Total hip arthroplasty has revolutionized the treatment of end-stage hip arthritis and is felt to be among the most cost effective of all medical interventions available. As a result of the combination of the high success rate, increasing population age, and increasing clinical indications for total hip arthroplasty the absolute number of complications experienced will inevitably increase. A thorough understanding of the more common complications following total hip arthroplasty aids in optimizing patient outcomes and allows for improved patient education during preoperative counseling. This review focuses on some of the aseptic complications of total hip arthroplasty including neurovascular injury, leg-length discrepancy, and instability.

Neurovascular Injury

Although uncommon, neurovascular injuries are associated with significant morbidity and mortality. Common mechanisms of injury include malpositioned internal fixation devices, intraoperative compression, traction, ischemia and/or direct transection.

With the popularity of non-cemented acetabular components inserted with screws to augment initial stability, there has been concern over an increased risk of neurovascular injury. The quadrant system as described by Wasielewski and colleagues is a simple method for understanding the relevant neurovascular anatomy surrounding the acetabulum and for guiding safe screw placement. This system divides the acetabulum into halves from the anterior-superior iliac spine caudally and then bisects this line to form four quadrants (Fig. 1). In their anatomical study of cadavers, the posterior-superior quadrant was found to offer the greatest margin of safety and the highest quality bone for adjunctive screw fixation.

Vascular Injury

The incidence of vascular injury has been reported to be 0.1% to 0.2% — the most commonly injured structures are the external iliac and common femoral vessels. Vascular structures may be injured by direct mechanisms (scalpel, retractor, or acetabular reamer) or indirectly from a stretching injury, particularly in patients with atherosclerosis.

External Iliac Artery and Vein

The external iliac artery and vein run obliquely down the medial border of the psoas muscle. A variable amount of the muscle itself is interposed between the vessels and the anterior column of the acetabulum. The amount of muscular interposition decreases from proximal to distal with minimal soft tissue coverage present where the external iliac vessels are opposite the anterior-superior quadrant of the acetabulum.

The external iliac artery is more commonly injured than the vein — the most common mechanism being direct injury from a retractor placed too far medially over the anterior acetabular rim. Injury is less likely with more proximally placed retractors since there is increased soft-tissue coverage by the psoas muscle. Excessive medial acetabular reaming or cement extrusion through a medial acetabular defect has been reported to result in direct injury to the external iliac vein. Avoidance of the anterior-superior quadrant during insertion of acetabular screw fixation is recommended to avoid injury to the external iliac vessels.
Common Femoral Artery and Vein

The common femoral artery and vein are the distal extensions of the external iliac vessels after they have passed below the inguinal ligament. They course anterior to the hip joint and are separated from it by the iliopsoas tendon. The artery is found lateral to the vein at the level of the hip joint and it is more prone to injury.

The most common mechanism of injury is from an anterior acetabular retractor placed too far medially over the anterior wall of the acetabulum. Resection of antero-inferior osteophytes can also lead to femoral artery injury. Traction injuries may also occur with dislocation and reduction maneuvers, particularly in patients with pre-existing atherosclerosis. Stamatakis and associates demonstrated that near occlusion of the femoral vein can occur during prosthetic dislocation.

Obturator Artery and Vein

The obturator artery, vein, and nerve travel together along the quadrilateral surface of the acetabulum. The obturator internus muscle lies between the obturator neurovascular bundle and the antero-inferior quadrant of the acetabulum. The neurovascular bundle then exits the pelvis at the superolateral corner of the obturator foramen. Injury to these structures has been reported, and can occur with acetabular screw fixation in the antero-inferior quadrant or from retractors placed underneath the transverse acetabular ligament.

Neural Injury

Injury to the peripheral nerves is an uncommon complication of total hip arthroplasty ranging in incidence from 0% to 3% in studies ranging in size from 385 to 825 patients. This complication is most commonly reported in patients with significant intraoperative leg lengthening, women, and those who have had prior operative procedures on the hip.

Neural injury may be caused by compression, traction, or ischemia, with two or more of these factors often playing a role in a given patient with a neurologic injury. Compressive injury may occur secondary to intraoperative retractor placement or a postoperative hematoma resulting in a delayed presentation of neurologic injury. Traction injury may be secondary to intraoperative manipulation (including hip dislocation and reduction maneuvers) or to either lengthening or lateralization of the hip. Limb lengthening of more than four centimeters has been strongly associated with an increased risk of neural injury during total hip arthroplasty. This clinical finding is supported by experimental models that have shown that nerve elongation of more than 6% is associated with neural injury. In a study...
of 100 patients who underwent total hip arthroplasty for degenerative arthritis secondary to developmental hip dysplasia, the rate of neurologic injury was 28% (13 of 46 patients) in those who had an acute lengthening of more than 4 cm while no patient who had a lengthening of less than 4 cm had a nerve palsy. Excessive perineural dissection with direct trauma to the neural blood supply may also cause neurologic dysfunction.

Somatosensory-evoked potentials (SSEP), initially used to detect neurologic injury during spinal surgery, have been used in an attempt to identify patients with neurologic injury undergoing total hip arthroplasty. In a prospective study of 100 patients undergoing total hip arthroplasty, Black and coworkers found no benefit to using SSEP monitoring with sciatic nerve palsies occurring in 2.0% of those who were monitored compared to 2.6% in those who were not. Given the expense and time required to perform SSEP, its routine use is not justified.

**Sciatic Nerve Injury**

The sciatic nerve exits the pelvis through the greater sciatic notch below the piriformis muscle continuing along the short external rotator muscles of the hip, lying over the postero-lateral aspect of the posterior column of the acetabulum. More than 90% of peripheral nerve injuries associated with total hip arthroplasty involve the sciatic nerve, with the majority affecting predominantly the peroneal division. The peroneal division is at increased risk for injury because it is tethered at both the sciatic notch and the fibular head and is also located more lateral than the tibial division. In addition, the tibial division of the sciatic nerve is associated with smaller nerve bundles surrounded by greater amounts of connective tissue, making it more able to tolerate elongation.

In a review of 70 patients with sciatic nerve palsies following total hip arthroplasty, the etiology was unknown in 29 of 70 cases. Leg lengthening was the most commonly identified etiology accounting for 20 of the 70 cases, with another 9 cases attributed to direct mechanisms including injury caused by a retractor, reamer, suture, scalpel, and electrocautery. Excessively long or inappropriately placed screws used for acetabular component fixation may also cause sciatic nerve injury.

**Femoral Nerve Injury**

Femoral nerve palsies are the second most common peripheral nerve injury following total hip arthroplasty. In a series of 440 patients, Simmons and colleagues reported that femoral nerve palsies were seen in 2.3% of patients. These injuries are more subtle in presentation and are not associated with prolonged disability unless the nerve has been entrapped by cement.

The femoral nerve lies over the iliopsoas muscle and is vulnerable to injury in the femoral triangle. The mechanisms of injury are similar to those that can lead to sciatic nerve palsy, including direct injury from retractor placement, leg lengthening, and injury from extruded cement. Of the 10 cases of femoral nerve palsy reported by Simmons, all were felt to be secondary to placement of the anterior acetabular retractor. Placement of screws for acetabular component fixation in the anterior quadrants can also lead to femoral nerve injury. A hematoma involving the iliacus muscle can produce postoperative femoral nerve palsy and has been associated with perforation of the medial wall of the acetabulum during acetabular reaming. Although controversial, if a hematoma is the presumed etiology of a femoral nerve palsy, decompression of the hematoma may be indicated.

**Obturator Nerve**

Obturator nerve injuries are infrequent events following total hip arthroplasty; Weber reported only one in 2,012 total hip arthroplasties. Obturator nerve injury is most commonly associated with extruded intrapelvic cement, although injury can also occur with placement of screws into the anterior inferior quadrant of the acetabulum.

The diagnosis of obturator nerve injury can be obscure. Patients with persistent groin pain and evidence of extruded intrapelvic cement on postoperative x-rays should be suspected of obturator nerve injury — electromyograms can confirm the diagnosis. Bone grafting or use of a barrier device is recommended for any medial acetabular defects if a cemented acetabular component is used for reconstruction in order to avoid obturator nerve injury.

**Superior Gluteal Nerve Injury**

Injury to the superior gluteal nerve is associated with the lateral or anterolateral approach to the hip if the gluteus medius muscle is split more than 5 cm proximal to the greater trochanter. The prevalence is unknown, but may manifest itself as prolonged or permanent weakness of the hip abductors.

**Prognosis of Neural Injuries**

The prognosis for neurologic injuries is variable and felt to be related to the severity of the initial injury. In general, recovery is better for femoral as opposed to sciatic palsies, and patients with isolated peroneal division injuries have a better prognosis than those with complete sciatic palsies. Isolated sensory neuropathies have a better prognosis than injuries that involve loss of motor function and those that show improvement in the early postoperative period tend to have good functional outcomes. Injuries secondary to traction from limb lengthening as opposed to direct trauma tend to have a poorer prognosis. Although improvements in neurologic function may be seen up to one year post-injury, further improvement is rare after 18 months. Persistent dysesthesias have been reported to complicate 28% of neurologic injuries and can lead to a poor outcome.
**Contralateral Leg Injury**

Injuries to the contralateral limb, although rare, are particularly troublesome to both patient and surgeon. Smith and associates\(^2\) reported 6 cases of contralateral limb injury during total hip arthroplasty. This complication was highly associated with lateral decubitus positioning in a clamp-type device and extended operative time. Complications included complete femoral and sciatic nerve palsies in 5 patients, rhabdomyolysis in 4 (one of whom developed acute renal failure), and popliteal artery occlusion in 1 patient that necessitated below knee amputation.

Lachiewicz and colleagues\(^2\) reported on 6 patients who developed rhabdomyolysis of the down leg’s gluteal musculature with nerve palsies and postoperative oliguria. Careful patient positioning and padding is required to avoid these complications, particularly if extended operative times are expected. Specific recommendations include the use of an axillary roll, padding beneath the down knee (to protect the peroneal nerve at the fibular head) and foot, as well as careful padding of the abdomen in the lateral position.

**Leg Length Discrepancy**

Maintenance or restoration of leg length equality after total hip arthroplasty is of great concern to both surgeon and patient. Leg lengthening of more than 1 cm has been associated with a vaulting gait, pelvic obliquity, the need for a shoe lift, and patient dissatisfaction.\(^2\) Although controversial, substantial leg lengthening has also been associated with an increased risk for aseptic loosening and prosthetic failure.\(^3\) Leg length discrepancy has been a common problem in the past. Williamson and Reckling\(^3\) reported an average lengthening of 1.6 centimeter among 144 patients that underwent total hip arthroplasty; 27% of these patients required a shoe lift on the contralateral side. More recent reports, where a systematic approach for equalizing leg lengths has been used, have reported much lower rates of leg length inequality; 97% of those in a series of 408 total hip replacements had a leg length discrepancy of less than 1 centimeter.\(^4\) A combination of preoperative radiographic templating and intra-operative assessment can be used to minimize the possibility of creating a significant leg length discrepancy.

**Preoperative Planning**

Some shortening of the extremity with an arthritic hip is expected given the loss of cartilage on both the femoral and acetabular sides of the joint. Although clinical measurement from the anterior superior iliac spine to the medial malleolus of the ipsilateral ankle can be useful, radiographic measurement is more accurate — however, a multitude of factors including flexion contractures of the hip or knee can affect this measurement. For accurate preoperative planning, an anterior-posterior (AP) view of both hips and lateral hip radiograph of the operative hip is needed.

Preoperative templating begins with an assessment of the preoperative leg length discrepancy as determined from the AP radiograph of the pelvis. A line is drawn tangent to the ischial tuberosity on both sides of the pelvis and the distance from this line to the top of the lesser trochanter of each hip quantifies the preoperative leg length discrepancy (Fig. 2). The acetabular component size and position are templated first and the center of rotation of the hip reconstruction is marked on the radiograph. The acetabular component should lie against the teardrop medially and the inferior margin of the component should lie at the level of the obturator foramen. Varying the level of the femoral neck cut and the length of the neck of the femoral component then equalizes leg length discrepancy.

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**Figure 2** Preoperative AP pelvis radiograph showing leg length discrepancy. A line is drawn tangent to the ischial tuberosities and the distance to the top of the lesser trochanter is measured on the affected and normal side to determine the amount of preoperative leg length discrepancy.
The appropriate size femoral component is selected based on an assessment of appropriate fit and fill on the AP and lateral radiographs of the hip (Fig. 3). When selecting femoral component size, careful consideration should be given to restoring the patient’s femoral offset to reproduce normal hip biomechanics and abductor function. A longer modular neck size can be selected to improve femoral offset. In addition, many manufacturers now offer components in both standard and higher offset to optimize femoral offset. Once the femoral component has been selected, the overlay template is placed onto the AP pelvis radiograph to determine the level of femoral neck resection. The level of resection is adjusted to adequately restore leg length as determined by the preoperative assessment of leg length inequality. A notation of the expected distance from the top of the lesser trochanter to the center of the femoral head is also made. This measurement is then used intra-operatively to confirm that substantial changes in leg length have not occurred.

**Intra-Operative Assessment**

Although preoperative templating can greatly assist the surgeon in avoiding the creation of a leg length discrepancy, knowledge of methods for intra-operative assessment are required to insure optimization of leg length. If an intra-operative discrepancy is discovered, adjusting the length of the modular femoral head or further resection of the femoral neck can restore appropriate leg length. A femoral component with increased femoral offset may be required if increased soft-tissue tension is needed to create a stable construct without compromising leg length equality.

After seating of the trial components, an assessment of the relative heights of the tip of the greater trochanter and the center of the femoral prosthesis are made. In general, these two points should be at the same level; a comparison with the preoperative plan can confirm any expected discrepancy in this measurement. In addition, a measurement from the center of the prosthetic femoral head to the lesser trochanter is made and compared to the same measurements made from the preoperative plan.

A variety of intra-operative measuring devices have also been used to assess intra-operative changes in leg length.44-37 All of these devices measure from a fixed point on the pelvis to another fixed point distal to the hip joint on the femoral shaft before and after the reconstruction. In order for these devices to work properly, the operating table must be level with the floor and the position of the hip must be reproduced precisely in all planes before and after the reconstruction is performed.

**Instability**

Instability is among the more common and distressing early complications following total hip arthroplasty. It has been estimated that a dislocation will complicate between 2% to 3% of primary total hip arthroplasties, although reported rates of instability range from 1% to 9% in studies ranging in size from 427 to more than 10,000 hips.38

**Variables Influencing Instability**

Variables that influence postoperative instability can be grouped into factors related to the patient and factors related to the surgical technique. Patients undergoing revision total hip arthroplasty appear to be at greatest risk for postoperative dislocation, with a risk of instability at least twice that of those undergoing primary total hip arthroplasty.39 Although females have also been associated with a greater risk of instability,40 more recent studies have not confirmed this association.41-43 Patient height, weight, preoperative diagnosis, and age have not been consistently shown to be risk factors for postoperative instability. Several recent reports have, however, related postoperative instability to what Woolson and colleagues termed cerebral dysfunction. Cerebral dysfunction includes patients who were confused in the postoperative period and those with a history of significant alcohol intake, inferring that these patients may have problems complying with total hip precautions.41,44 Pa-
tients with greater preoperative range of motion are also believed to be at higher risk for instability after total hip arthroplasty.

Component Position
An important operative factor for hip stability is the proper orientation of the acetabular and femoral components. Appropriate acetabular component position of 40° of abduction (±10°) and 15° of anteversion (±10°) has been generally accepted as appropriate. Retroversion of the acetabular component can lead to posterior instability and excessive anteversion predisposes to anterior instability. Placement of the cup in a more vertical position also leads to increased rates of instability. Intraoperative assessment of acetabular version is difficult and anteversion of the acetabular component has been found on average to be 5° to 7° less when total hip arthroplasty is performed through a posterior approach.

In addition, patients operated on in the lateral decubitus position may have unrecognized forward rotation of the pelvis that may lead to a retroverted position of the acetabular component. Femoral component anteversion of 10° to 15° is considered optimal. Although less common than malposition of the acetabular component, the most commonly sited error for femoral component malposition is excessive anteversion.

Although component orientation is important, when patients with postoperative dislocations are compared to those who have not dislocated, component position has been found to be very similar, indicating that patient-related factors are more important.

Surgical Approach
The surgical approach commonly has been cited as a risk factor for postoperative instability. Specifically, the posterior approach has been cited as having a higher risk of postoperative instability than the anterior or trans-trochanteric approaches. Recent studies, however, have shown that the posterior approach can be associated with a low rate of postoperative instability and that the experience of the surgeon is an important factor. Specifically, Hedlund and coworkers, in a study of 4,230 primary total hip arthroplasties, found that inexperienced surgeons had twice the number of dislocations as more experienced surgeons with the frequency of dislocations decreasing by 50% for every 10 hip replacements performed annually. This effect leveled off after 30 procedures per year.

Femoral Head Size
Smaller femoral head sizes, in particular 22 mm heads, have been thought to have a higher risk of postoperative instability. Theoretically, larger femoral head sizes must travel a greater distance before dislocation occurs and are less likely to impinge against the rim of the acetabular component. Clinical studies, however, have not shown a clear relationship between femoral head sizes and instability. The presence of a skirt on modular femoral heads can also lead to increased instability, as this configuration leads to early impingement against the rim of the acetabular component.

Femoral Offset
The mechanical relationship between the abductor musculature and the orientation of the femoral component has been described as femoral offset. Femoral offset is measured as the distance from the center of the femoral head to the axis of the stem of the femoral component. Inadequate restoration of femoral offset results in decreased tension in the abductor musculature and subsequent instability. In addition, inadequate offset may lead to an increased risk of bony impingement leading to instability. Fackler and Poss found a significant decrease in the femoral offset in patients with postoperative dislocations and concluded that enhanced stability is offered by lateral rather than distal displacement of the femoral stem. Many prosthetic manufacturers now offer femoral stems with increased femoral offset to more precisely recreate patient anatomy. These stems can be used in cases where increased stability is required without significant additional lengthening of the extremity.

Elevated Rim Liners
Elevated rim liners were first used by Charnley in an attempt to increase prosthetic stability. Cobb and colleagues reviewed 5,167 total hip arthroplasties and found that the rate of instability was 2.19% (2,469 hips) with an elevated rim liner compared to the 3.85% (2,698 hips) with a standard liner. Although elevated rim liners may decrease the rate of instability, there has been concern that these liners may lead to an increased rate of polyethylene wear and loosening secondary to impingement, although clinical studies have not found an association between the use of elevated rim liners and an increased rate of mechanical failure or loosening.

Miscellaneous Factors
In addition to the aforementioned variables, significant soft tissue laxity has also been commonly identified in patients with recurrent instability following total hip arthroplasty. Potter and associates, in a study of 15 patients evaluated by MRI, found that patients with instability did not have a well-developed posterior pseudocapsule, which is normally present after total hip arthroplasty. They hypothesized that this lack of a posterior soft tissue restraint may have contributed to their instability.

Trochanteric non-union has also been associated with instability as this greatly weakens the stabilizing forces provided by the hip abductors. Charnley and Cupic reported that 28% of their 56 patients with a postoperative
dislocation had a non-union of the greater trochanter. In addition, Coventry⁵⁷ reported that the rate of instability for patients with a non-union of the greater trochanter was 17%. Deep sepsis or severe polyethylene wear may also lead to instability secondary to distension or failure of the pseudocapsule surrounding the prosthesis. Finally, the surgeon should consider voluntary dislocations as a potential etiology for recurrent instability.

**Treatment of Instability**

Initial management of a dislocated total hip arthroplasty includes prompt closed reduction with intravenous sedation or general anesthesia in the operating room. Among the advantages of a closed reduction in the operating room is the opportunity to perform an examination under anesthesia to confirm the direction and potentially the cause of instability. A brace can then be used to limit flexion, adduction, and internal rotation in the case of posterior instability, which is most commonly the direction of dislocation.³⁹ Dorr and associates described their experience with this protocol and found that stability was achieved in 10 of 12 patients.⁵⁸ It is estimated that two-thirds of patients will be successfully treated by closed methods.⁵⁰

**Evaluation of Recurrent Instability**

Approximately 1% to 2% of patients undergoing primary total hip arthroplasty will require a revision for recurrent instability, making this the second most common cause of revision after aseptic loosening.³⁸ When contemplating operative treatment for recurrent instability, it is crucial to ascertain the etiology of the dislocation, as this leads to optimal results.³⁹ A thorough history should identify the circumstances surrounding the dislocation, the position of the leg at the time of dislocation, and previous operative or non-operative treatment modalities. It is important to determine if there is a history of heavy alcohol intake or periods of delirium that may be contributing to instability.⁴³,⁴⁴ The original operative notes should also be reviewed to confirm the surgical approach and prosthetic components used. The physical examination should include an evaluation of relative leg lengths, abductor muscle mass, and range of motion. AP and lateral radiographs should be obtained with the hip dislocated to confirm the direction of the dislocation. Plain radiographs are also useful for determining acetabular component abduction and for identifying severe polyethylene wear or aseptic loosening that may contribute to instability. Computed tomography can be used to accurately determine the version of the acetabular component as this is difficult to measure on plain radiographs.⁶⁰

**Operative Treatment of Soft Tissue Laxity**

If excessive soft tissue laxity has been identified as the etiology of instability, options include exchange of a modular femoral neck (if present) to a longer neck, use of a lateralized acetabular liner (if available), or trochanteric advancement. Although shortening of the modular femoral neck can correct instability, it may lead to unwanted leg lengthening. In addition, longer modular femoral heads often require a skirt to maintain biomechanical strength, which can lead to a new source of impingement and instability. Trochanteric advancement is a preferable option, with a success rate of approximately 80% if soft tissue laxity has been identified.⁵¹,⁶² A capsulorrhaphy can also be attempted to restore stability.

**Component Reorientation and Elevated Rim Liners**

If component malposition has been identified, correction should be undertaken; there is approximately a 70% chance of correcting the instability.⁵⁹ If femoral component malposition is identified, the use of a higher offset stem is recommended to augment stability. Elevated rim liners can be used to further protect against recurrent instability by orienting the elevated portion in the direction of instability. Although rarely an isolated cause of instability, any sources of impingement should be sought after and identified.

**Constrained Liners**

Constrained liners or liners with a capture mechanism have been used with increasing frequency for the treatment of recurrent dislocation. The advantage of these devices is that they provide immediate stability and can be easily inserted if compatible with the acetabular shell that is already in place. Alternatively, they can be cemented in a well-positioned, stable component if it is large enough to accommodate both the liner and an adequate cement mantle. Experience with these devices has been reported by Goetz and coworkers.⁴² In 56 hips treated with this device for recurrent instability, there were 2 recurrent dislocations (4%). In a report with a different constrained liner, the failure rate was 29% for 21 patients, 18 of which were operated on for recurrent instability.⁶³ Although the use of these devices is attractive, increased polyethylene wear and high stress transmission to the prosthesis-bone interface are serious concerns. These devices should be reserved for cases where other modalities fail to provide adequate stability.

**References**

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