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Total Hip Arthroplasty

Series Editor and Contributing Author:

Robert T. Trousdale, MD

Associate Professor of Orthopaedic Surgery

Mayo Graduate School of Medicine

Consultant, Department of Orthopaedic Surgery

Mayo Clinic

Rochester, MN

Contributing Author:

Richard Steinfeld, MD

Chief Resident

Department of Orthopaedic Surgery

Mayo Clinic

Rochester, MN

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Total Hip Arthroplasty

I. INTRODUCTION

Total hip arthroplasty (THA) has become one of the most successful surgical procedures. Initial surgical intervention aimed at restoring joint surfaces of the hip centered on realignment osteotomy of the upper femur. The first “arthroplasty” may have been Gluck’s attempt in the 1800s to insert an ivory ball onto the neck of the femur. Eventual attempts at replacing the worn surfaces involved the use of cobalt-chromium alloy (Vitallium) by Smith-Petersen followed by the addition of an intramedullary stem by Moore. In 1948, Wiles inserted a ball-and-socket hip prosthesis, and 3 years later McKee and Farrar implanted their first stainless steel total hip prosthesis. Sir John Charnley used methylmethacrylate to cement both the femoral and acetabular components in 1958. In 1961, high-density polyethylene was used as an alternative bearing surface to oppose the femoral head. These pioneers and others opened the door to what has become one of the most successful operative procedures ever developed.

II. ANATOMY

A. Femur

1. The average **angle** between the neck and the shaft of the femur is 127 degrees in adults.
2. The **center of the head** of the femur is approximately one diameter medial to and level with the tip of the greater trochanter.
3. Femoral **version** is determined by the angle between the femoral condyles and the axis of the neck of the femur. Average anteversion in adults is 10 to 15 degrees.

B. Acetabulum

1. The acetabulum is formed through **fusion of the ischium, ilium, and pubis**.
2. The lateral column includes the ilium and the superior dome. The anterior column is composed primarily of the pubis and the posterior column of the ischium.
3. On **radiographic** evaluation, the true position of the acetabulum is determined by the intersection of the **line of Köhler** (drawn from the

acetabular teardrop to the lateral tangent of the pelvic ring) and the **line of Shenton** (curve formed by the top of the obturator foramen and medial neck of the femur to the level of the lesser trochanter).

4. **Correct acetabular version** seats the implant in approximately 45 degrees of abduction and 15 degrees of anteversion. The position can be determined with use of internal or external landmarks.
5. The **labrum** deepens the acetabulum and is most prominent at the posterior superior region of the acetabulum.

C. Capsule

1. The capsule extends to the intertrochanteric line anteriorly and the femoral neck posteriorly. It is reinforced anteriorly by the iliofemoral ligament of Bigelow.
2. The ligamentum teres lies in the acetabular fovea and extends to the femoral head. This structure contains branches of the obturator artery.
3. The capsule becomes thickened with degenerative disease of the hip.

D. Nerves

1. The **lateral femoral cutaneous nerve** can be encountered during the anterior approach to the hip. It lies 2 to 3 in (5 to 7.5 cm) below the anterior superior iliac spine.
2. The **femoral nerve can be injured** with excessive retraction or poor placement of retractors along the anterior acetabulum.
3. Six different arrangements of the **sciatic nerve** in relation to the piriformis muscle have been described.¹ The nerve passes below the piriformis muscle in 85% of instances. It is protected by the short external rotator muscles during the posterior exposure for THA.
4. The **superior gluteal nerve** is in the space between the gluteus medius and gluteus minimus muscles. When the abductors are split, a “safe area” is present 5 cm from the tip of the greater trochanter.² The nerve can be damaged when the anterior portion of the gluteus medius muscle is retracted during an antero-lateral approach to the hip.



Figure 1. Anteroposterior radiograph of an 81-year-old patient with a well-fixed cemented total hip arthroplasty.



Figure 2. Anteroposterior radiograph of a 50-year-old patient with a well-fixed uncemented total hip arthroplasty.

III. INDICATIONS

- A. **General indications.** The primary indication for THA is pain caused by arthritis that has not responded to a well-structured, nonsurgical treatment program.
1. It is essential to **rule out other sources of pain in the hip**; arthritis of the hip must be the primary pain generator.
 - a. Disorders of the back, vascular disease, stress fractures, and pain from soft tissues must be ruled out.
 - b. When a patient has severe pain but minimal radiographic evidence of arthritis, the source of the pain probably is not arthritis.
 - c. Intraarticular injection of bupivacaine is a helpful diagnostic tool to ensure that the hip is the primary pain generator in cases that are not clear.
 2. **Preoperative treatment modalities** that should be tried before deciding on THA include non-steroidal antiinflammatory drugs, modification of activity, use of a cane, and physical therapy.
- B. **Cemented total hip arthroplasty.** A THA performed with cemented fixation is shown in **Figure 1**. Indications are as follows:

1. Age older than 65 years
 2. Poor bone quality
 3. Excessive femoral anteversion or retroversion
 4. Excessively large, small, or deformed femoral canals
 5. A chronic medical condition, such as inflammatory arthropathy or long-term use of corticosteroids
 6. Neoplasm affecting the hip
- C. **Uncemented total hip arthroplasty.** A THA performed with uncemented fixation is shown in **Figure 2**. Indications are as follows:
1. Age younger than 65 years
 2. Active lifestyle
 3. Adequate bone quality and geometric features

IV. CLINICAL EXAMINATION

- A. **History**
1. **Pain**
 - a. The most frequent symptom of arthritis involving the hip is **groin or buttock pain**.
 - b. Patients also may report **knee or back pain**.
 - c. Lateral **thigh pain** suggests hip bursitis or irritation of the iliotibial band.
 - d. Arthritic pain usually **increases with activity**.
 - e. Burning pain and pain below the knee may be neurogenic.
 2. **Infection.** The existence of chronic infection (eg, dental or urinary tract infection) must be identified preoperatively.

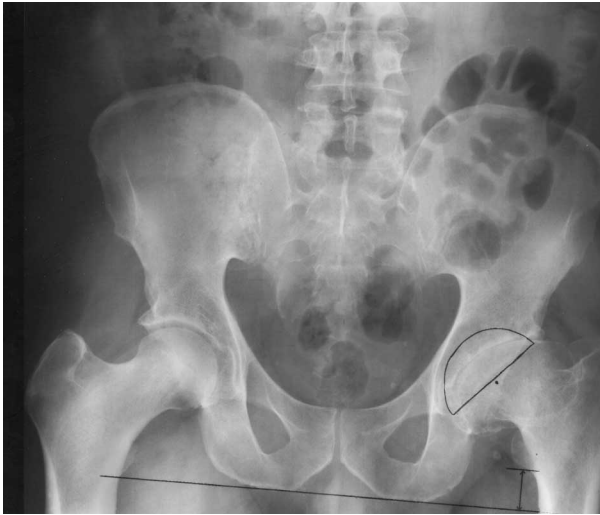


Figure 3. Anteroposterior pelvic radiograph demonstrates templating of leg length difference and center of rotation of the hip. Leg length discrepancy can be measured by means of drawing a line across the inferior aspects of both ischia and recording the difference between the levels at which this line crosses the lesser trochanters. This example shows a 1.5-cm leg length discrepancy (left shorter than right).

3. **Skin breakdown and ulceration** involving the lower extremity should be managed before arthroplasty.

B. Physical examination

1. **Gait** is assessed for abnormalities. Patients with severe arthritis attempt to unload the hip by lurching to the ipsilateral side during the stance phase of the gait (Trendelenburg gait).
2. Palpable **tenderness** along the lateral hip suggests trochanteric bursitis.
3. **Range of motion** is evaluated. Loss of internal rotation is typical early in degenerative disease of the hip.
4. **Joint contractures** are measured.
5. **Leg length discrepancy** must be accurately determined.
 - a. **Actual** leg length discrepancy is measured from the anterior superior iliac spine to the medial malleolus.
 - b. **Apparent** leg length discrepancy is measured from the umbilicus to the medial malleolus of the ankle.
 - c. Differences between the actual and apparent leg lengths may be caused by spinal deformity or muscular contracture.

- d. Pelvic obliquity caused by scoliosis can cause functional leg length discrepancy.
6. Detailed **neurologic and vascular examinations** are performed preoperatively.

C. Diagnostic imaging

1. Preoperative radiographs include anteroposterior (AP) views of the pelvis and hip and a lateral view of the hip.
 - a. The **AP view of the pelvis** can be used to assess leg length discrepancy and is useful for making a template with the uninvolved hip (**Figure 3**).
 - b. The **AP view of the hip** is used to assess the shape and proximal configuration of the femur.
 - c. The **lateral view of the hip** shows the bow of the femur and the anterior-posterior diameter of the femoral canal.
2. A **false-profile** radiograph can be helpful in detecting occult degenerative changes and gives an excellent view of the posterior column.
3. Radiographic inspection of the acetabulum may reveal sclerosis and cyst formation.
4. Radiography of the lumbar spine may be indicated in the examination of patients with low back pain and those with symptoms of spinal stenosis.

V. PREOPERATIVE PLANNING

A. Acetabular component (**Figure 4**)

1. The size of the acetabular component is best determined using the lateral radiograph of the hip.
2. The template is medialized close to the fovea (teardrop) and angled to traverse the middle of the obturator foramen. This optimizes abduction and adduction of the implant.

B. Femoral component

1. The uninvolved hip is used to reproduce the normal geometric configuration of the femur.
2. Duplication of normal offset and length should be attempted by reproducing femoral neck angulation.
3. Preoperative radiographs of a hip with external rotation contracture can suggest a greater neck angle than actually is present. Slight internal rotation of the affected limb during acquisition of the preoperative image may help to better define the normal anatomic features.

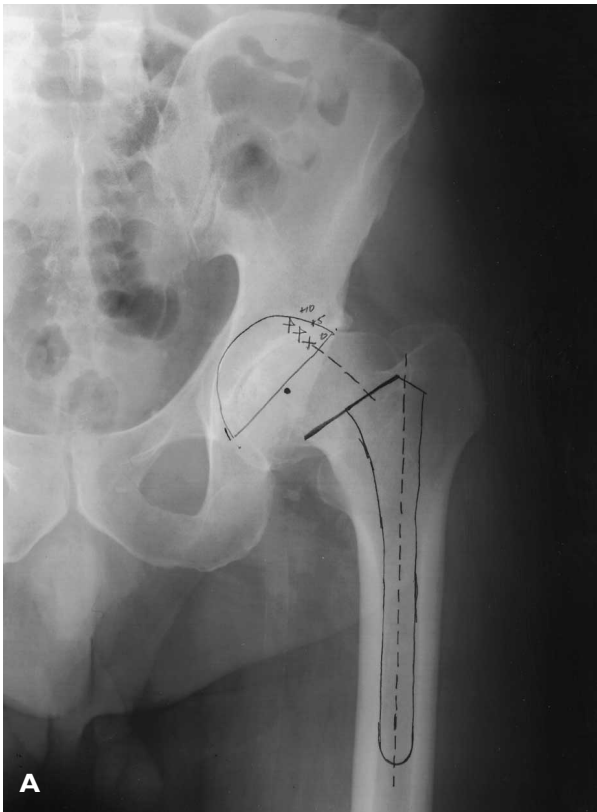


Figure 4. (A) Anteroposterior radiograph demonstrates templating of the acetabulum and femur. It is helpful to draw the desired socket position. The socket is drawn against the medial wall of the acetabulum (teardrop) and angled to transect the obturator foramen. Placing the inferior aspect of the cup level with the teardrop usually places the cup in proper abduction. An anteroposterior femur radiograph is helpful in sizing the femoral component and assessing proper varus and valgus alignment. Femoral offset is shown here, as well. (B) Lateral radiograph demonstrates templating of the acetabulum. Sizing of the socket is easy to determine with this view. The position of the socket relative to the ischium is helpful in determining proper anteversion.

VI. SURGICAL APPROACHES

A. Anterolateral approach (modified Hardinge)

1. The area between the **tensor fascia lata** and **gluteus medius** muscles is used. (In the lateral [Hardinge] approach, the gluteus medius and vastus lateralis muscles are split.)
2. The anterior halves of the muscles are divided and elevated subperiosteally as a sleeve. This allows skeletization of the proximal femur. This approach is useful for patients who have flexion contractures or a neurologic condition such as spasticity or Parkinson's disease.
3. An assistant to hold the leg is not needed because the leg is placed in a pocket across the operating table.

B. Posterior approach

1. **Advantages**
 - a. The posterior approach avoids disruption of the abductor mechanism and provides excellent exposure of the acetabulum and femur.
 - b. Use of the posterior approach may decrease the incidence of limping. It

facilitates rapid rehabilitation because the abductor muscles remain intact.

This approach can be converted easily to more extensible exposures if needed, as for revision surgery.

2. **Disadvantage.** The posterior approach has historically been associated with a higher incidence of postoperative dislocation (*see page 9*).
3. **Technical considerations**
 - a. The skin incision can be curved slightly posteriorly proximal to the trochanter. The gluteus maximus is split bluntly in line with its fibers. The short external rotator muscles are cut as close to bone as possible to facilitate repair. The posterior capsule is incised and saved for repair.
 - b. The rotator muscles insert into the posterolateral aspect of the greater trochanter and femur. They protect the sciatic nerve during the posterior approach.
 - c. The medial femoral circumflex artery arises from the deep femoral artery and may be encountered during the posterior approach.

- d. Additional exposure can be gained with resection of the anterior capsule, releasing the origin of the rectus femoris and the insertion of the gluteus maximus muscles into the femur.
- e. Closure involves repair of the capsule and external rotators through the trochanter.

VII. COMPONENT FIXATION

A. **Advances in cementing technique.** Efforts to extend the life span of cemented THA implants have centered on improving the mechanical properties of polymethyl methacrylate and improving the techniques of delivery.

1. **Porosity reduction** by means of centrifugation or vacuum mixing improves the mechanical characteristics of polymethyl methacrylate.^{3,4}
2. **Microinterlock**, the depth of cancellous bone penetration, is important to the stability of the THA. Thin cement mantles are at risk of fracture, which can cause loosening and eventual failure. Efforts to improve cement delivery (thereby improving microinterlock) have focused on various techniques involving bone preparation, lavage, hemostasis, delivery, and pressurization.
3. **Macrointerlock**, the shape of the cement mass within the bone envelope, depends on the geometric features and preparation of the bone as well as the geometric features and size of the implant.
4. Results of cemented THA are subdivided according to the **generation of cement technique**.
 - a. **First generation:** hand packing without use of a canal plug
 - b. **Second generation:** retrograde filling of the femoral canal and use of a distal cement plug
 - c. **Third generation:** vacuum or centrifuge mixing to reduce cement porosity, pressurization of cement into bone, and surface treatment of the femoral prosthesis

B. **Acetabular component**

1. **Cemented.** Cemented fixation is useful for patients with poor ingrowth potential (eg, because of previous pelvic irradiation).
 - a. The acetabulum is typically over-reamed by 2 mm to ensure an adequate cement mantle.

b. The surgical technique involves placing small defects (cement fixation holes) to ensure adequate cement fixation.

2. **Uncemented.** Uncemented fixation was developed in an effort to decrease the rate of long-term loosening that occurred with use of cemented sockets.

- a. Advantages include the ability to change socket position intraoperatively and the use of modular liners.
- b. Current technique involves under-reaming the socket by 1 to 3 mm to decrease motion at the implant-bone interface.
- c. For ingrowth to occur, the following conditions must be met:
 - 1) No excessive motion between implant and host bone
 - 2) Intimate contact between porous surface and host bone
 - 3) Pore size within the optimal range (150 to 400 μm)
- d. Socket fixation typically is augmented with screws, pegs, or spikes. Errant placement of these screws may place neurovascular structures at risk.⁵

3. **Results**

a. **Cemented**

- 1) The medium- to long-term rate of loosening of cemented acetabular components (determined radiographically) ranges from 25% to 75%.⁶⁻⁸ Considerable disparity exists between radiographic and clinical results.
- 2) Wroblewski et al⁹ found that loosening can be caused by debris generated at the bone-cement interface.
- 3) Hartofilakidis et al¹⁰ reported that the rate of satisfactory results in patients with a cemented acetabular component decreased markedly after 10 years of follow-up.
- 4) In a study of cemented metal-backed acetabular components, the acetabular failure rate was more than 23% after follow-up of 10 to 13.5 years.¹¹

b. **Uncemented.** Overall favorable results have been reported for uncemented acetabular sockets.

- 1) In a review of the results of 136 arthroplasties performed with Harris Galante-I components using

supplemental screw fixation, Latimer and Lachiewicz¹² found no radiographic evidence of loose cups and no revisions performed after an average follow-up period of 7 years.

- 2) In 1995, the Norwegian Arthroplasty Registry showed an acetabular revision rate of 7.1% over 6 years for 4352 uncemented cups.¹³
- 3) Accelerated polyethylene wear occurs with use of some uncemented acetabular designs (dual geometry, porous-coated anatomic designs).¹⁴
- 4) In a review of 199 THA patients with porous-coated anatomic sockets, 30 had pelvic osteolysis at 5- to 7-year follow-up.¹⁵

C. Femoral component

1. Cemented

- a. Most prostheses have a modular coupling between the head and the stem to allow variation of neck length to enhance abductor tension for stability.
- b. Some designs have a collar that acts as an insertion stop and transfers load to the proximal bone and cement.
- c. Design of the femoral component includes a tapered stem to enhance pressurization and maintenance of a uniform cement mantle.
- d. Optimum stem length for primary arthroplasty is 100 to 130 mm.
 - 1) Very short stems cause high proximal stress.
 - 2) Long stems increase stress in the stem and cause distal stress transfer, which results in stress shielding of the proximal bone.
- e. The optimal surface for a femoral implant is controversial. Roughened stem surfaces (precoated with polymethyl methacrylate, porous coat) may allow excessive cement adhesion and resist distal migration. Rough surfaces also may be a source of particulate debris if the stem debonds.

2. Uncemented

- a. Uncemented femoral components are typically indicated for young, active patients—those younger than 65 years with bone quality and geometric features that allow firm fixation.

- b. Relative contraindications include chronic disease (eg, rheumatoid arthritis, metabolic bone disease, chronic steroid use, osteoporosis) and limited life expectancy.
- c. The implant should attain immediate stable fixation and long-term biologic fixation.
- d. Sintered beads, wire mesh, and hydroxyapatite are the 3 main forms of surface treatments to promote osseous integration. The optimum surface attributes known to allow ingrowth include a pore diameter of 150 to 400 μm .
- e. Circumferential surface treatment has been favored to avoid access for debris to the distal aspect of the stem.
- f. Intraoperative fracture has been reported to occur during 3.5% of primary uncemented THA procedures.¹⁶
- g. Thigh pain after uncemented THA can be caused by component instability or a mismatch between stiffness of the implant and femoral bone.

3. Results

a. Cemented

- 1) **First generation.** In a 20-year follow-up study, 91% of patients with Charnley THAs implanted using first-generation technique were free of revision.
- 2) **Second generation.** Stauffer⁸ reported that 95% of patients with second-generation cemented THAs were free of aseptic loosening at 10 years follow-up.
- 3) **Third generation.** Few data are available regarding third-generation cement technique. Oishi et al,¹⁷ after follow-up of 100 THAs for a mean of 7 years, recorded a mean Harris Hip Score of 91 and only 1 revision (for femoral loosening).

- b. **Uncemented.** Results of the use of some uncemented femoral components are excellent.

- 1) Engh et al¹⁸ reported a 97% stem survival rate in 174 hips at a minimum of 10 years of follow-up.
- 2) In a study of 100 THAs that used proximally coated stems (porous-coated anatomic), Xenos et al¹⁹



Figure 5. Anteroposterior radiograph of a 67-year-old patient shows results of hybrid total hip arthroplasty.

found a 5% rate of loosening and a 2% rate of revision at 10- to 13-year follow-up.

- 3) Capello et al²⁰ reported a 0% revision rate after an average follow-up period of 6.4 years with use of a hydroxyapatite-coated stem.

VIII. HYBRID TOTAL HIP ARTHROPLASTY

A. Introduction

1. Hybrid THA consists of a **cemented femoral** component and an **uncemented acetabular** component (**Figure 5**).
2. This procedure is favored by some surgeons because of lessons learned with cemented femoral designs and surgical technique and because of improvement in acetabular designs.

B. Results

1. Berger et al²¹ reported on 150 primary hybrid THA prostheses followed for 7 to 10 years. Aseptic loosening occurred in 2 femoral components (1.3%), and 2 acetabular components migrated.
2. Lewallen and Cabanela²² followed 152 consecutively implanted hybrid THA prostheses for 5 to 9 years and reported a 2.2% revision rate for femoral aseptic loosening and 0.7% revision rate for acetabular loosening. These rates are markedly better than those previously

reported for use of uncemented acetabular components.

3. Smith and Harris²³ evaluated the results of 52 hybrid THAs. After 10 to 13 years, there was no radiographic evidence of femoral or acetabular loosening. Pelvic osteolysis occurred in 1 patient (2%) whereas femoral osteolysis occurred in 8 patients (15%).
4. Long-term results of hybrid THA are not available.

IX. BEARING SURFACES

- A. **Metal on polyethylene.** Introduced by Charnley in 1962, metal on polyethylene is the most frequently used bearing surface in THA. Ultrahigh-molecular-weight polyethylene is used as the acetabular bearing surface.
 1. Concerns remain over wear rates and methods of sterilization. Generation of particulate debris from polyethylene has been determined to be the primary cause of osteolysis and the main mechanism of failure after THA.
 2. Alternative bearing surfaces have been studied, and the results justify further consideration.
- B. **Ceramic.** The two main types of ceramic heads are alumina and zirconia.
 1. Advantages of ceramic implants include hardness, wettability (ability to maintain surface lubrication), and superior biocompatibility. Ceramic heads have a smoother surface finish and do not roughen from oxidative and third-body wear as do metal heads; thus, the polyethylene wear rate is reduced.
 2. Disadvantages of ceramic implants center on cost and risk of fracture.
- C. **Metal on metal.** Marked improvement in wear rates is possible with metal-on-metal bearing surfaces. Concerns center on particle size and systemic levels of cobalt and chromium. Smaller particle size can cause greater particle number outside the hip joint. Although elevated serum levels of cobalt have been found in patients with metal-on-metal bearings,²⁴ no marked clinical effects have been reported.
- D. **Highly cross-linked polyethylene.** Cross-linking between chains of polyethylene appears to produce a 3-dimensional structure with improved wear characteristics. Laboratory data show improvement in wear rates^{25,26}; however, limited clinical information exists.

X. COMPLICATIONS

- A. **Infection** complicates approximately 1% of primary THA procedures.
1. **Clinical course.** The clinical course is variable. Infection can manifest as occult pain with or without fever, chills, and wound drainage. Patients with subacute or chronic infection may not have systemic signs of infection.
 2. **Diagnosis**
 - a. **Laboratory tests** can assist in the diagnosis.
 - 1) Erythrocyte sedimentation rate (ESR) is a nonspecific test and may not be suitable as a diagnostic aid. In a study at the Mayo Clinic,²⁷ investigators found an elevated ESR in only 29% of samples from patients with late hematogenous infection diagnosed more than 1 year from the index procedure.
 - 2) Measurement of C-reactive protein has been shown more sensitive than ESR for diagnosis and postoperative monitoring of therapy.²⁸ In the absence of infection, the level of C-reactive protein returns to baseline within 3 weeks of an operation.
 - b. **Imaging** includes the use of plain radiographs to evaluate for signs of infection (ie, endosteal scalloping, progressive radiolucent lines, periosteal new bone formation, or mechanical loosening). Radionuclide scans are expensive and have varying levels of sensitivity and specificity but can be enhanced with the addition of indium-111 labeled leukocytes (sensitivity 83% and specificity 85%) or sulfur colloid indium-111 (sensitivity 100% and specificity 97%).
 - c. **Aspiration** can be a valuable tool in the assessment of hip infection. With proper technique, results of aspiration confirm the organism 90% of the time. Overall, this method of assessment possesses 92% sensitivity and 97% specificity with an accuracy of 96%.
 3. **Treatment** may be dictated by the timing of the diagnosis.
 - a. **Early postoperative infections** (3 weeks or less of symptoms) can be treated with surgical débridement, component retention, and intravenous antibiotics.
 - b. **Late chronic infections** are managed with aggressive débridement, removal of components, antibiotics, and 1-stage—or more commonly, 2-stage—reimplantation.
 - c. Long-term antibiotic suppression typically is reserved for patients who are ill or whose condition may preclude future surgery.
- B. **Dislocation.** Woo and Morrey²⁹ reported an incidence of 3.2% after reviewing more than 10,000 THAs. Posterior dislocation is more common than anterior dislocation.
1. **Risk factors.** Female sex and a history of hip surgery are risk factors for instability of the hip. Other factors to consider include limb length inequality, femoral offset, and component orientation.
 2. **Pathogenesis**
 - a. Posterior dislocation usually is caused by excessive hip flexion, adduction, and internal rotation.
 - b. Anterior dislocation is caused by extension, adduction, and external rotation.
 - c. Use of the anterior approach to THA has been associated with a lower incidence of hip dislocation (2.3%) than has use of the posterior approach (5.8%).²⁹
 3. **Treatment** is centered on defining the cause of the hip instability.
 - a. **Nonoperative treatment** (hip guide brace, spica cast, or knee immobilizer) appears to be most effective if the initial dislocation occurs within 3 months of the procedure. This method is effective for approximately two thirds of patients.
 - b. **Revision surgery.** Approximately 1 in 100 patients needs revision hip surgery because of instability.
 - 1) Daly and Morrey³⁰ reported the most common surgical finding at revision was malorientation of the acetabular component. Corrective surgery was successful for 61% of the patients studied.
 - 2) The second leading cause of hip instability in this study was abductor mechanism deficiency.³⁰
- C. **Thromboembolism.** Venous thromboembolism is a frequent complication of THA. The estimated incidence of deep venous thrombosis (DVT) after THA is 50%; 20% of patients have proximal

DVT.³¹ Symptomatic DVT appears to be the most common reason for hospitalization after THA.

1. **Risk factors** for DVT include advanced age, immobilization, history of DVT, vessel injury during surgery, malignant disease, obesity, congestive heart failure, and use of oral contraceptives.
 2. **Prophylaxis** of DVT centers on use of anticoagulants and mechanical measures.
 - a. **Low-dose warfarin** appears safe and effective. International normalized ratio is closely monitored during administration of warfarin to ensure an international normalized ratio of 1.5 to 2.2.
 - b. **Low-molecular-weight heparin** also is used effectively for prophylaxis of DVT. This medication has the added advantage of longer plasma half-life, does not require laboratory monitoring, and may have a more consistent anticoagulant effect.
 - c. The optimal duration of anticoagulation therapy after surgery is controversial.
- D. **Heterotopic ossification.** Formation of ectopic bone can compromise function and cause pain after THA.
1. **Etiology.** Although the exact cause is unknown, the following factors have been implicated: muscle damage, hematoma formation, and damaged periosteum.
 2. **Classification.** The Brooker classification is used to describe heterotopic ossification.
 - a. **Class I:** islands of bone within the soft tissues
 - b. **Class II:** bone spurs from pelvis or proximal femur with at least 1 cm between bone surfaces
 - c. **Class III:** bone spurs from pelvis or proximal femur with less than 1 cm between bone surfaces
 - d. **Class IV:** ankylosis of the hip
 3. **Incidence.** The incidence of heterotopic ossification ranges from 20% to 80%. Only 5% to 10% of these patients have Brooker class III or IV ossification.
 4. **Risk factors** include active ankylosing spondylitis, DISH syndrome (diffuse idiopathic skeletal hyperostosis), history of ectopic bone formation from previous hip surgery, and limited preoperative hip motion. Men with hypertrophic osteoarthritis appear more likely than women to have heterotopic ossification after THA.
 5. **Prevention.** Low-dose external beam radiation administered within the first 72 hours after surgery is effective and safe prophylaxis.
 - a. Concern has been generated over the effect of radiation on bone ingrowth into porous-coated components. A shielding technique has been developed to minimize radiation to areas of bone ingrowth.³²
 - b. Alternatives include nonsteroidal anti-inflammatory drugs, and diphosphonate therapy.
- E. **Leg-length discrepancy.** The incidence of marked leg-length discrepancy has decreased owing to increased awareness and attention to detail. In 1978, Williamson and Reckling³³ reported an average lengthening of 16 mm. Twenty-seven percent of patients needed a shoe lift, and 3% had sciatic nerve palsy. In 1985, Woolson and Harris³⁴ found only 2.5% of 84 limbs were lengthened more than 6 mm.
1. **Preoperative assessment.** Existing leg length inequality is measured clinically and radiographically before surgery.
 - a. Both the true inequality (from the anterior superior iliac spine to the medial malleolus) and the apparent inequality (from umbilicus to medial malleolus) are measured. The Coleman block test also can be used (the pelvis is leveled with different thickness blocks placed under the short leg).
 - b. Radiographic studies have shown that the ischial tuberosities are more accurate reference points than are the femoral heads.³⁵ Direct measurements can be obtained with a scanogram. Use of a 14- by 17-cm cassette allows direct measurement of the lower extremity.
 2. **Intraoperative assessment**
 - a. This includes the tension test, in which longitudinal traction is placed on the extended limb. The limb must be in neutral extension, abduction, adduction, and rotation.
 - b. Numerous authors have described direct intraoperative methods of measuring pelvic-femoral length.³⁴⁻³⁶ Most these entail markers in the pelvis and proximal femur that allow measurement before and after completion of the procedure.
 3. **Treatment.** Leg-length inequality usually is treated with a shoe lift. Surgical management of symptomatic inequality may necessitate alteration of modular neck lengths.

F. **Neurologic complications.** The true incidence of nerve palsy after THA is unknown. It has been estimated that neural injury occurs among 1% to 2% of patients.³⁷

1. **Risk factors**

- a. Women appear to be at greater risk than men.^{33,38,39}
- b. Increased risk of neural injury with revision surgery also has been reported.^{38,40}

2. **Specific patterns of injury**

- a. **Sciatic nerve injury** occurs in 0.7% to 1% of THA procedures.^{39,41}

- 1) The variable course of the sciatic nerve in relation to the piriformis muscle and direct trauma from retraction places the nerve at risk during the **posterior approach**.
- 2) **Limb lengthening** also has been implicated as a cause of sciatic nerve palsy. Sunderland⁴² described damage caused by stretch of more than 6% of the nerve length. On the basis of the average length of the sciatic nerve (75 cm), this translates into lengthening greater than 4 cm.

- b. **Femoral nerve injury.** The second most frequently injured nerve is the femoral nerve.
 - 1) Injury seems to be related to the type of approach and excessive retraction around the anterior acetabulum.
 - 2) Simmons et al⁴³ reported femoral nerve palsy among 2.3% of patients who underwent a Hardinge approach.

- c. **Superior gluteal nerve injury.** Risk to the superior gluteal nerve appears greatest with a gluteal splitting approach (Hardinge). The nerve appears to be most at risk when the gluteus medius muscle is split proximally more than 4 cm.⁴⁴

3. **Treatment** is centered on prevention.

- a. Awareness and recognition of risk factors (eg, female sex, revision surgery) and controllable causes (eg, hematoma) associated with nerve palsy assist the surgeon in diminishing the incidence.
- b. Observation appears to be appropriate when there is no discernible cause.
- c. Sciatic nerve palsy due to leg length inequality after THA with modular com-

ponents can be addressed with shortening the femoral head and neck.

- d. Decompression of hematoma has been shown to partially or completely relieve symptoms of nerve palsy.⁴⁵

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