Tips & Tricks: Preoperative Planning and Templating for Total Hip Arthroplasty

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Introduction

The total hip arthroplasty is one of the most successful surgical procedures invented over the past century. It has revolutionized treatment of arthritic conditions of the hip and allowed improved quality of life for the majority of patients with acceptable risk and morbidity. Improvements in surgical technique, implants, peri-operative pain and blood management in many cases have led to less blood loss, increased implant survivorship, more rapid rehabilitation and reduced complications. However, optimal outcome of a total hip arthroplasty remains predicated on a detailed pre-operative evaluation, templating and surgical plan. Here, we discuss the critical components to evaluate when planning for a total hip procedure. Clinical examination and diagnosis are critical components to preoperative planning, but are outside the scope of this article.

Radiographic Evaluation

Radiographs

Standard imaging of the arthritic hip includes anteroposterior (AP) view of the pelvis centered over the pubic symphysis, as well as AP and lateral of the affected hip. In anticipation of surgical templating, it is best to perform these studies with a standardized scale marker ball at the level of the greater trochanter for later calibration and accurate sizing. When possible it is best to internally rotate the hip 10-15 degrees to correct for femoral anteversion and allow more accurate assessment of femoral offset. Prominence or lack of the standard profile of the lesser trochanter may indicate external or internal rotation of the limb. The film should be examined for signs of rotation, as evidenced by the symphysis not lying directly below the sacrum or asymmetry between the obturator foramina. Additionally, evaluate the lumbosacral region for signs of scoliosis or degenerative spine disease, which could confound the diagnosis of hip arthritis.[1] In some cases, dynamic spine imaging sitting and standing is helpful to evaluate pelvic tilt and assess spino-pelvic mobility.[2]

Evaluation of the hip should include assessment of the grade of arthritis. Standard radiographic signs of arthritis include joint space narrowing, subchondral cysts, and osteophyte formation. Especially in younger patients, it is important to assess for signs of acetabular dysplasia, such as increased inclination of the acetabular sourcil and/or decreased lateral coverage on the AP view. In subtle cases there may only be decreased anterior coverage on a false profile view. Signs of Pincer femoral acetabular impingement and acetabular retroversion include the prominence of the ischial spine and the crossover sign of the anterior and posterior walls. Make note of any hardware from prior hip surgery. This may require full-length femur imaging to determine whether the femoral implant will fit, assess the need to remove prior hardware, bypass stress risers or perform a concurrent osteotomy to allow placement of an appropriate femoral hip prosthesis.

Landmarks

Begin by marking the horizontal inter-teardrop line, passing through the base of the teardrops on both sides of the pelvis. Identify the ilioischial line, which marks the medial border of the true acetabulum.[1]

Acetabular Templating

Manual templates or computer templating software may be utilized. For manual templates confirm magnification by comparing the marker ball with the reference scale on the template. Alternatively, the marker ball in the computer templating program may be used for image calibration. Assessment of any length discrepancy is performed by comparing a fixed point on the lesser or greater trochanter with a perpendicular to the inter-teardrop line. If the teardrop is obscured by arthritic changes, the inter-teardrop horizontal can be replaced by the horizontal connecting the ischial tuberosities or a horizontal line across the top of the obturator foramen. The radiographic leg length difference should be compared with the assessed clinical difference to determine the planned center of rotation for the cup and stem to restore the desired change in leg length and off-set. In some cases it is helpful to template the normal hip to allow restoration of equal radiographic length and off-set when indicated. Beware that flexion contracture may cause compensatory lumbar lordosis that makes the AP radiograph appear more like an inlet view.[1] Flexion contractures may cause limb lengths to appear significantly

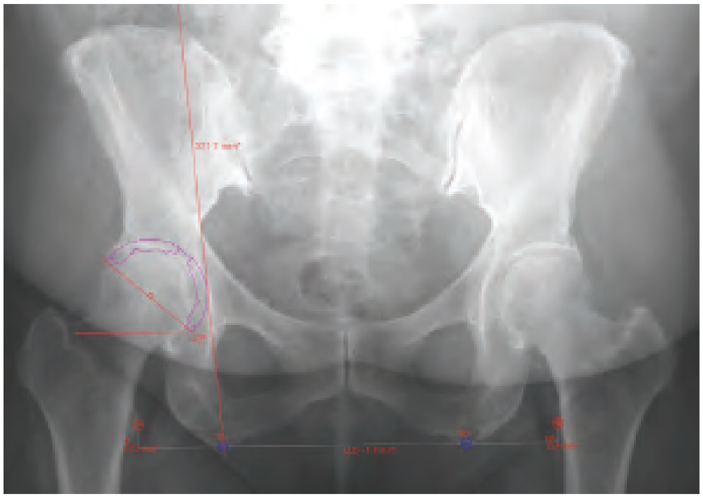

Figure 1. Limb length discrepancy using horizontal line drawn across the bilateral ischial tuberosities. Vertical measurements made perpendicularly to equivalent prominence of the lesser trochanters. Medialization of the cup to Kohler's line (oblique vertical red line), with inferomedial cup placed at level of teardrop. Hip center of rotation marked with red circle in middle of acetabular cup template. Note is made of superolateral osteophytes.

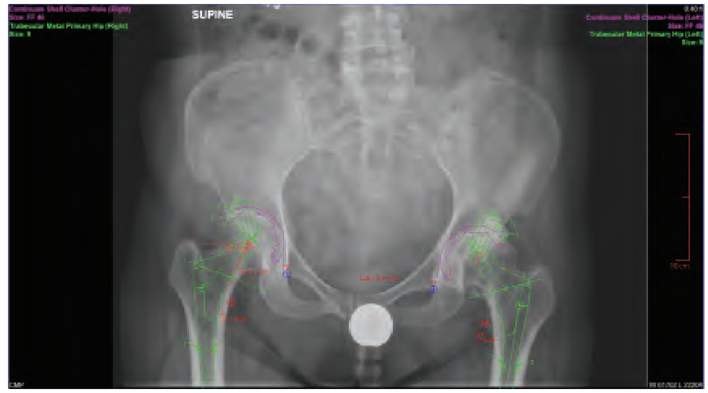

Figure 2. Templating using the operative (left) and non-operative (right) hips. Goal is to restore operative hip to same muscle tension as normal side. A neck resection at the level of the green line (templated here) can be measured intraoperatively. By templating the normal side, we can visualize where our resection is. The patient below has a 5.3 mm leg length discrepancy. The cup is medialized to the teardrop and abducted between 40-45 degrees. The stem will be limited by the shape of the stem hitting the calcar.

different. Before adjusting the preoperative plan to fix a large limb length discrepancy (anything greater than 1 cm), review carefully the physical exam and imaging for indications of a flexion contracture that may confound the measurements. Figure 1 demonstrates how to assess limb length discrepancy and template the acetabular cup on the AP pelvis radiograph.

Femoral Templating

Once satisfied with the acetabular templating process and planned center of rotation, then we proceed to femoral templating. It is important to understand the stem geometry and the method by which the planned stem achieves fixation. Begin with sizing the stem, independent of acetabular component. Choose the implant that will provide appropriate fit along the medial cortex and calcar in addition to allow restoration of leg length. Different implants will have a variety of metaphyseal shapes to best fit the patient's native contour. Depending on the femoral canal size and Dorr classification, size options may be limited by diaphyseal inner diameter. (Figure 2) Sequentially check femoral stems of increasing size until the appropriate implant body is selected. (Figure 3) When the desired restoration of leg length and offset is not possible using a cementless stem, cemented stems can be at a more distal or proximal level without optimal stability prior to placement of bone cement, but with markedly improved stability as well as excellent long term results following polymerization of bone cement.

With the femoral stem size chosen, move to evaluate neck offset. The lateral or extended offset neck designs offer either a more varus neck angle or a medially translated neck at the same neck angle. Points along the standard or extended offset line represent the head length. In order to correct for limb length discrepancies and restore native offset, select the neck offset and head-neck offset point in the vertical plane of the center of rotation of the acetabulum. If limb lengths are equal, the femoral point should overlie the center of rotation. If the limb length is short compared to the unaffected side, the point should lie proximal to the center of rotation to gain length when the hip is reduced. Conversely, if the limb length is long compared to the unaffected side, the point should lie distal to the center of rotation to decrease length when the hip is reduced. However, we would caution against planned reduction in length or offset due to the risk of instability.

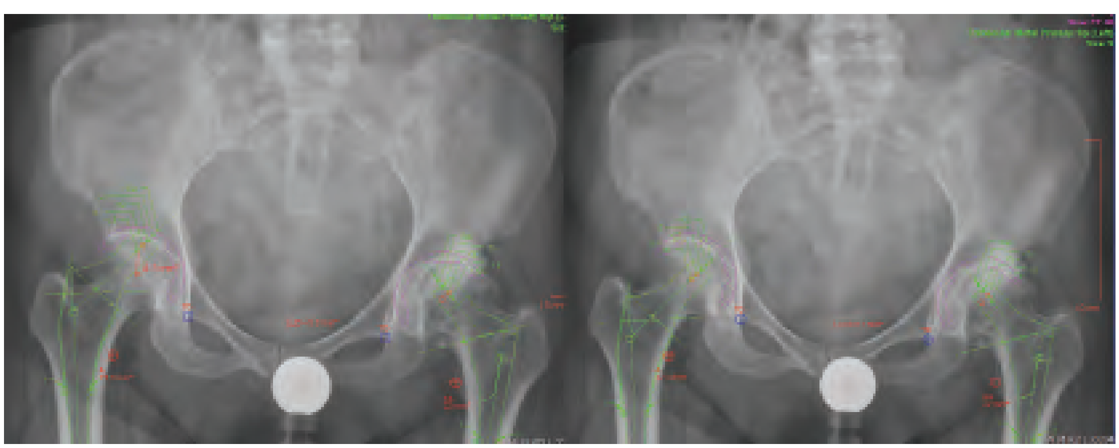

Figure 3. The appropriate geometry stem for this patient is changed to a different geometry stem (Left, Zimmer ML taper). Even with downsizing to the smallest available size, it would not be possible to sink the stem past the calcar. With the -3.5 mm head and the shortest neck available, this patient would be lengthened by 14 mm. Demonstration of attempt to sink the inappropriate geometry stem to achieve equal leg lengths. Here, the stem perforates through the calcar. Without templating this could lead to intraoperative fracture (Right).

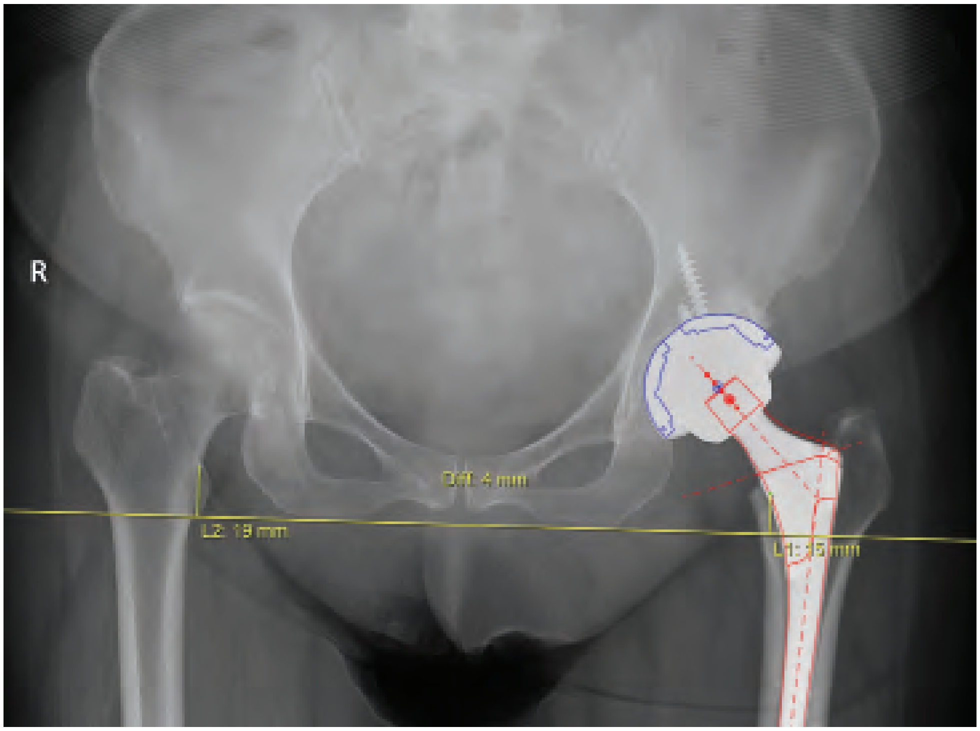

Figure 4. Postoperative x-ray with template demonstrating the actual implant and size selected. Leg length discrepancy improved to within 4 mm.

size, which can aid in minimizing time and beginning preparation closer to the templated sizes. In addition, when planned size is much larger than the size achieved, there should be strong suspicion that the femoral implant may be in excessive varus alignment. While templating is important, the intra-operative fit and implant stability ultimately will dictate implant sizes. An example postoperative radiograph is demonstrated in Figure 4. The ability to successfully plan for hip arthroplasty preoperatively improves with experience. Senior orthopaedists have demonstrated accuracy to within one size compared with their template 94.6% of the time, while resident estimates were within one size only 82.4% of the time.[3] Pre-operative planning allows the surgeon to confirm their diagnosis, become familiar with the details of the patient's anatomy, avoid potential hazards, and move expediently in the operating room.

Surgical Execution

Once the template has been completed, evaluate carefully for challenges such as large medial or superolateral osteophytes. Review the template in detail to confirm the center of rotation has been restored, particularly in cases of protrusion, dysplasia, or hypertrophic arthritis.

With this complete, the surgeon is prepared to efficiently execute their plan in the operating room. Intraoperatively, the surgeon now has an idea of expected cup and femoral stem

References

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