Early Postoperative Complications After Total Hip Arthroplasty: Current Strategies for Prevention and Treatment

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Abstract
Total hip arthroplasty is a highly successful treatment for end-stage arthritis that substantially improves patients’ symptoms and function. Unfortunately, complications in the early postoperative period are inevitable, even in procedures performed by experienced surgeons using careful surgical techniques. Current strategies to prevent and effectively manage the most common early complications after total hip arthroplasty, including periprosthetic joint infection, instability, leg-length inequality, and periprosthetic femoral fracture, are discussed.


Total hip arthroplasty (THA) remains a successful cost-effective solution for end-stage degenerative joint disease and substantially improves patients’ symptoms, quality of life, and function.1 There has been a 50% increase in the rate of primary THAs from 47 individuals per 100,000 to 69 per 100,000 and a 60% increase in the rate of revision THAs from 1990 to 2002 in the United States alone.2 Similar increases have been reported worldwide.2 THA utilization rates are anticipated to increase even further with an aging population and increasing longevity. In general, postoperative complications substantially affect the overall cost for managing hip arthritis for healthcare systems. A thorough knowledge of the most commonly occurring complications can aid clinicians in avoiding, rapidly diagnosing, and effectively treating such complications to limit their morbidity.

Periprosthetic Joint Infection Prevention
Periprosthetic joint infection (PJI) is among the most serious complications of THA. There are several clinical
interventions that can lower the risk of PJI in the early postoperative period. The most important intervention is the appropriate administration of preoperative prophylactic antibiotics. A first-generation cephalosporin administered within 1 hour prior to the skin incision is standard, with clindamycin or, in some cases, vancomycin, administered to patients with a known allergy. The use of vancomycin, however, should be reserved for patients with known methicillin-resistant Staphylococcus aureus colonization, healthcare workers, and patients who have been hospitalized preoperatively to negate the risk of developing vancomycin-resistant infections. Prophylactic antibiotics are recommended for use only within the first 24 hours postoperatively.

Preparation of the surgical site also is of the utmost importance. Any hair at the incision site should be removed before preparing the skin. Existing evidence suggests that hair removal with an electric clippers is associated with fewer surgical site infections than razor hair removal. The skin may then be prepared with an alcohol-based solution, which according to a meta-analysis is effective at reducing surgical site infections. Another strategy to reduce infection is changing surgical gloves frequently because perforations and bacterial contamination are common intraoperatively. There also are some data to suggest the efficacy of dilute betadine lavage administered prior to wound closure to reduce the bacterial load in the wound at the time of closure, leading to a decreased risk of PJI.

Several patient-related factors have been associated with PJI, including advanced age, male sex, depression, cardiac arrhythmia, a history of prior surgical site or native joint infection, recurrent urinary-tract infections, diabetes, obesity (particularly a body mass index > 40), malnutrition, skin disorders (such as psoriasis), inflammatory arthritis, chronic renal failure, immunocompromise secondary to medication intake (such as corticosteroids), and the presence of malignancy or viral infections such as HIV. Although diabetes has been repeatedly shown to be related to PJI, it is unclear if perioperative or long-term glycemic control (as measured by the hemoglobin A1c test) is more important in preventing PJI. If these comorbidities are identified in patients, efforts should be made to optimize parameters (for example, glycemic control), and patients should be educated about their higher risk of PJI.

Diagnosis
The diagnosis of PJI can be extremely difficult in the early postoperative period secondary to normal postoperative pain, edema, and peri-incisional erythema, which make the appearance of the wound and normal cues to diagnosis unreliable. The erythrocyte sedimentation rate and C-reactive protein level are essential laboratory investigations commonly used as initial screening tests for diagnosing PJI. However, these inflammatory markers are known to be elevated in the early postoperative period because of the recent surgical trauma and may not be predictive of septic complications.

Yi et al performed a retrospective review of 6,033 consecutive primary THAs and identified 73 patients who underwent a revision procedure within the first 6 weeks postoperatively; 36 procedures were performed secondary to PJI. Mean serum values for infected and noninfected revisions are shown in Table 1. A wide spread of values was found between the infected and noninfected groups, and the authors suggested optimal cutoff values for the serum C-reactive protein level of approximately 100 mg/L (normal < 10 mg/L), a synovial fluid white blood cell (WBC) count of approximately 10,000 WBC/μL, and a differential (percentage of polymorphonuclear cells) of 90% (Table 2).

Based on these results, if PJI is suspected in the early postoperative period, it is recommended that a serum C-reactive protein level be obtained. If the level is near or greater than 100 mg/L, an aspiration of the hip is obtained.
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the aspiration yields greater than 10,000 WBC/μL combined with a differential of greater than 90% polymorphonuclear cells, the patient is returned to the operating room for surgical management of PJI. If the diagnosis of PJI is uncertain, the clinician can wait for culture results prior to deciding on appropriate management.

Treatment

Traditional treatment for early postoperative PJI is débridement, antibiotics, and implant retention with exchange of the modular bearing surface. Candidates for this approach include select healthy patients who present within the first 4 to 6 weeks postoperatively with a stable implant, no sinus tract, and an organism of low virulence.10 This approach has recently been questioned because of a high rate of failure, including one multicenter study that highlighted a 63% failure rate among 86 patients.11 The potential alternative treatment is one-stage exchange arthroplasty. The potential benefits of this approach include the relative ease of cementless component removal in the first few weeks postoperatively (as full osseointegration has probably not occurred at this point), improved exposure, better access to the retroacetabular bone and femoral canal, and removal of colonized implants that may harbor bacterial biofilm.

Support for this approach comes from a decision analysis that favored a one-stage exchange if a success rate of 69% could be achieved, assuming that the results of treatment with débridement, antibiotics, and implant retention were less than 60% successful.12 A clinical series of 27 hips treated at three centers showed a success rate of 70% at a minimum of 2 years.13 These results suggest that a one-stage exchange should be considered for the treatment of an early postoperative infection if cementless components were used.

Table 2

Optimal Cutoff Values and Performances of Diagnostic Measures

<table>
<thead>
<tr>
<th>Diagnostic Measure</th>
<th>Optimal Cutoff Values</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESR (mm/hr)</td>
<td>44</td>
<td>92%</td>
<td>53%</td>
<td>76%</td>
<td>80%</td>
<td>77%</td>
</tr>
<tr>
<td>CRP level (mg/L)</td>
<td>93</td>
<td>88%</td>
<td>100%</td>
<td>100%</td>
<td>83%</td>
<td>92%</td>
</tr>
<tr>
<td>Synovial fluid WBC count</td>
<td>12,800</td>
<td>89%</td>
<td>100%</td>
<td>100%</td>
<td>88%</td>
<td>94%</td>
</tr>
<tr>
<td>% PMN</td>
<td>89%</td>
<td>81%</td>
<td>90%</td>
<td>91%</td>
<td>79%</td>
<td>85%</td>
</tr>
</tbody>
</table>

ESR = erythrocyte sedimentation rate, CRP = C-reactive protein, WBC = white blood cell, % PMN = percentage polymorphonuclear cells.


Instability

Despite the best efforts of both the patient and the surgeon, dislocation after THA will inevitably occur. The incidence of dislocation is variable in the literature, ranging from 0.2% to 7% after primary THA and 10% to 25% after revision surgery.14 Risk factors for an early dislocation include advanced age, cerebral dysfunction, neuromuscular disease, alcoholism, prior hip surgery, and a diagnosis of femoral neck fracture as the indication for primary THA.15 Higher dislocation rates are associated with a posterior approach; however, recent studies demonstrate that repairing the capsule may mitigate this risk in the early postoperative period.16,17

Acetabular orientation is the most sensitive variable for predisposition to instability. Dislocation rates rise when the acetabular cup is oriented outside the safe zone (40° ± 10° abduction and 15° ± 10° anteverision).14 Correct patient positioning is critical because inadvertent pelvic tilt on the surgical table can predispose the patient to acetabular retroversion. The transverse acetabular ligament is often used as an intraoperative landmark to ensure satisfactory cup version (Figure 1).

The ideal implant position will provide a maximum range of impingement-free motion, which may be
assessed by preoperative templating, combined femoral-acetabular anteversion, and an optimal head-to-neck ratio. An implant combination (for example, a small femoral head with a skirted neck and a lipped liner) will reduce the available arc of motion to the highest degree before impingement occurs and dislocation results. Using a femoral head of 36 mm or greater diameter reduces dislocation risk in primary and revision THA.\textsuperscript{16,17} Larger diameter heads improve the head-to-neck ratio, resulting in a greater arc of impingement-free movement.\textsuperscript{15} They also show similar wear characteristics to smaller diameter heads when articulating with highly cross-linked polyethylene and avoid the need for a skirt, which can be a source of impingement.\textsuperscript{14} However, larger femoral heads may increase frictional torque at the modular trunnion. Longer-term data on wear with larger femoral heads are not yet available. Elevated acetabular rim liners also have been shown to reduce the impingement-free arc of motion.\textsuperscript{15}

Dislocation from impingement also can result from insufficient abductor tension secondary to inadequate femoral length and/or decreased offset. Modular components, variable angled stems, and offset liners may be required to restore abductor tension while ensuring equal leg lengths; this highlights the importance of preoperative planning and templating.

Instability is best prevented in the operating room where the anatomy and components are directly visualized with various intraoperative tests while the hip is taken through a primary arc of motion (Table 3). Intraoperative radiographs can aid in confirming and allowing immediate correction of any component malposition in addition to restoring lateral offset, total offset, and leg lengths. If hip instability is still evident, causes of extra-articular impingement such as osteophytes, a thickened hip capsule, and heterotopic bone formation should be sought.

### Treatment

The initial treatment for most postoperative dislocations includes closed reduction and abduction bracing, which has been shown to be successful in two-thirds of patients.\textsuperscript{14} However, the value of abduction bracing has been questioned because of the high cost of the brace and the limited scientific evidence to support its use.\textsuperscript{18} To perform a closed reduction, general anesthesia with brief paralysis and fluoroscopy is preferred to prevent repeated reduction maneuvers that may damage the femoral head and harm the patient.\textsuperscript{14}

If instability is recurrent, revision THA is warranted. When evaluating a patient with recurrent instability, identifying the cause of instability is of paramount importance. An underlying periprosthetic infection must always be ruled out. Modular component exchange is an attractive, simple, low morbidity solution that allows for alteration in head diameter and neck length and can be combined with anteverted, lateralized, or elevated acetabular rim

### Table 3

<table>
<thead>
<tr>
<th>Test</th>
<th>Maneuver</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shuck test</td>
<td>Index and middle finger are placed around the femoral stem neck, applying force away from the acetabulum. Distraction should be less than 1 cm.</td>
<td>Assessment of soft-tissue tension. Excessive laxity may suggest that femoral offset or length may not have been restored.</td>
</tr>
<tr>
<td>Drop kick</td>
<td>Hip is brought into extension while holding the knee flexed at 90°.</td>
<td>Knee swings into extension if soft-tissue tension has been increased secondary to the leg being lengthened or increased femoral offset.</td>
</tr>
<tr>
<td>Pins, rods, calipers</td>
<td>Pin is inserted into a specific point in the pelvis, which is then measured against a marked point on the femur.</td>
<td>Allows direct intraoperative measurement before a neck osteotomy and post insertion of the trial implant to determine if the length of the leg and/or the offset has been changed.</td>
</tr>
<tr>
<td>Posterior instability</td>
<td>Hip flexed to 90° in neutral abduction and then internally rotated.</td>
<td>Internal rotation should be without impingement to approximately 45°.</td>
</tr>
<tr>
<td>Anterior instability</td>
<td>Hip extended in neutral abduction and then externally rotated.</td>
<td>External rotation should be without impingement to approximately 45°.</td>
</tr>
<tr>
<td>Ranawat maneuver</td>
<td>Align the trial femoral head parallel to the acetabular liner.</td>
<td>The amount of femoral internal rotation corresponds to the combined anteversion of the components.</td>
</tr>
</tbody>
</table>
liners. Jumbo femoral heads improve the head-to-neck ratio and “jump distance” and are recommended for recurrent instability if there is no evidence of component malpositioning.\textsuperscript{14}

Malpositioned components are a major cause of recurrent instability and must be revised to achieve good outcomes.\textsuperscript{14} Although acetabular component malposition is most commonly seen, in some instances, femoral component malposition is identified, or increased offset may be needed to increase soft-tissue tension without overlengthening the surgical limb. In general, CT of the pelvis and ipsilateral femur is useful to objectively quantify both acetabular and femoral component anteversion (Figure 2). If either a modular component exchange or a component revision is planned, the surgeon should evaluate the patient for extra-articular impingement, which should be addressed simultaneously with the removal of a redundant capsule and/or osteophytes. In rare instances, if soft-tissue tension remains inadequate, trochanteric advancement may be an effective solution to restore stability. Other options for treatment include the use of dual-mobility articulations, which have been associated with low dislocation rates and seem to be effective for the treatment of instability as well.\textsuperscript{17,19} However, these articulations should be used with caution in highly active patients secondary to concerns about wear, which can lead to recurrent failure.\textsuperscript{19}

Constrained acetabular liners mechanically prevent dislocation and are reserved in contemporary practice as a salvage option for patients with recurrent dislocation. Problems with constrained liners include a reduced range of motion before impingement, increased wear, and catastrophic component failure with unacceptably high failure rates.\textsuperscript{20} A failure rate of 42% in 755 consecutive constrained acetabular components has been reported at 10-year follow-up.\textsuperscript{20} Better survival has been demonstrated in lower-demand patients with cognitive deficits or neuromuscular diseases.\textsuperscript{20} Constrained liners should be considered only in patients with abductor incompetence or if all other sources of instability have been ruled out, and they should not be used to compensate for even minor amounts of component malpositioning.\textsuperscript{20} If the components are well positioned and well fixed, cementation of the liner into the shell can be used if required, with success rates of more than 90%.\textsuperscript{14} Salvage with a bipolar hemiarthroplasty and even definitive resection arthroplasty are treatments that can be considered as last options for recurring, symptomatic dislocation that is recalcitrant to other treatment modalities.

**Leg-Length Inequality Prevention**

Leg-length inequality after THA can result in patient dissatisfaction and a poor outcome and is a common cause of litigation.\textsuperscript{21} Patients with preexisting leg-length inequality are at higher risk for postoperative leg-length inequality and should be identified preoperatively and appropriately counseled. A patient’s awareness of leg-length inequality must be elicited directly because a leg-length inequality of as much as 20 mm may be present in asymptomatic individuals.\textsuperscript{22} The average postoperative leg-length inequality reported in a series of 68 patients was 9.7 mm, with one-third of the patients being aware of the inequality.\textsuperscript{23} Patients with a shortened contralateral limb, scoliosis, and low physiologic reserve are less likely to tolerate leg-length inequality.\textsuperscript{22} Although no validated standard currently exists, a discrepancy of less than 10 mm may be considered acceptable.

It is helpful to identify apparent leg-length inequality at the preoperative physical examination. Causes of an apparent leg-length inequality include lumbar spine pathology and fixed adduction and abduction deformities of the hip. An abduction contracture results in the leg feeling longer, whereas an adduction contracture yields an apparently shorter leg. Because THA...
should eventually alleviate an abduction contracture and pelvic tilt, the surgeon should surgically correct only a true leg-length inequality, not an apparent leg-length inequality; however, preoperative patient education is critical.

Radiographic measurements are more sensitive than clinical examinations in determining true leg-length inequality. The two most common methods use a reference line drawn on an AP pelvic radiograph (inferior interischial line or inferior part of the acetabular teardrop) and the vertical distance from this line to a set point on the lesser trochanter. Measurement is repeated for the contralateral hip, and the two measurements are compared (Figure 3).

Preoperative templating is vital in planning the implant size and determining the position of the acetabular component, which defines the center of rotation, the height of the femoral neck osteotomy, the proposed size and offset of the femoral stem, and the femoral head length. Templating has been shown to reduce the incidence of leg-length inequality after THA. Because errors can result from image magnification, the actual size of the intraoperative implant may vary. Digital templating may enhance the accuracy of templating.

Intraoperative prevention of leg-length inequality can be achieved through direct and indirect methods. Indirect techniques include an assessment of soft-tissue tension and comparison with the contralateral limb (Table 3). Regional anesthesia may lead to increased soft-tissue laxity, which should be considered when assessing soft-tissue tension. Direct techniques generally rely on fixed reference points using pins, rods, or calipers placed into the ilium prior to dislocation of the native hip (Figure 4). Although customized calipers have been shown to reduce the incidence of leg-length inequality in THA, inaccurate abduction or adduction repositioning of the femur (with respect to the pelvis) during the procedure can lead to inaccuracy; therefore, it is safest to use multiple intraoperative reference points to determine appropriate length and offset.
Treatment
Patients with leg-length inequality can present with mechanical symptoms and/or discomfort from other joints. Some patients remain asymptomatic until the leg-length inequality is noticed by others, and the functional effect of the inequality depends on the individual’s physiologic reserve. Limb shortening is often symptomatically better tolerated than limb lengthening. Overlengthening can cause nerve damage, which is noticed immediately postoperatively as anesthesia wears off. Postoperatively, a shortened limb may result in a mechanical limp, instability, and dislocation.

It is important to understand that many patients will sense a leg-length inequality in the early postoperative period secondary to an abstraction contracture. Patients should be educated that with time and physical therapy, most abstraction contractures improve within the first few postoperative months. If a patient has a true leg-length inequality, nonsurgical management with a shoe lift and gait correction can provide sufficient improvement for 90% of patients. Patients with apparent leg-length inequality should be managed with physiotherapy, not orthoses, which may limit any correction of soft-tissue deformity.

If a true leg-length inequality is present and nonsurgical treatment has been unsuccessful in relieving symptoms, revision surgery can be considered. When evaluating patients with leg-length inequality, the surgeon should be cautious regarding acetabular or femoral component malpositioning, which was the reason that the limb was lengthened during surgery to obtain intraoperative stability. Preoperative CT to determine femoral and acetabular component version is usually valuable. Correction of leg-length inequality usually starts with optimizing component position to reduce the risk of instability associated with subsequent shortening of the leg. At the time of revision, an assessment of soft-tissue tension is critical, and the surgeon should be ready to perform a trochanteric advancement (if needed) at the time of surgery.

In some cases, leg-length inequality can be caused by inferior positioning of the acetabular component. In this situation, removing the cup and placing the revision component more proximally into a more anatomic position will correct the inequality. If excessive soft-tissue laxity is present after repositioning the cup, consideration can be given to using a large femoral head, dual-mobility bearing, a constrained liner, or trochanteric advancement. As previously mentioned, the leg-length inequality may have been caused by an overly anteverted or retroverted cup creating an unstable hip during trial placement at the time of the primary surgery, leading the surgeon to lengthen the limb to achieve stability.

Leg-length inequality also can occur secondary to problems with the femoral component, including a neck ostetomy that was too high, a femoral component that is either too large or too small, and either increased or inadequate offset or anteversion that leads to intraoperative instability. In these situations, revision of the femoral component will be required. In selected cases in which there is inadequate femoral offset, a lateralized acetabular liner can be used to compensate for inadequate femoral offset if the positions of the femoral and acetabular components are otherwise optimal.

Periprosthetic Fractures
Prevention
A periprosthetic femoral fracture can occur either intraoperatively or in the early postoperative period before osseointegration has been successfully achieved. The reported incidence of intraoperative fractures is 0.1% to 5% in primary THA and as high as 21% in revision THA. Reported risk factors for an intraoperative femoral fracture include female sex, advanced age, rheumatoid arthritis, developmental dysplasia, cementless femoral stems, poor bone quality (osteoporosis and/or osteolysis), and revision surgery. In patients who are identified to be at risk, careful bony preparation is mandatory, and, in some situations, a cemented femoral component may be the best choice.

The number of early postoperative periprosthetic fractures is increasing because of the popularity of cementless stems in North America. Patients requiring surgical intervention for a periprosthetic fracture in the first 90 postoperative days have been shown to have a high risk of complications and may require reoperation. Specifically, these patients appear to be at higher risk for deep infection and heterotopic ossification if an early revision is required for a periprosthetic femoral fracture. Risk factors for early periprosthetic fractures include female sex, advanced age, developmental dysplasia of the hip, and the use of flat, wedged-tapered cementless femoral components.

Diagnosis and Classification
It is critical to identify any fracture that occurs at surgery, especially during femoral stem insertion, and define the extent of the fracture with direct visualization and/or intraoperative
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In general, rapid advancement of the broach or an implant that sits deeper than the final broach or trial should alert the surgeon to the possibility of periprosthetic fracture. If this occurs, the stem or broach should be removed, and the proximal femur should be carefully inspected for a fracture.

Intraoperative and early postoperative fractures are most commonly classified according to the Vancouver classification (Table 4). This classification is based on fracture location and subcategorized based on the configuration and stability of the fracture pattern. The discernible difference in the classification of early postoperative periprosthetic fractures versus later periprosthetic fractures is based on the lack of osseointegration of the implant; therefore, prosthesis fixation is not generally considered in an intraoperative or early classification system.

In proximally coated stems, a clamshell fracture pattern that can occur in the early postoperative period has recently been described. Patients may have pain after sustaining low-energy trauma in the early postoperative period. Radiographs may show femoral component subsidence (Figure 5).

**Table 4**
The Vancouver Classification of Intraoperative Periprosthetic Femoral Fractures

<table>
<thead>
<tr>
<th>Type</th>
<th>Fracture Location</th>
<th>Subtype and Description</th>
</tr>
</thead>
</table>
| A    | Proximal metaphyseal, not extending into diaphysis | A1: Cortical perforation  
A2: Undisplaced linear crack  
A3: Displaced or unstable fracture |
| B    | Diaphyseal, able to bypass with stem     | B1: Cortical perforation  
B2: Undisplaced linear crack  
B3: Displaced or unstable fracture |
| C    | Distal diaphyseal/metaphyseal, unable to bypass with stem | C1: Cortical perforation  
C2: Undisplaced linear crack  
C3: Displaced or unstable fracture |

**Treatment**
The primary goal of treatment is anatomic reduction with stable prosthetic fixation. Historically, nonsurgical management has achieved poor results. Surgical treatment is now preferred and allows earlier return to function.

**Type A Fractures (Proximal Metaphyseal)**
Cortical perforations are rarely of consequence in this region and, if modest, do not require supplemental fixation if they do not compromise the area of cortical support needed for implant fixation. Nondisplaced linear cracks are treated with a cerclage wire, which is typically placed prior to the insertion of the final stem. Displaced fractures of the proximal femur can compromise fixation of proximally coated implants and should be stabilized with cerclage cables, distal fixation, and bypass of the fracture with a diaphyseal-engaging stem. Fractures of the greater trochanter are unstable because of the vector force pull of the abductors and require fixation with cerclage wires or other trochanteric fixation devices. Minimally or nondisplaced metaphyseal femoral fractures that occur intraoperatively and are treated with a single cerclage cable have excellent long-term results of up to 100% survivorship in multiple series.

**Type B Fractures (Proximal or Middle Diaphyseal)**
Fractures in the proximal or middle diaphyseal region should be bypassed with a diaphyseal engaging revision prosthesis. Although the evidence is not conclusive, bypassing the fracture by a minimum of two cortical diameters or by at least 4 cm is generally recommended to ensure adequate scratch fit in the femoral isthmus. Cerclage cables should be placed just distal to any nondisplaced crack, perforation, or stress riser (ideally prior to preparation for and insertion of the revision stem) to prevent fracture propagation. Cerclage cables may provide sufficient fixation for long spiral or oblique fractures if adequately reduced; however, short...
oblique or transverse fractures require supplemental fixation with allograft struts and/or plate fixation.

**Type C Fractures (Distal Diaphyseal or Metaphyseal)**

Cortical perforations and fractures in the distal diaphyseal or metaphyseal region represent substantial stress risers and are typically too distal to bypass with a revision-type prosthesis. Non-displaced cracks or cortical perforations can be reinforced with allograft struts and cerclage cables, whereas displaced fractures require stable fixation with either plate fixation or a combination of plate fixation and allograft struts.

**Summary**

THA provides an effective solution for managing patients with end-stage hip arthritis. Unfortunately, early postoperative complications, which can potentially lead to patient dissatisfaction, poor outcomes, and litigation, cannot be eliminated despite great care. Meticulous preoperative planning allows the surgeon to anticipate potential intraoperative complications and identify, counsel, and obtain consent from patients who are at increased risk for complications.

**References**


23. Edeken J, Sharkey PF, Alexander AH: Clinical significance of leg-length inequality after total hip


