

Mako Total Hip Express workflow guide Direct Anterior Approach





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Express workflow overview



CT- based planning



Pins, pelvic array, exposure and landmarks



Pre-op hip length and offset capture



Acetabular registration



Guided reaming



Guided cup impaction



Femoral preparation



Trial reduction and reduction results

Mako Total Hip with Direct Anterior

workflow resources



Mako Total Hip pre-planning with Insignia®



Mako Total Hip express workflow procedural video - Standard table



Mako Total Hip express workflow procedural video

- Ipsilateral pins
- Specialty table

Consider pre-op patient clinical assessment and pre-op history with emphasis on any observed leg length discrepancy.

- Set new M/L axis if needed at beginning of planning (ex. Teardrop) (Figure 1).
- Review femoral landmarks for consistency between sides.



Figure 1: Assess M/L axis

Hip length and combined offset assessment

Hip length and combined offset will change based off of planned cup and stem positioning.

Observe hip length and combined offset in millimeters vs. the opposite hip as well as vs. the pre-op hip (Figure 2).

Plan hip length and combined offset to what the clinical goals are for the patient.



Figure 2: Hip length and combined offset matrix

Understanding hip length and combined offset calculations in the pre-plan

Hip length calculation



ASIS axis or redefined M/L axis to the lesser trochanters

Combined offset calculation



Midline to two points in the femur creating a canal axis (femoral offset + M/L position of cup)

Cup planning workflow

Reaming view

Use reaming view and picture-in-picture (PIP) views to plan the size and position of the cup (Figure 3).

Coronal PIP (Figure 4):

- Position height and medialize the cup using the teardrop
- Restore center of rotation (COR)

Transverse PIP (Figure 5):

- Center between A/P columns
- Limit any anterior overhang
- Restore COR
- Confirm medialization using the fossa
- •Cup should approximately bisect the magenta line



Figure 3: Reaming view





Fig. 4: Coronal PIP

Fig. 5: Transverse PIP

Considerations:

- Bone deficiency
- Iliopsoas impingement
- Contralateral leg length discrepancy
- Combined anteversion goals
- Femoral head size

> 3D cup view

Assess cup position in the 3D cup view (Figure 6). Rotate the view to ensure the cup is adequately buried anteriorly.



Figure 6: 3D cup view

Stem planning workflow

Stem options

Cementless: Insignia[®], Accolade[®] II **Cemented:** Exeter[®]

Plan the stem in the coronal, transverse and sagittal views.

CT view

Coronal view (Figure 7):

• Size stem, view planned neck cut

Sagittal view (Figure 8):

• Ensure stem is planned within cortices, but not undersized. Three points of contact help limit version changes.

Transverse view (Figure 9):

• Plan version at level of neck resection

Neck resection view

Use as a visual reference intraoperatively when preparing the femur to help guide stem version (Figure 10).

Scroll through to see planned stem relative to canal and broaching path.



Figure 7: Coronal view





Figure 8: Sagittal view

Figure 9: Transverse view



Figure 10: Neck resection view *Insignia Hip Stem

Digital ruler

Capture preoperative measurements (Figure 11) to use intraoperatively (Figure 12) to help execute the neck cut.

- 1. Select an identifiable landmark on the femur (i.e. the head/neck junction, osteophyte, divot or ridge on bone).
- 2. Measure to the planned neck resection line.



Figure 11: Preoperative



Figure 12: Intraoperative

Functional Hip Positioning[™]

Pelvic tilt planning

Cup planning mode

Obtain pre-op seated and standing lateral x-rays.

- Measure pelvic tilt (PT) or sacral slope (SS).
- Enter seated and standing values (Figure 13).

View the cup position and combined version in the seated, standing and supine poses.

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Figure 13: Input PT/SS values

Calculating pelvic tilt and sacral slope

Pelvic tilt or sacral slope measurements can be measured using a PACS system or any other preferred method of calculating an angle between two lines on the X-ray image.

Pelvic tilt

- Create a line from the pubic tubercle to the ASIS
- •Create a vertical plumb line from the pubic tubercle
- Measure angle between the two lines
- Specify direction (posterior in this case, i.e., APP is posterior to VP)



Figure 14: Pelvic tilt

or

Sacral slope

- Create a line that goes through the anterior corner of the S1 endplate to the posterior corner
- Create a horizontal line
- Measure angle between the two lines



Figure 15: Sacral slope

Functional Hip Positioning[™]

Virtual range of motion

Visualize bone-on-bone, implant-on-implant and bone-on-implant impingement pre-operatively.

Adjust range-of-motion values to evaluate potential impingement. **Recommended poses to check: Standing (Figure 16):** 10° extension/ 30° external rotation **Sitting (Figure 17):** 90° flexion/ 50°- 60° internal rotation





Figure 16: Standing pose Figure 17: Sitting pose

If desired, maximum hip flexion can be assessed in the seated position. Minimum acceptable is 140° flexion (0° internal rotation).

Addressing potential impingement

Implant-on-implant impingement

- Adjust cup inclination, version, or both
- Adjust planned stem version if possible
- Increase head size when appropriate
- Use MDM when impingement cannot be avoided

Bone-on-bone impingement

- Plan to remove osteophytes
- Consider offset (eccentric) liner, increasing head length, lateralizing the cup, or increase offset of the stem

Common areas for bone-on-bone impingement:

- Extension lesser trochanter on ischium
- Flexion greater trochanter/ anterior neck on the anterior inferior iliac spine

Bone-on-implant impingement

- Plan to remove osteophytes
- Adjust planned stem version if possible
- Consider offset (eccentric) liner, increasing head length, lateralizing the cup, or increase offset of the stem







Final implant size and placement

X-ray view

Assess final planned hip length and combined offset in X-ray view.

Intraoperative considerations:

- Consider using neck resection view to assess native femoral version and guide broach version.
- Adjust plan and reassess VROM after preparing the femur.



Figure 18: X-ray view

Possible OR set up options



Tips

- Position the robotic-arm as cephalad as the arm board will allow (if present).
- Place robotic-arm on the operative side of the patient.
- Check the reach of the reamer prior to lowering the robotic-arm to the floor.

See page 21 for more on OR layout options

Pins and pelvic array placement

Pins and pelvic array placement workflow

Place pins on contralateral or ipsilateral side. Placement should be at least two finger breadths posteriorly from the ASIS.



Mark the stab incisions using laser markings on the Crest Pin Clamp.



Use the drill guide to insert the first two pins.



Insert the third pin using the Crest Pin Clamp. Make sure the clamp sleeve contacts the iliac crest prior to tightening.



Attach the pelvic array. Adjust orientation towards the camera.

Example



Two finger breadths from the ASIS



45° angle trajectory on the iliac crest

Ipsilateral pins:

Drape cephalad to expose the iliac crest. Position the tightening knob on the Crest Pin Clamp and the array towards the midline to help limit broaching interference.



Figure 19: Ipsilateral pins

Tips

- Angle the pelvic array in the direction of the camera. Keep in mind the position of the array throughout the entire case, especially if you are planning on airplaning the table.
- Use the pin to gently feel the medial and lateral edges of the crest before centering it across the width.
- To help facilitate crest visibility, make one incision for all three pins.

Pelvic checkpoint and landmarks

Pelvic checkpoint

Place checkpoint outside the reaming area.

Proximal and distal landmarks

Proximal and distal landmarks are captured prior to dislocation and after the hip is reduced to measure the difference in hip length and combined offset.

- Proximal checkpoint (Figure 20): Place as lateral as accessible on the greater trochanter
- Distal checkpoint (Figure 21): EKG lead on the patella





Fig. 20: Proximal checkpoint Fig. 21: Distal checkpoint

Understanding hip length and combined offset calculations *intraoperatively*

Center of rotation (COR): Femoral head center pre-op **or** cup liner center intra-op

"Mechanical" axis: COR to distal checkpoint

"Anatomical" axis: Proximal checkpoint to distal checkpoint

Change in hip length

(Figure 22):

• Femoral length (proximal checkpoint to COR distance in direction of mechanical axis) + Δ cup length (COR change in the superior/inferior direction)

Change in combined offset

(Figure 23):

• Femoral offset (COR to anatomical axis distance) + Δ cup offset (COR change in the medial/lateral direction)





Figure 22: Hip length

Figure 23: Combined offset

- COR (native or impacted cup)
- Proximal checkpoint
- Distal checkpoint

Direct Anterior registration

Tips

- Be sure to review CT landmarks and select points that are obtainable intraoperatively.
- Airplane the table away from you (the surgeon) to enhance visibility to the camera.

Crest landmark



- 3 points on the crest pin clamp or 1 point on crest bone surface
- If capturing point on crest bone surface, ensure the point is centered on the crest.
- If capturing point on the crest pin clamp, ensure the sleeve of the clamp is flat on the crest's surface.

Articular surface



- Ensure the points captured are through cartilage on bone.
- Do not capture points in the fovea.
- Match the spread determined in the COR CT landmark.
- If access to the anterior acetabulum is difficult, bias your points on the posterior side. Be sure to update the COR landmark in the CT landmark page to match the spread of points.

Direct Anterior registration

Posterior and anterior landmark



• Try to capture the landmarks close to the point on the anatomic model. If necessary, the Mako Product Specialist (MPS) can move the location of the CT landmarks to ensure the points are accessible intraoperatively.

Extra-articular surface



• Capture and spread these points outside the rim; go under or through muscle if necessary.

Verification





- Manual verification or Auto verification
- Hold the probe steady on bone within the verification regions to confirm registration. If a verification region is inaccessible, walk the bone to confirm distance to bone.

Guided reaming

AccuStop[™] haptic technology

- During guided reaming, audible, visual and tactile perception control are features designed to aid in achieving accurate bone preparation to plan.¹
- Ream until the green has been removed (Figures 24 and 25).

Tips

- Slow the progression of the reamer as you near 0,0,0 (M/L, S/I, A/P references) to allow the system to more accurately capture reamer and cup depth.
- After reaming to the planned depth, toggle reamer in a 15-degree cone to "dust the rim", this will help ease full seating of the cup.



Figure 24: Reaming beginning



Figure 25: Reaming final

Control features

Orientation constraint

A reamer size within 3mm of the desired final reamer is designed to prohibit the robotic-arm from moving more than 15 degrees from the desired cup plan for inclination or anteversion.



COR constraint

The center of rotation (COR) of the reamer basket is designed to be constrained to the center of rotation of the planned cup placement.



Haptic boundary

The bone model is designed to turn red when the surgeon has reamed more than 1mm past the planned cup position. When the surgeon has reamed 2.3mm past the stereotactic boundaries, the power drill is designed to turn off.



Guided cup placement

Implant the cup at the desired inclination and version determined in the pre-plan (Figure 26).



Figure 26: Impaction page

Intraoperative feedback

• The distance remaining value (Figure 27) will appear as the cup is being impacted. Ensure that the black laser line is showing and impaction handle is all the way down to help obtain accurate values.

▶ Tip

• The distance remaining is measured relative to the deepest reamed location. If a smaller reamer was used first, the final reamer size may have not reached the same depth.



Figure 27: Distance remaining value

Reduction results

After reducing the hip, capture the proximal and distal landmarks to gain intraoperative feedback on hip length and combined offset. Use this feedback to help finalize implant selection.



Figure 28: Hip length and combined offset feedback post reduction

Tips

- Ensure the leg is in the same position when capturing the landmarks as it was in the beginning of the case during the initial captures.
- Do not move the femur between proximal and distal captures. If access to the EKG tab at the patella is difficult, take the distal landmark first to avoid moving the femur between captures.
- Check to make sure the impactor handle is fully seated when capturing final distance remaining value in the impaction page.
- Visualize where the neck cut was planned vs. where the neck cut was made.
- Hip length does not always match leg length. Clinically assess the patient's leg length discrepancy preoperatively.

Intraoperative examples

Draping | Contralateral pin placement

Contralateral side





Final drape: Contralateral side

Operative side



Final drape: Operative side



Final pin placement

Draping | Ipsilateral pin placement

Operative side





Final drape: Contralateral side



▶ Tip

• Drape high to expose the iliac crest for pin placement.







Figure 29: Camera base on the operative side of patient at the head of the table



Figure 30: Camera angled in view of the pelvic array



Figure 31: Robotic-arm as cephalad as possible during reaming and impaction



Figure 32: Angle the back of the robotic system away from the operative area for greater range of motion



Figure 33: Camera base on the contralateral side at the foot of the table



Figure 34: Pelvic array angled towards the foot of the table



Figure 35: Ensure base array on robotic system is visible throughout the case



Figure 36: Camera across the table



Figure 37: Ensure camera is positioned high for a greater field of view



Figure 38: Airplaning the table away from the operative side during registration may be beneficial. Make sure the pelvic array will be visible

Ipsilateral pin placement in the OR



Figure 39: Pin and array placement



Figure 40: Registration



Figure 41: Reaming



Figure 42: Femoral preparation

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