Preoperative Planning for Primary Total Hip Arthroplasty

Alejandro González Della Valle, MD, Douglas E. Padgett, MD, and Eduardo A. Salvati, MD

Abstract

Preoperative planning is of paramount importance in obtaining reproducible results in modern hip arthroplasty. Planning helps the surgeon visualize the operation after careful review of the clinical and radiographic findings. A standardized radiograph with a known magnification should be used for templating. The cup template should be placed relative to the ilioischial line, the teardrop, and the superolateral acetabular margin, so that the removal of the supportive subchondral bone is minimal and the center of rotation of the hip is restored. When acetabular abnormalities are encountered, additional measures are necessary to optimize cup coverage and minimize the risk of malposition. Templating the femoral side for cemented and cementless implants should aim to optimize limb length and femoral offset, thereby improving the biomechanics of the hip joint. Meticulous preoperative planning allows the surgeon to perform the procedure expediently and precisely, anticipate potential intraoperative complications, and achieve reproducible results.

Dr. González Della Valle is Assistant Attending Orthopaedic Surgeon, Hospital for Special Surgery, New York, NY, and Instructor in Orthopaedic Surgery, Weill Medical College, Cornell University, New York. Dr. Padgett is Attending Orthopaedic Surgeon, Hospital for Special Surgery, and Associate Professor of Orthopaedic Surgery, Weill Medical College, Cornell University. Dr. Salvati is Director of the Hip and Knee Service, Hospital for Special Surgery, and Clinical Professor of Orthopaedic Surgery, Weill Medical College, Cornell University.

None of the following authors or the departments with which they are affiliated has received anything of value from or owns stock in a commercial company or institution related directly to or indirectly to the subject of this article: Dr. González Della Valle, Dr. Padgett, and Dr. Salvati.

This study was partially funded by the generous donation of Daniel and Geraldine Soba, Trustees of the Grace R. and Alan D. Marcus Foundation.

Reprint requests: Dr. González Della Valle, 535 East 70th Street, New York, NY 10021.

J Am Acad Orthop Surg 2005;13:455-462

Since the introduction of modern hip arthroplasty, hip prostheses have consistently relieved pain and improved function.[1] Advancements in implant design, materials, surgical technique, and anesthesia have increased durability of the arthroplasy and decreased the prevalence of complications.

However, component malposition leading to excessive wear or dislocation, fixation failure, limb-length discrepancy, and dislocation remain important concerns. Dislocation may be related to component orientation, soft-tissue tension, or failure to restore hip biomechanics. Mechanical failure is also multifactorial and dependent on materials, design,[2] surface finish,[3,4] position, and bone quality, as well as biologic response to wear debris.[5] Many of these factors are under the control of the surgeon; thus, a thorough preoperative plan may mitigate the likelihood that any of these factors will contribute to arthroplasty failure.[6]

The step-by-step process of a hip replacement should begin before the operation after careful review of the clinical and radiographic findings. This review should result in an exact preoperative plan that will guide surgery to achieve optimal, reproducible results.[6-10]

Besides improving precision during surgery, preoperative planning forces the surgeon to think in the three dimensions demanded during surgery. Preoperative planning also

allows the surgical team to prepare the instrumentation required for each operation, have the proper inventory of implants available, and predict complications and needs that may arise during surgery.

History and Physical Examination

The medical history and current medical status of the patient should be considered during preoperative planning in order to choose implant fixation, implant designs, and surgical approaches. The following also should be considered: the patient's age, sex, preoperative diagnosis, level of activity, and mental status; involvement of other joints; conditions precluding the use of crutches or walker; medical problems; and the patient's expectations from the surgery and life expectancy.

Patients at high risk for dislocation because of neuromuscular problems, substance abuse, or other reasons may benefit from particular surgical approaches or specific implant characteristics (eg, larger femoral head diameter) that optimize hip stability. Constrained cups may rarely be considered for patients at a very high risk for dislocation.[11]

The preoperative examination should include assessment of the patient's gait and hip range of motion, as well as evaluation of the ipsilateral knee, lumbosacral spine, and fixed or functional deformities.[12] Both the actual and functional limb-length discrepancy should be established. The actual limb-length discrepancy is determined by measuring the distance between the anterosuperior iliac spine and the medial malleolus. The functional limb-length discrepancy is what the patient perceives while in a standing position; it can be determined by placing blocks under the affected side until the patient feels the limbs' length to be "equal."[13] The most common cause for functional limb-length discrepancy is either flexion and/or abduction contracture.[14]

When there is a difference between the actual and functional limb length, pelvic obliquity may be evaluated by comparing the level of both hemipelvises with the patient standing and sitting. Suprapelvic obliquity, in association with scoliosis or degenerative disease of the lumbosacral spine, persists in the seated position. Conversely, pelvic and infrapelvic obliquity resolves in the same positon. Intrinsic pelvic abnormalities resulting in obliquity include loss of bone or cartilage as a result of arthritis, necrosis, or infection, and fractures of the pelvic ring resulting in deformity. In addition, the surgeon should be aware of infrapelvic obliquity resulting from limb-length discrepancy related to the following: previous fracture of the limb, congenital hemihypertrophy, sequela of poliomyelitis, and undisclosed prior trauma affecting epiphyseal growth. In these cases, there is a difference between the predicted limb-length discrepancy seen in hip radiographic findings and the clinical picture. When suprapelvic or infrapelvic obliquity exists, equalizing the functional leg length often provides the patient improved gait and increased comfort, provided the stability of the arthroplasty is not jeopardized.

Radiographic Technique

A standardized radiographic evaluation of the hip usually includes an anteroposterior (AP) view of the pelvis centered over the pubic symphysis. Such a radiographic evaluation will also include AP and true lateral views of the affected hip, which will depict a lateral view of the femur as well as of the acetabulum.

The AP views are obtained with the patient lying supine on the table with the hips in 10° to 15° of internal rotation. This allows a true AP view of the femoral neck, which has a normal anteversion of 10° to 15°. If the radiographs are obtained with the hips externally rotated, the true femoral offset will be underestimated. If there is tilt or rotation of the pelvis with the patient lying supine, lumbosacral spine pathology or hip contracture should be suspected.

For adequate preoperative planning, the surgeon needs to know the magnification of the hip radiographs. Assuming that the x-ray tube is at a distance of 1 meter from the tabletop, and that the film is placed in a tray 5 cm below the table, the radiograph magnification will be approximately 20% ± 6% (2 SDs).[15] Magnification is directly proportional to the distance between the pelvis and the film; therefore, increased magnification should be expected in obese patients and, conversely, less magnification in thin patients.

For patients in whom absolute precision is required (eg, a candidate for a custom prosthesis), a magnification marker can be taped to the patient's skin at the level of the greater trochanter.[16] The magnification marker consists of a Plexiglas tube with two lead spheres embedded at an exact distance of 100 mm. A coin with a known diameter can also be used as a magnification marker.[16]

Radiographic Review

Before templating, the radiographs should be reviewed to confirm the diagnosis and eliminate the possibility of limb or pelvis malpositioning that might mislead the surgeon in planning, as well as to allow consideration of anatomic challenges that might be confronted intraoperatively. Pelvic rotation is suggested by the absence of superimposition of the center of the sacrum and coccyx on the pubic symphysis and asymmetry of the obturator foramina.[17] In the presence of lumbosacral hyperlordosis resulting from hip flexion contracture, the AP view of the pelvis resembles an inlet view, and the acetabular landmarks may not be accurately visualized for templating. Rotation of the upper femur