Functional hip positioning

with Mako Total Hip 4.0

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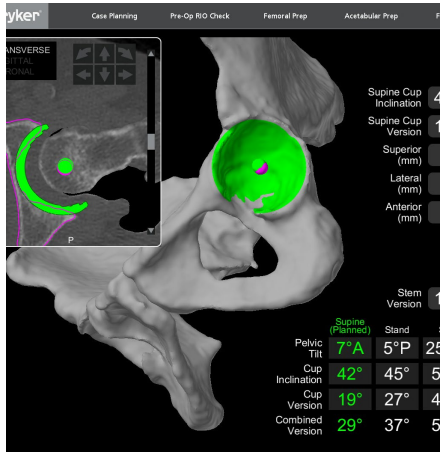
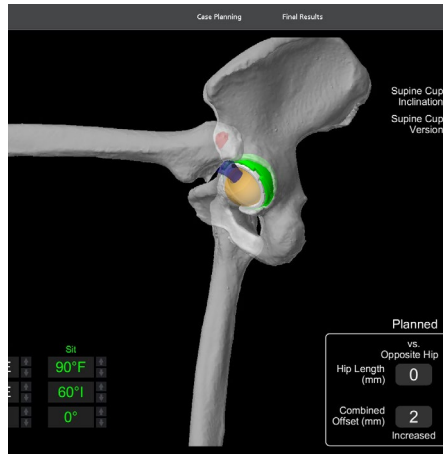




Patient spine classification

Stiff

- Change in pelvic tilt/sacral slope <10° from standing to sitting[1]
- Examples: spine fusions[2], multilevel degenerative disc disease[2], spinal deformity[2], and ankylosing spondylitis[2]

Normal

- Change in pelvic tilt/ sacral slope 10°-30° from standing to sitting[1]
- Examples: minimal spine degenerative disc disease[1], normal lumbar lordosis

Hypermobile*

- Change in pelvic tilt/ sacral slope >30° from standing to sitting[1]

* Additional clinical assessment may be necessary to determine the origin of the stiffness (spine or hip). Spine mobility driven by hip stiffness pre-operatively may be reduced post-operatively when the hip stiffness is addressed.[3,4]

Image protocol

Standing upright lateral image protocol (standing cross-pelvic lateral)

Patient positioning:

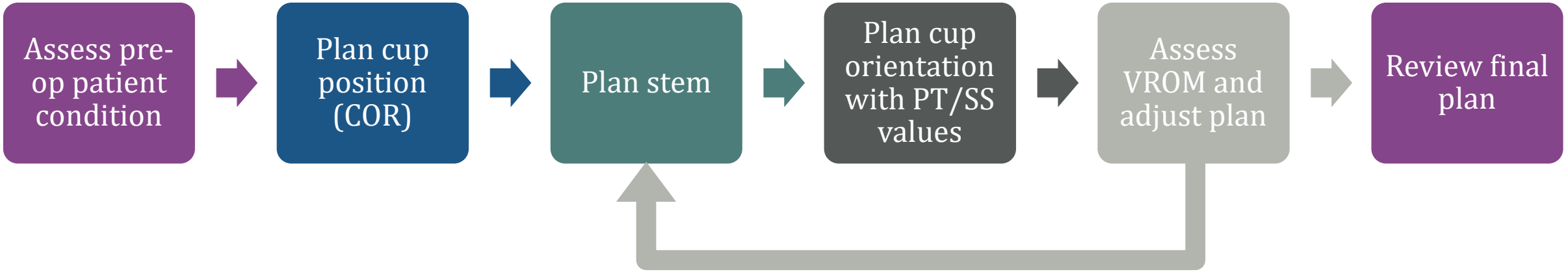
1. Have the patient stand at 90° to the direction of imaging. Feet should also be positioned 90°to the direction of imaging.
2. It is important that the patient stand as erect as possible without slouching.
3. Arms should be away from the imaging field.

Seated upright lateral image protocol (seated cross-pelvic lateral)

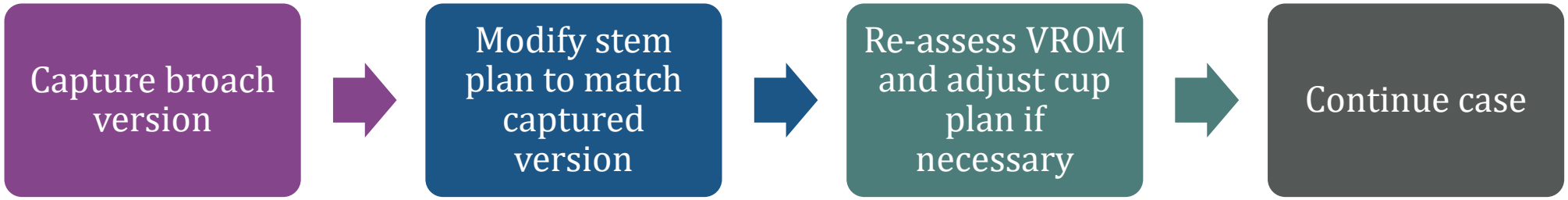
Patient positioning:

1. Have the patient sit comfortably at 90°with the thighs perpendicular to the torso.
2. The patient should be sitting as upright as possible without slouching.
3. The patient should not twist their upper torso.
4. Thighs should be parallel to each other.
5. Thighs should be parallel to the floor.
6. Feet should be flat on the floor.
    - Note: Consider using an adjustable chair or stool to accommodate patients of different heights.
7. Arms should be away from the imaging field and placed as shown or behind the head.
8. The patient should look straight ahead.

Pre-op planning workflow



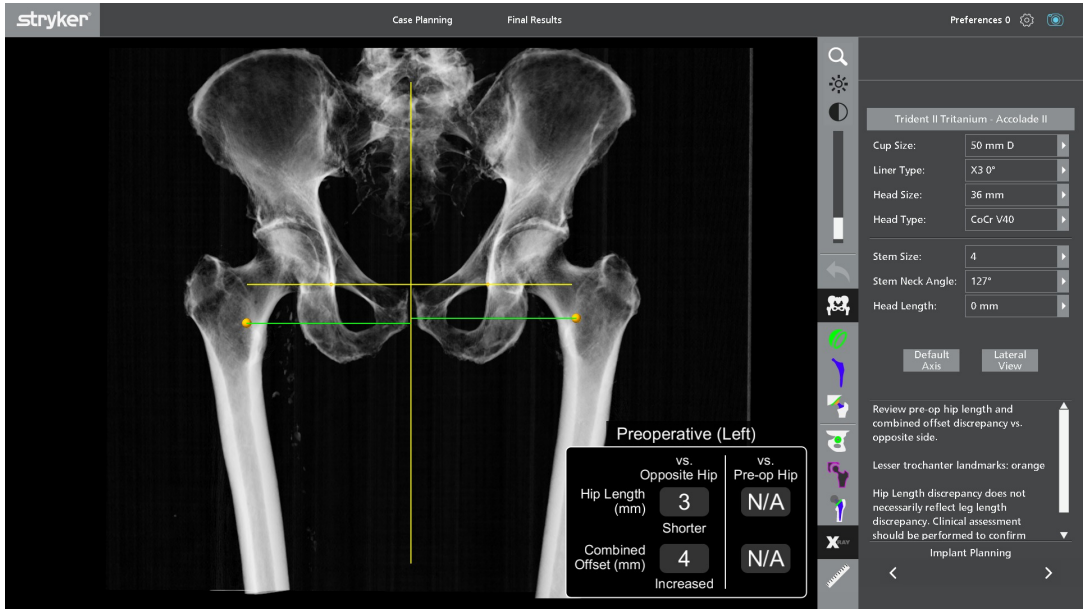
Intra-op review for Enhanced workflow



Pre-op planning workflow

- Assess and compare hip length and offset to pre-op x-ray template
- Consider pre-op patient clinical assessment, pre-op history and physical with emphasis on any observed difference in leg length
- Set new M/L axis if needed (ex. teardrop)
- If the hip length discrepancy indicated by Mako does not match the clinical leg length assessment (including full femur and tibia) measured by the surgeon, surgeons can rely on the "vs. pre-op" values throughout the case to achieve the desired change in hip length

Proceed to plan cup and stem in order of surgeon preference



Cup planning workflow

- Use reaming view and transverse CT PIP to plan the size and position of the cup (Figure 1)
- Position height and medialize the cup using the teardrop in the coronal view. Confirm medialization using the fossa in the transverse view (Figure 2)
    - Cup should approximately bisect the magenta line in the transverse and sagittal views
- Using the transverse PIP view, confirm that the center of the cup is between the anterior and posterior columns (Figure 1)
    - It is important to preserve some of the posterior column
- Confirm planned bone removal and centered resection using the reaming view (Figure 1)
- Assess cup position using the 3D cup view (Figures 3 & 4)

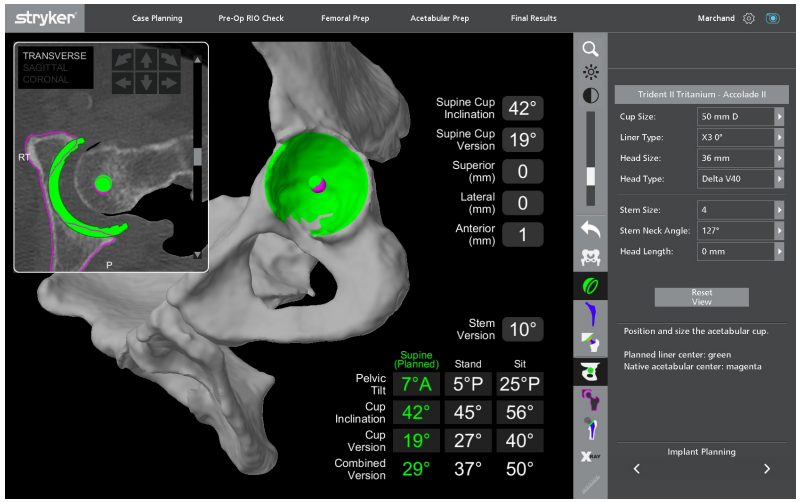


Figure 1

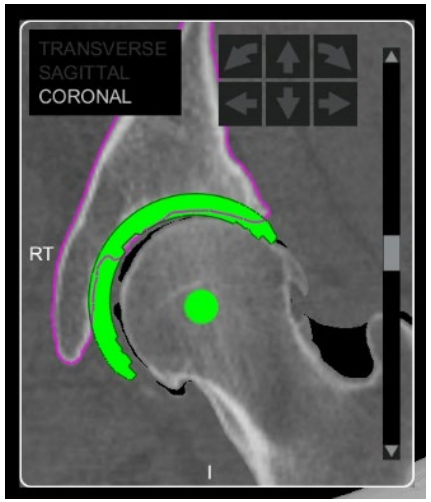


Figure 2

Figure 3

Figure 4

Stem planning workflow

- Use x-ray view and then CT view (coronal plane) to plan stem size
- Ensure stem is planned within the cortices by slicing through the sagittal PIP view (Figure 1)
- Use the transverse slice at the level of neck resection medially to plan the stem version (Figure 2)
- Review neck resection view to establish visual reference for use intraoperatively when preparing femur (Figures 3 & 4)

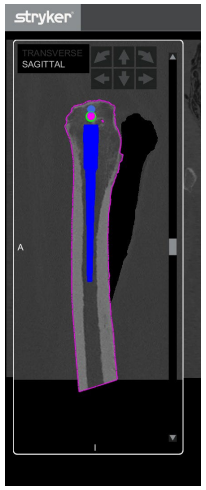


Figure 1

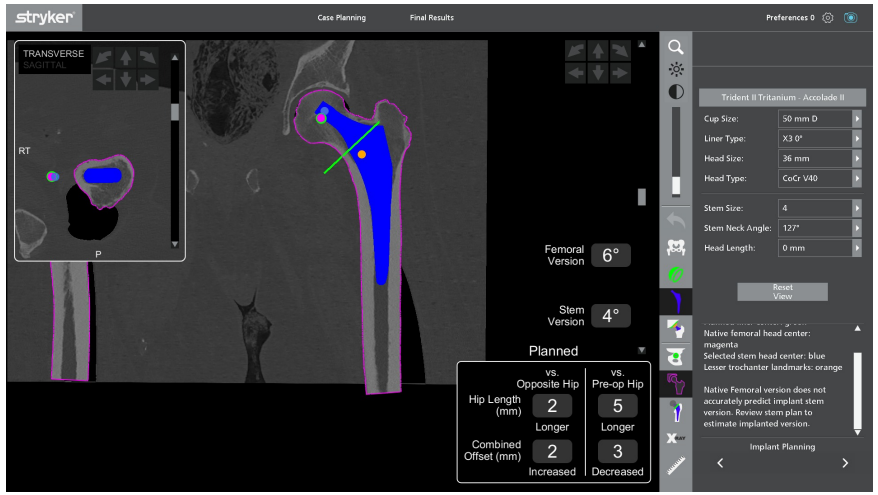


Figure 2

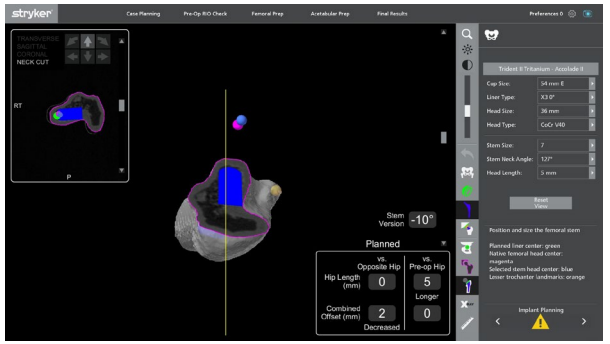


Figure 3

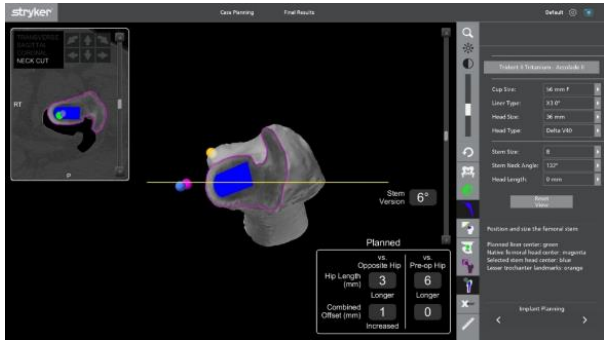


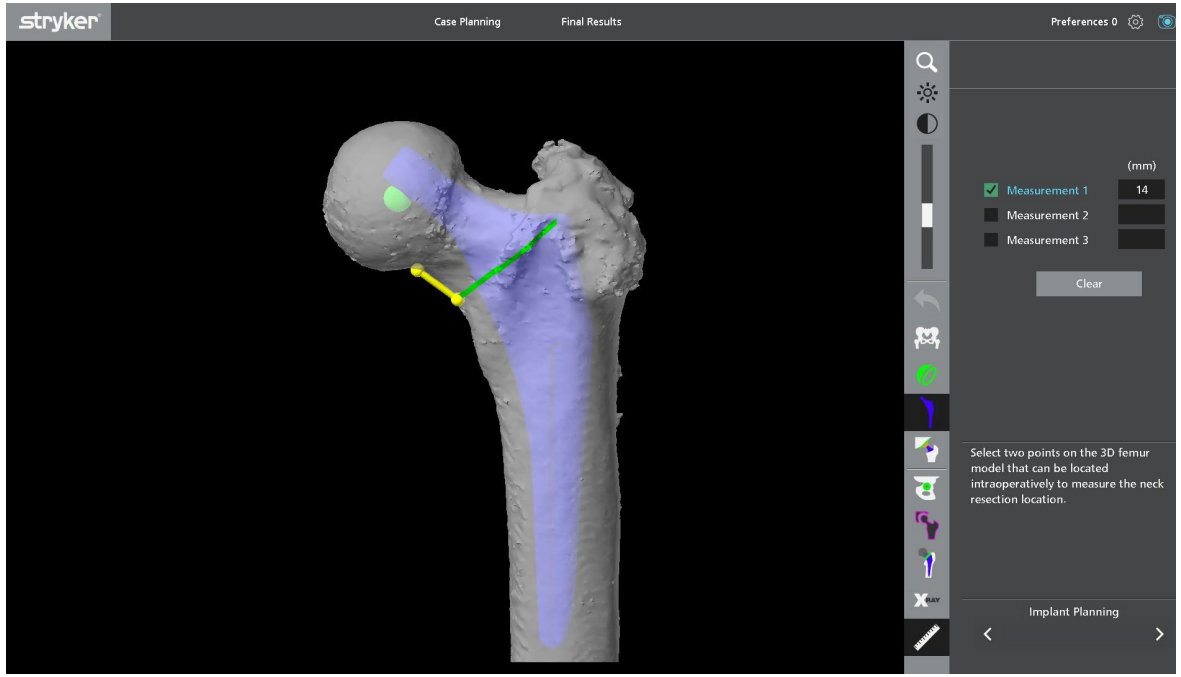
Figure 4

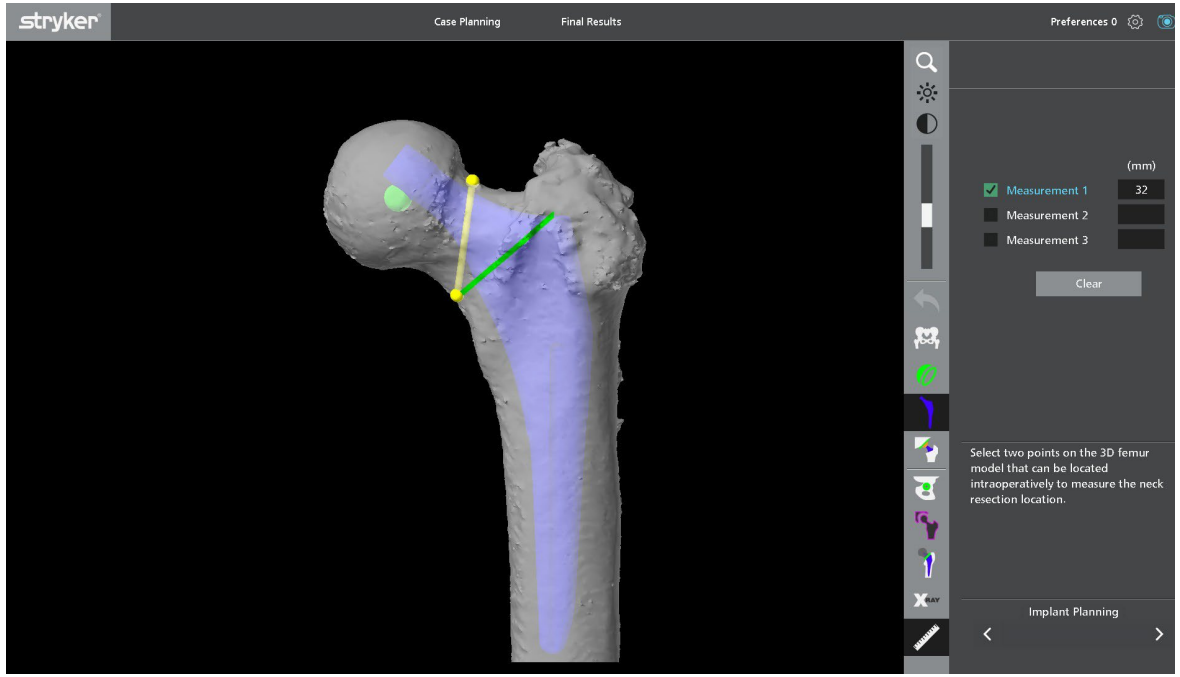
*Cementless stem planning in express workflow helps the surgeons predict where the stem will securely reside. Actual stem position may vary due to variation in bone density and broaching technique.

Neck resection in express workflow

Potential options for digital ruler measurements for direct anterior approach

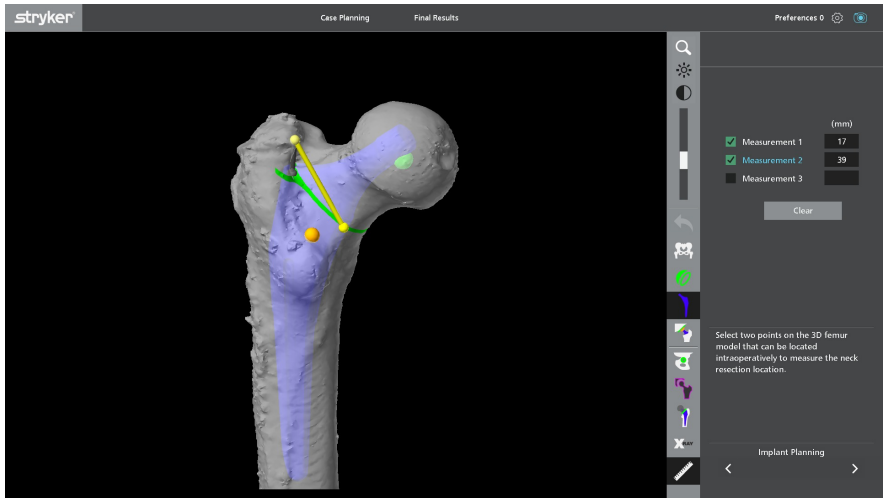
- Identifiable landmark on neck proximal to osteotomy level (usually osteophyte, divot or ridge on bone)



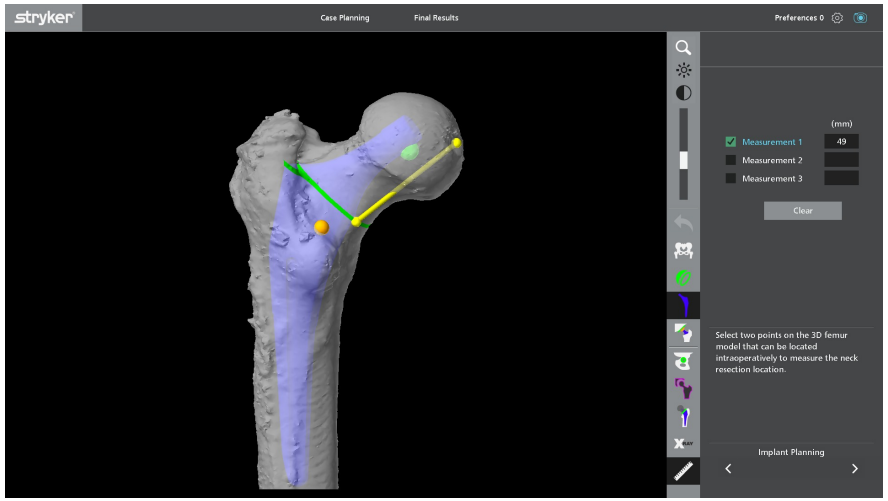


Neck resection in express workflow

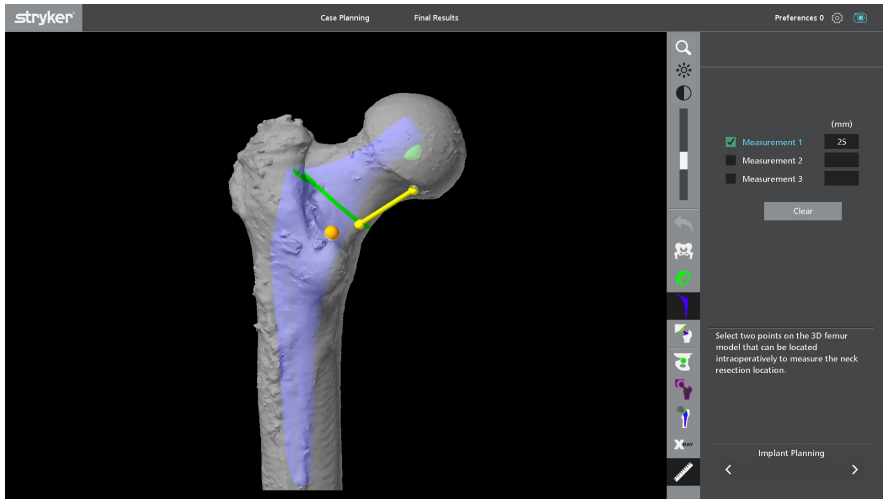
Potential options for digital ruler measurements for posterior and direct superior approaches



Greater trochanter to lateral aspect of calcar



Tip of femoral head to medical calcar

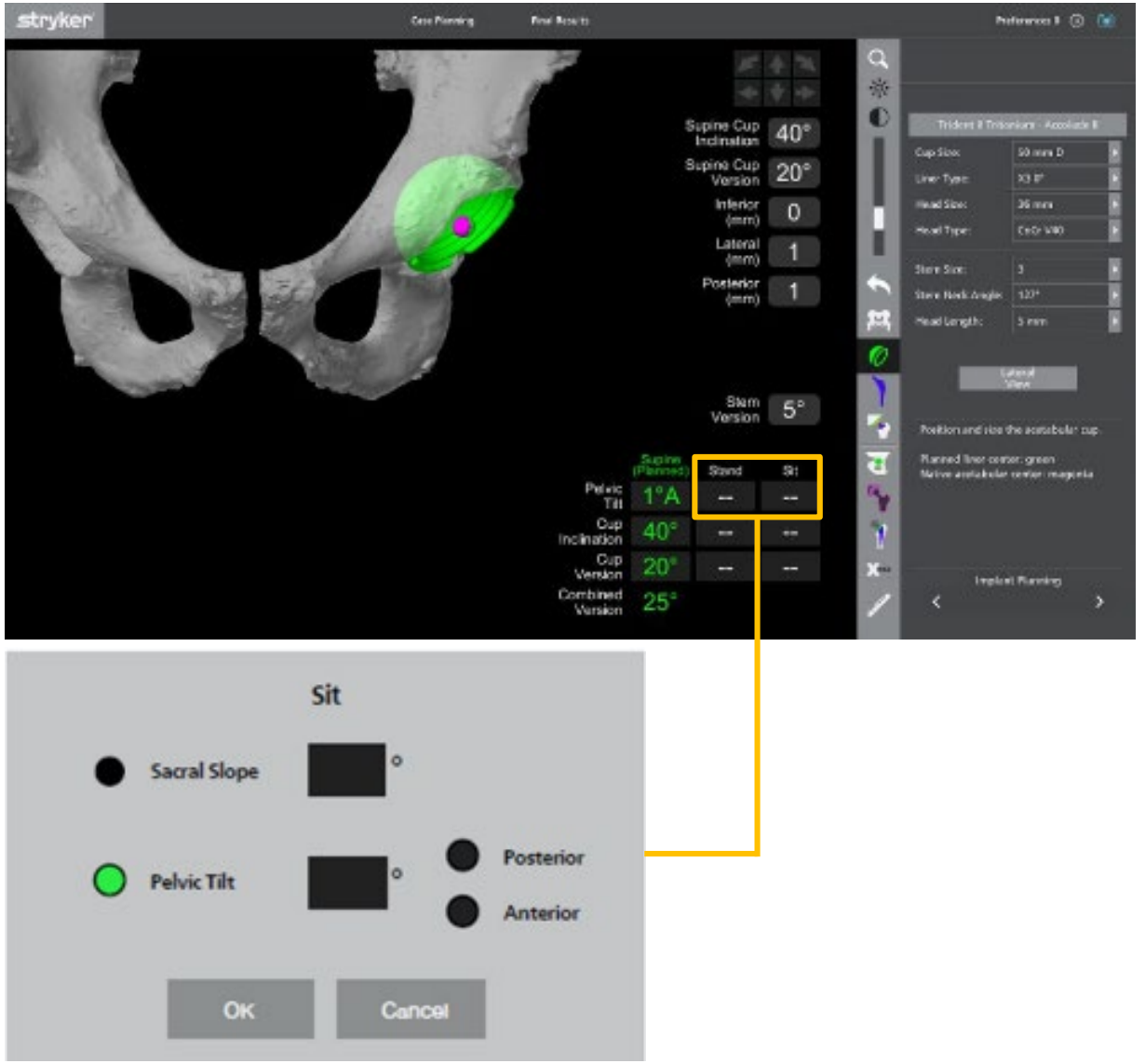


Femoral head neck junction to medical calcar

Top of the lesser trochanter to the medial calcar

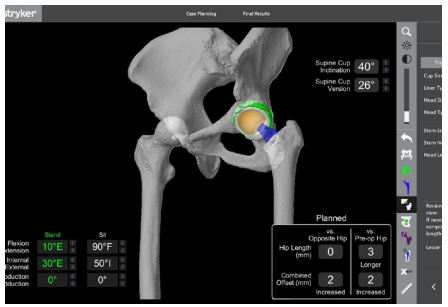
Pelvic tilt planning

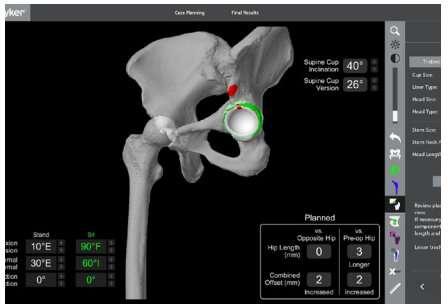
- Enter pelvic tilt or sacral slope values into pelvic tilt planning pop-up
- Set an initial cup orientation prior to entering VROM (e.g. 45° of inclination and 20° of version, or anatomically)
    - The exact initial orientation is not critical as VROM will drive final component inclination and version
- Despite recent challenges to the efficacy of the large Lewinnek zone in avoiding dislocation, the maximum 50° of cup inclination and 30° of cup anteversion are still widely accepted limits to avoid edge loading and liner wear.[5,6]

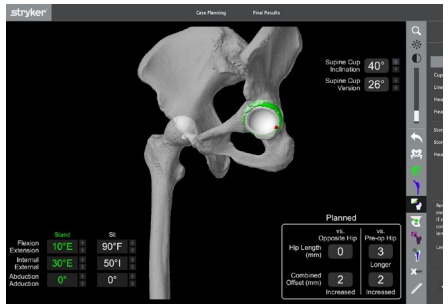


Virtual range of motion (VROM)

- Adjust range-of-motion values to evaluate for impingement
  Examples:
  - **Stand**- 10° extension/ 30° external rotation
  - **Sit**- 90° flexion/ 50°- 60° internal rotation
- If desired, maximum hip flexion can be assessed in the seated position.
  Minimum acceptable is 140° flexion (0° internal rotation)







VROM considerations

- Assess cup position to ensure coverage anteriorly to prevent psoas impingement and acceptable posterior cup coverage
- Osteophyte impingement should be noted for removal but ignored when assessing range-of-motion to impingement
- Approximation of the non-diseased contralateral leg range-of-motion in clinic may be helpful in considering the maximum range of motion for the operative hip
- Visualization of soft tissue impingement is not available using the VROM tool. In general, lower BMI patients can achieve greater range-of-motion and therefore require higher VROM values for assessment. In high BMI patients, the planned VROM values for impingement assessment can be lowered as soft tissue constraints will likely limit mobility.7,8
- Increased allowable range-of-motion to impingement should be considered for Ehlers Danos patients and those who are flexible and active (yoga, gymnast, etc.)
- Range-of-motion to impingement on the OR table may not align with the VROM features because the supine pelvic position is not necessarily representing a patient in the standing and seated position

*Refer to surgical technique for additional considerations

Potential impingement profiles

Implant on implant impingement:

- Adjust cup inclination, version, or both
- Adjust planned stem version if possible
  - Note: Use of the Enhanced workflow will provide intraoperative broach/stem version tracking. User should adjust plan and reassess VROM after broach version capture
- Increase head size when appropriate
- Use MDM when impingement cannot be avoided

Bone on bone impingement:

- Common areas for bone-on-bone impingement:
  - Extension - lesser trochanter on ischium (rare)
  - Flexion - greater trochanter/anterior neck on the anterior inferior iliac spine (more common)
- Plan to remove osteophytes (acetabular or anterior portion of femoral neck – reference red highlighted region on bone model)
- Consider offset (eccentric) liner, increasing head length, lateralizing the cup, or increase offset of the stem

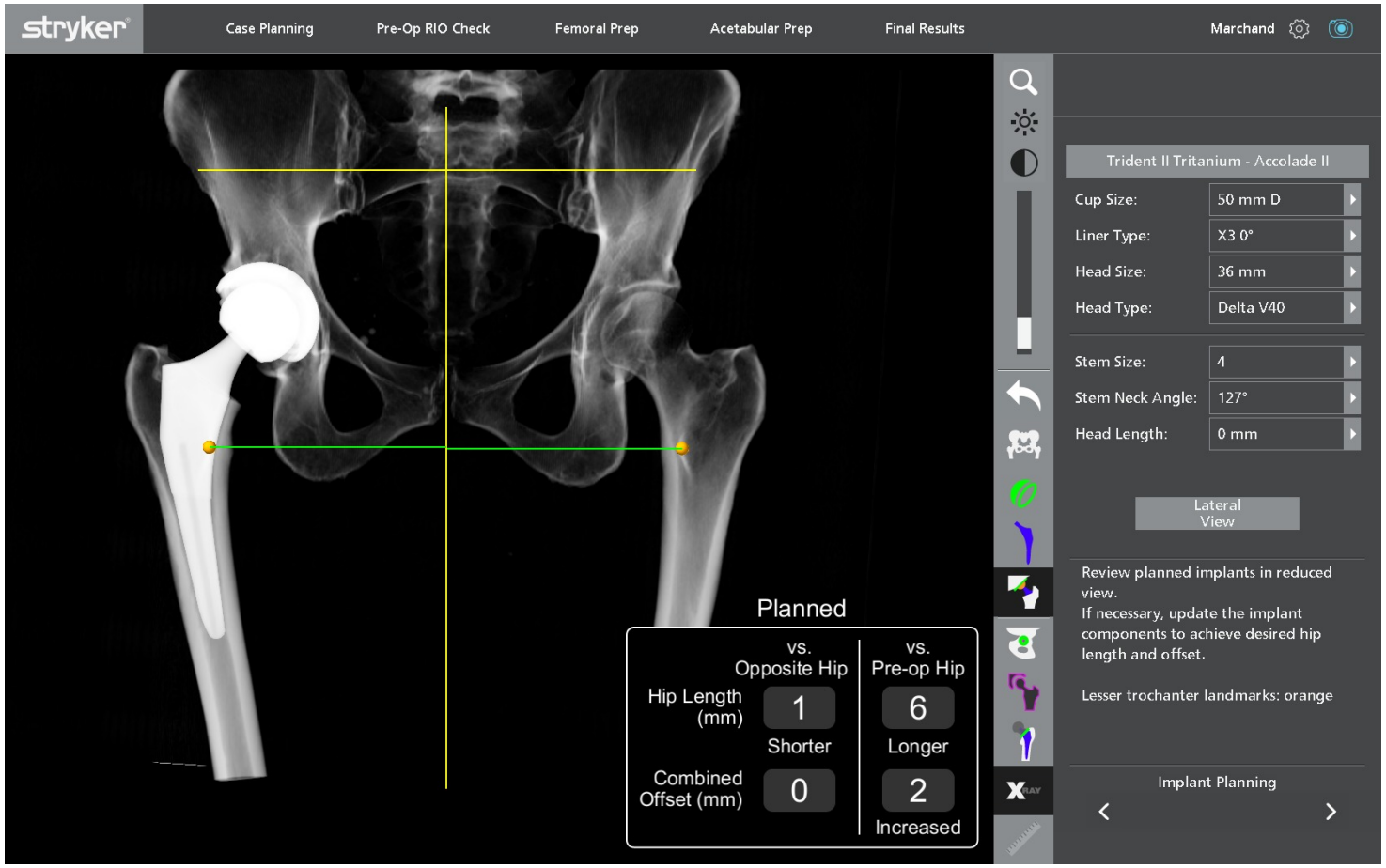
Bone on implant impingement:

- 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

Review plan

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

Consider using broach capture in the enhanced workflow or neck resection view in the express workflow to assess broach version, adjust plan, and reassess VROM after preparing the femur



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