.T-handle
1	NE190R	Sliding connection block 0° F. tibial sawing guide
1	NE171R	Revision adapter F. distal sawing guide
1	NE445R	e.motion® insert, 5° femoral alignment block
1	NE446R	e.motion® insert, 6° femoral alignment block
1	NE447R	e.motion® insert, 7° femoral alignment block
1	NE324T	Columbus® femoral alignment plate, nav.
1	NE441RM	Posterior condyle plate, left, modif.
1	NE442RM	Posterior condyle plate, right, modif.
1	NP615R	OrthoPilot® spiral drill, Ø 3.2 mm, 160/80 mm
1	NP618R	Orthopilot® screw driver RB-screw F.motor
3	FS601	OrthoPilot® active rigid body
1	FS604	OrthoPilot® active pointer, 0°
1	NP617RM	OrthoPilot® tibial control plate
1	NM769R	OrthoPilot® footplate
2	NM743R	OrthoPilot® elastic holding strap
1	NE162R	Revision extension, F.rigid body adapter
1	NM743R	Revision thread cutter
1	NQ597R	Columbus® PS/REV storage F.NQ596

26.2 Passive transmitter technology



26.3 OrthoPilot® TKR Columbus® software

Columbus® PS/REV passive navig. instr. supplement

NQ594

1	NE191899	Revision femur rigid body adapter
1	NE163R	Revision femur rigid body adapter, small
1	NE191801	Rigid body attachment, complete
1	NE192R	Revision tibia rigid body adapter
1	NE199R	Revision navigation adapter F.T-handle
1	NE190R	Sliding connection block 0° F. tibial sawing guide
1	NE171R	Revision adapter F. distal sawing guide
1	NE445R	e.motion® insert, 5° femoral alignment block
1	NE446R	e.motion® insert, 6° femoral alignment block
1	NE447R	e.motion® insert, 7° femoral alignment block
1	NE324T	Columbus® femoral alignment plate, nav.
1	NE441RM	Posterior condyle plate, left, modif.
1	NE442RM	Posterior condyle plate, right, modif.
1	NP615R	OrthoPilot® spiral drill, Ø 3.2 mm, 160/80 mm
1	NP618R	OrthoPilot® screw driver RB-screw F.motor
1	FS633	OrthoPilot® passive rigid body, yellow
1	FS634	OrthoPilot® passive rigid body, blue
1	FS635	OrthoPilot® passive rigid body, red
1	FS604	OrthoPilot® active pointer, 0°
1	NP617RM	OrthoPilot® tibial control plate
1	NM769R	OrthoPilot® footplate
2	NM743R	OrthoPilot® elastic holding strap
1	NE162R	Revision extension, F.rigid body adapter
1	NE292R	Revision thread cutter
1	NQ595R	Columbus® PS/REV storage F.NQ594
1	JH217R	1/1 sieve tray lid, large, perforated, 489 x 257 mm

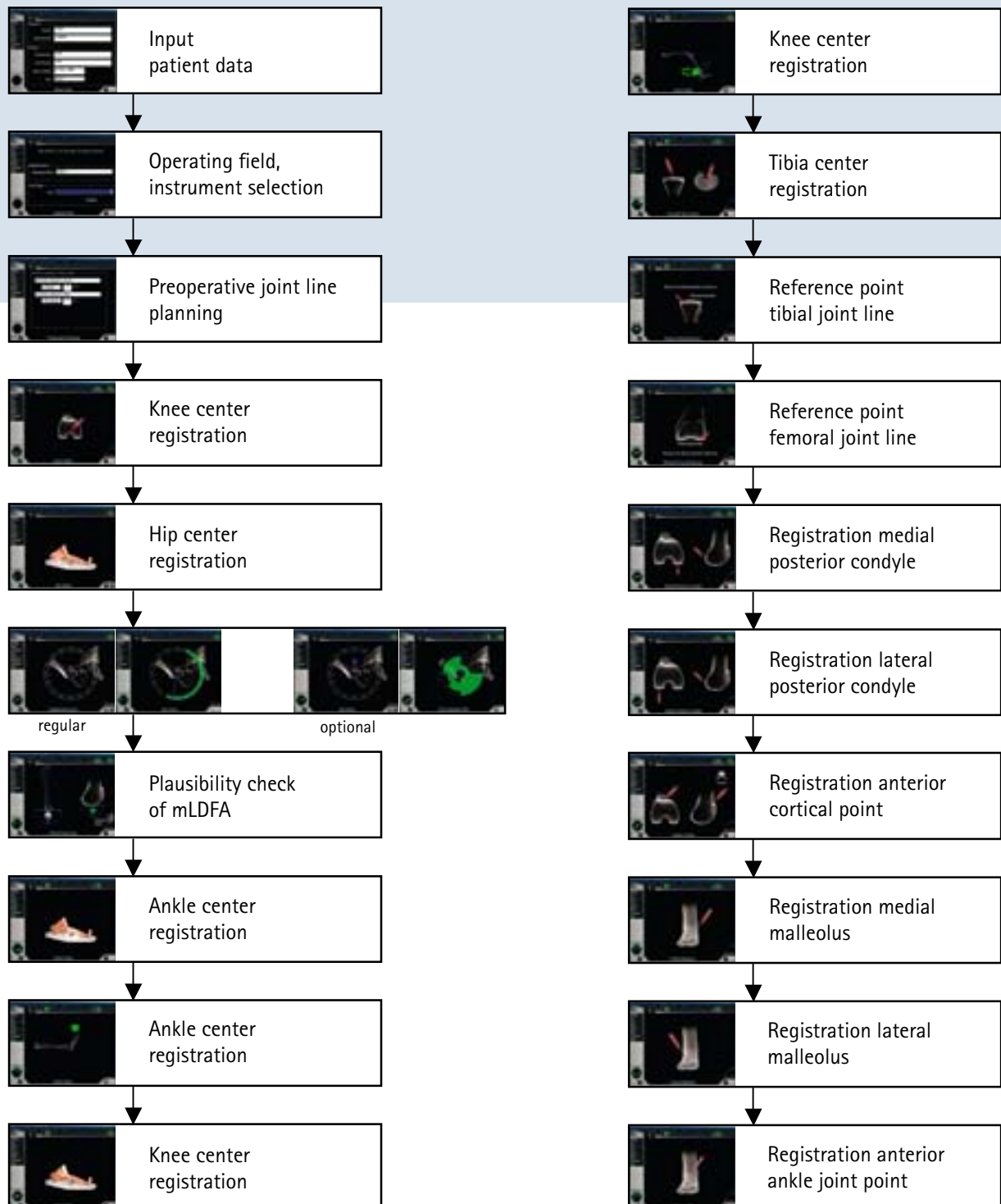
Software module

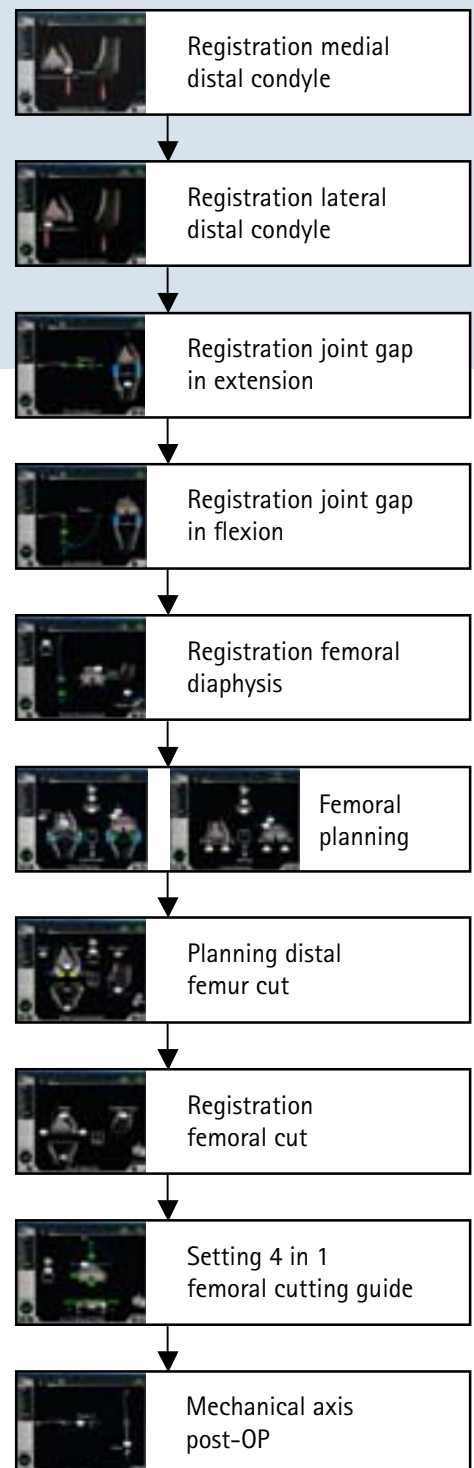
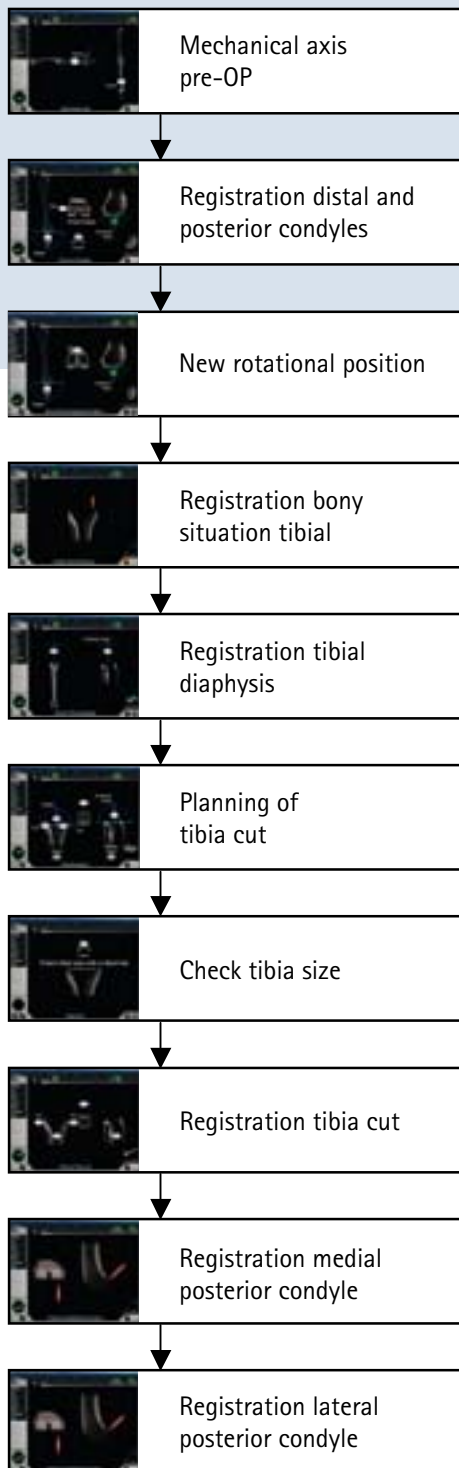
OrthoPilot® TKR Columbus® FS222

OrthoPilot® TKR – Total Knee Revision

27 | Schematic program flow TKR 1.0

27.1 Schematic program flow – tibia first

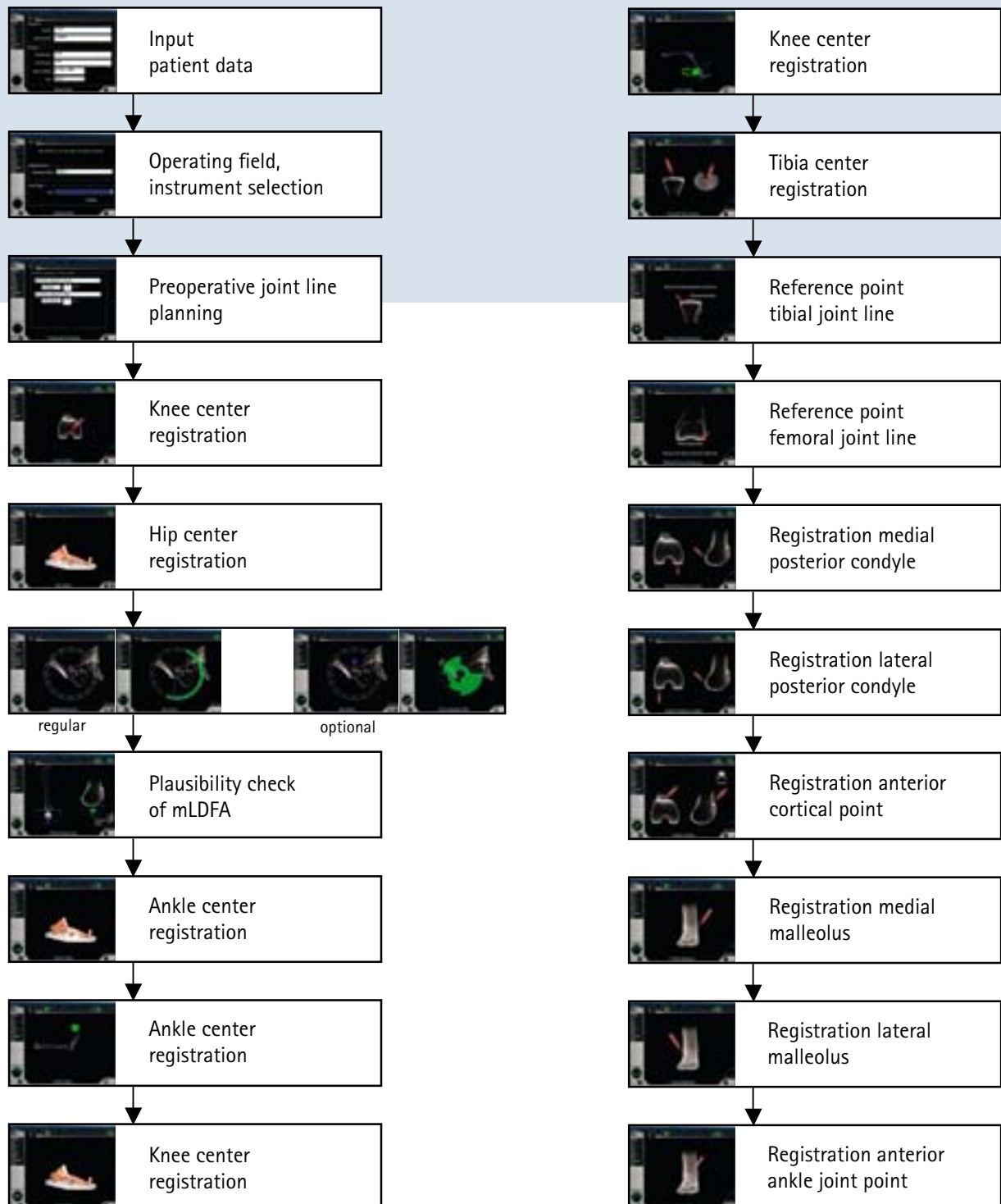


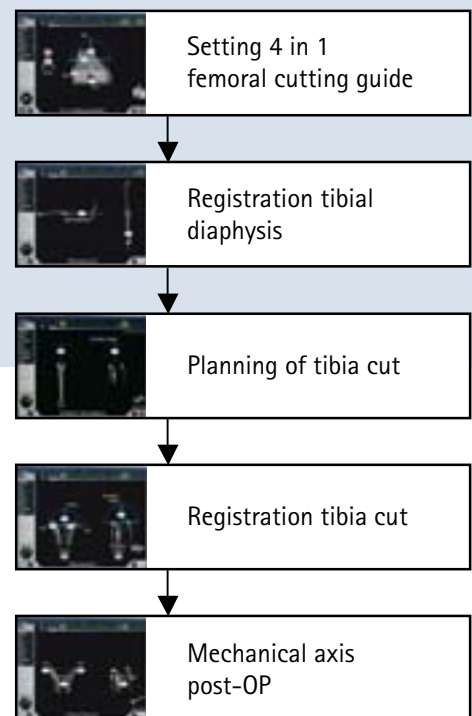
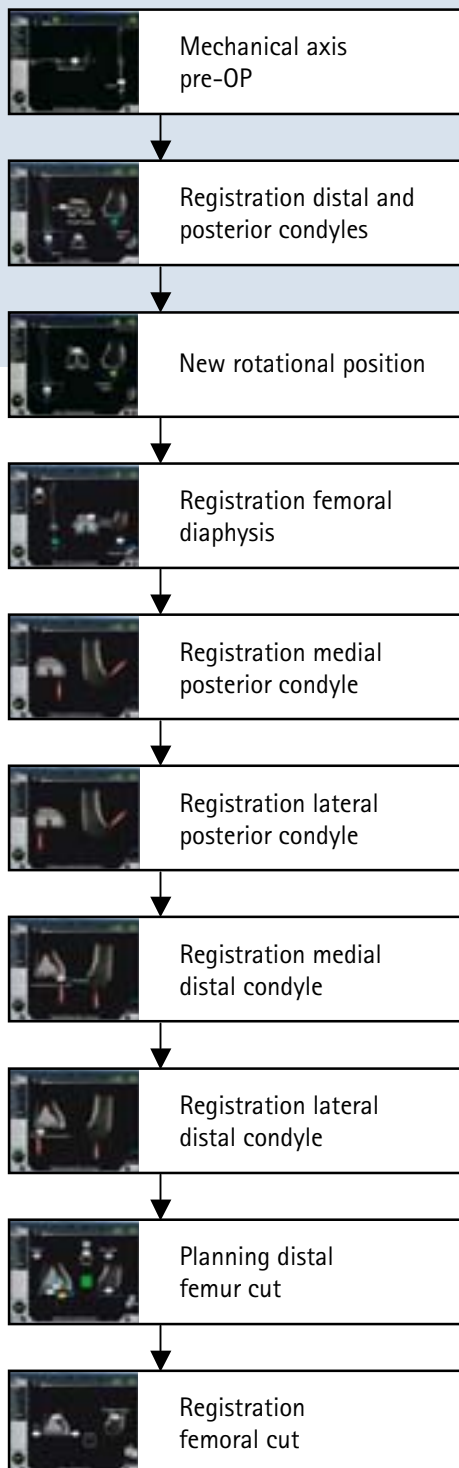


OrthoPilot® TKR – Total Knee Revision

27 | Schematic program flow TKR 1.0

27.2 Schematic program flow – femur first





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