DIAGNOSIS AND SURGICAL APPROACHES: TOTAL HIP REPLACEMENT

PART 1

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Abstract

Arthritis, fractures, and repetitive strain can cause significant pain in the hip joint over time, but hip replacement surgery is an option for many patients each year in the United States. Plastic, ceramic, and metal components can be used to wholly replace the ball-and-socket hip joint and restore mobility in patients. Although most patients who undergo total hip replacement surgery are either retired or elderly, it can be useful for any patient who suffers pain that is not relieved by traditional methods. Rehabilitation that is clinic-based or home-based is discussed in terms of expected outcomes of success as well as factors that may limit the patient’s full recovery.
Policy Statement

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Continuing Education Credit Designation

This educational activity is credited for 4 hours. Nurses may only claim credit commensurate with the credit awarded for completion of this course activity. Pharmacology content is 0.5 hours (30 minutes).

Statement of Learning Need

Health clinicians need to know their role and responsibilities in helping patients understand treatment options for hip replacement surgery. Whether in the contemplation phase or having decided to undergo total hip replacement, patients need to be prepared for the benefits and risks of the varied methods of total hip replacement, such as minimally invasive versus traditional methods. Moreover, rehabilitation and what to expect both in hospital and when at home can impact the success and longevity of a hip prosthesis, as well as the patient’s mobility and strength, and ability to function in daily activities.
Course Purpose

To provide learning for clinicians interested in total hip replacement and rehabilitation and that will support them to guide and intervene to ensure the best patient care outcomes.

Target Audience

Advanced Practice Registered Nurses and Registered Nurses
(Interdisciplinary Health Team Members, including Vocational Nurses and Medical Assistants may obtain a Certificate of Completion)

Course Author & Planning Team Conflict of Interest Disclosures

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There is no commercial support for this course.

Please take time to complete a self-assessment of knowledge, on page 4, sample questions before reading the article.

Opportunity to complete a self-assessment of knowledge learned will be provided at the end of the course.
1. The native acetabular cartilage and subchondral bone plate ______________ during hemiarthroplasty.
   a. are reformatted
   b. are replaced
   c. lack screw holes
   d. are preserved

2. If the bipolar head of a hemi-prosthesis has worn down the acetabular cartilage and protrudes into the subchondral bone plate, it could be misinterpreted
   a. as an acetabular cup in a reamed acetabulum from total hip arthroplasty.
   b. as having a slightly greater than hemispheric shape.
   c. as lacking screw holes.
   d. as a bipolar head that is smooth, rather than textured.

3. Because of its durability and performance, ______________ has been the leading artificial hip component material chosen by surgeons since hip replacement surgeries were first performed.
   a. polyethylene
   b. ceramic
   c. metal-on-polyethylene
   d. plastics

4. True or False: Polyethylene is a plastic material that is often used in the THA procedure by itself.
   a. True
   b. False

5. A good fit is essential to successful outcome of the total hip replacement surgery but
   a. hardware-fitting issues are expected because hospitals do not always have the correct size in stock.
   b. the lack of a wide array of options makes this inconsistent.
   c. a poor fit should never happen.
   d. operating room exigencies make it difficult.
Introduction

Hip replacement surgery has been performed for over fifty years. Sir John Charnley, a British orthopedic surgeon, pioneered the procedure in the 1960s and the fundamental principles of his innovative research and techniques are still in use today. Total Hip Replacement (THR) is indicated when physiotherapy, analgesics, and steroid injections can no longer alleviate pain, nor restore functionality. The procedure is also known as Total Hip Arthroplasty (THA). It is used primarily for late stage arthritis to alleviate pain and disability. The current long-term success of THR surgery has led to the observation that total hip replacement might be the orthopedic operation of the century.

Total Hip Arthroplasty: An Overview

The decision to replace the hip joint is made by an orthopedic surgeon in consultation with the patient. One of the key factors in this decision-making process is quality of life for the patient. A total hip replacement (or total hip replacement (THA), which will be used interchangeably in the following sections) involves replacing the diseased or damaged hip joint with an artificial joint. The implanted joint consists of a ball component (metal or ceramic) that replaces the femoral head, and a socket component (metal cup that may include a polyethylene, ceramic or metal insert or liner) that replaces the acetabulum. Surgeons select the materials used in the ball and socket articulation, also called the bearing surface, after considering many factors, including the patient’s age, sex and level of physical activity, and the surgeon’s own preference. The following overview of THA will provide a fundamental basis for understanding the general goal and prognosis of THA in various case scenarios, as discussed in later sections of this 2-part series on total hip replacement.
The most common bearing surface group in modern total hip replacements is metal-on-polyethylene, which indicates a metal femoral head articulating against a polyethylene acetabular insert. A failed THA is marked by the need for a subsequent surgery to revise the original implant. Reasons for revision may include infection of the joint and mechanical complications of the implant.

The success of total hip arthroplasty (THA) in relieving pain and improving function in patients with end-stage degenerative or inflammatory arthritis of the hip is undisputed. The number of procedures per year is estimated to further rise in the next years, as even younger patients with hip arthritis are expected to seek surgical treatment.

A total hip replacement is a procedure that requires removal of the affected joint lesions and replacing the hip with artificial elements. Nevertheless, like any invasive surgery, it is associated with the risk of complications, including joint infection, fracture of the bone during and after surgery, scarring and limitation of motion of the hip, and loosening of the prosthesis. Even as one of the most successful surgical procedures, health clinicians must be aware of the challenges involving the total hip replacement surgery.

Unfortunately, the hip prosthesis is not the ultimate solution to health problems. The daily activities of the human body act as cyclic forces on the joint prosthesis leaving dynamic stresses on the prosthesis and the cement. During service life, surgical implants are exposed to an aggressive environment in terms of corrosion, wear and loading. This wide range of environmental effects has resulted in varied failure mechanisms. Of significance, fracture of the femoral stem constitutes a dramatic long-term complication of total hip surgery. The incidence of this complication varies
with many factors, including the device used, the material from which the prosthesis was made, the surgeon, and the patient population.

Relatively high rates of fracture of the femoral stem of total hip arthroplasties were seen with early designs manufactured in the 1960s and 1970s because of the material’s low fatigue strength and the presence of metallurgical defects. Stems generally failed because of a fatigue mechanism due to unfavorable biomechanics such as various positioning, loosening, loss of proximal support, geometry of the stem, or surface damage of the implant. Fractures have been reported in a variety of prosthetic designs and materials. The use of high-strength materials including forged cobalt chrome, titanium alloy and high-nitrogen stainless steel, as well as further development of stem design and stem geometry, have led to a reduction in the incidence of this complication, and the occurrence of fracture with modern femoral stems is now a very rare event.

**Artificial Joints**

In total hip replacement surgery, the acetabulum (hip socket) is replaced with a single-piece cup made from one material (polyethylene, ceramic or metal) or a two-piece (modular) cup made from a metal outer shell and a polyethylene, ceramic or metal liner. The head of the femur (thigh bone) is replaced with either a single-piece metal stem or head, or a modular component consisting of a metal stem (which may consist of more than one piece) with a metal, ceramic or ceramicised metal head. In general, a hip replacement is either a *hemi-prosthesis* or a *total prosthesis*, depending on whether the femoral half or the entire joint was replaced at surgery. The two main subtypes of hemi-prostheses are unipolar and bipolar in design.
Total hip prostheses can be conventional or resurfacing types, as explained in the following sections.

Distinguishing a hemi-prosthesis from a total hip prosthesis is fundamental to proper image interpretation. The native acetabular cartilage and subchondral bone plate are preserved during hemiarthroplasty, and they can often be recognized on coronal reformatted computed tomography (CT) images of a hemi-prosthesis. However, if the bipolar head of a hemi-prosthesis has worn down the acetabular cartilage and protrudes into the subchondral bone plate, it could be misinterpreted as an acetabular cup in a reamed acetabulum from total hip arthroplasty. Therefore, it is critical to recognize the distinguishing features of a bipolar hemi-prosthesis, such as a bipolar head that has a slightly greater than hemispheric shape or lacks screw holes. Also, the outer surface of a bipolar head is smooth, rather than textured, but this fact may be more difficult to appreciate on CT scans than on radiographs.

It is very clear from the medical research on THA that a poorly sized hip device is a huge problem for many reasons. First, it will reduce the longevity of the device. Perhaps more importantly, it virtually guarantees more harmful wear particles. A good fit is essential to successful outcome of the total hip replacement surgery. Given the modular nature of these hip devices and the wide array of options, a poor fit should never happen. However, hardware-fitting issues could potentially happen if the operating room and/or hospital do not have the correct size in stock on the day of the surgery. The orthopedic team should determine the size of the components required and ensure that the hospital has those stocked before proceeding with total hip replacement surgery.
Plastic Components

Polyethylene is a plastic material that is often used in the THA procedure, but not by itself. The components made from plastic are used in combination with metal and ceramic components. Because of its durability and performance, metal-on-polyethylene has been the leading artificial hip component material chosen by surgeons since hip replacement surgeries were first performed. It is also the least expensive bearing. Metal-on-plastic wears at a rate of about 0.1 millimeters each year. The other materials, metal and ceramic, being more modern developments, already have high wear resistance built in. The metal-to-polyethylene surface is still the one most used in total hip arthroplasty. Its advantage is that it is inexpensive, is technically easier to implant, allows immediate load-bearing, surgeons have wide experience with this method, and present-day acetabula made of cross-linked polyethylene will bring better future results than seen with older types of polyethylene.

The disadvantages of metal-on-polyethylene are that the cement ages and then disintegrates, which may give rise to the well-known cement disease. This surface shows greater wear than is seen with newer surfaces, and the particles thus produced may, in addition to polyethylene disease, also cause osteolysis. Berry, et al. showed a survival rate of 92% after a 10-year follow-up and 77.5% after a 25-year follow-up, among patients with conventional Charnley prostheses.
Schulte, et al., Keener, et al. Callaghan, et al. and Buckwalter, et al. presented rates of good results from using the Charnley prosthesis ranging from 69% to 90%, after 20 to 30 years of follow-up. Wroblewski, et al. reported on an even longer follow-up period (30 to 40 years) of Charnley prosthesis use with 90% presenting with good results.

Polyethylene wear is the biggest obstacle to prosthesis longevity. Young and active patients, and especially male patients under the age of 55 years, are the ones who present greater risk of accelerated wear.

Cross-linked polyethylene is obtained by means of a process of irradiating polyethylene with gamma rays. The irradiation of the material produces "cross-bonding" in the molecular structure of the material. The polyethylene is then subjected to heating up to a few degrees below the melting point, for a precise period, to remove the free radicals.

Although polyethylene failure may occur because of external fracturing or wear, the most common type of polyethylene failure is internal wear at the metal-plastic interface. This wear occurs more frequently in the superolateral portion of the component, and the determining factors are the coefficient of friction, lubrication, load applied, diameter of the head, number of cycles and hardness of the materials. There are three types of wear at the metal-plastic interface: 1) abrasive wear, in which the harder surface produces grooves on the softer surface, 2) adhesive wear, in which the softer material releases fragments that adhere to the harder material, and 3) fatigue, whereby cyclical loading gives rise to fissures, particles or delamination and the material goes beyond the elastic regime, thus causing plastic rupture.
An ongoing concern with plastic components is the fact that all components shed some of their material into the body over time. These foreign bits of material may be viewed by the body as invasive and can possibly lead to infections. An infection inside or near the prosthesis would likely necessitate a revision (a new prosthesis).

**Ceramic Components**

Ceramic components were first introduced into the hip surgery process in the 1970s. One of the major advantages to this specific surface is its characteristic of being scratch resistant. Although they can fracture just as other components, ceramics tend to have an extremely low fracture rate of 0.5%. Another advantage is utilizing the technique of ceramic-on-ceramic ball bearings in the replacement procedure which allows for a lower rate of wear reduction, and offers the patient a longer rate of success with the new joint. Newer ceramic components are being developed on a regular basis, with some of the more recent innovations developed by researchers in Germany.

A well-positioned ceramic-on-ceramic hip, tested under the loads and motions expected during the standard walking cycle, performs exceptionally well in terms of friction, lubrication and wear. Friction tests using different viscosities of carboxy-methyl cellulose (CMC) solution show that these joints operate close to full-fluid film lubrication with very low friction factors (0.002 at physiological viscosities). These ceramic-on-ceramic joints have been shown to have very low surface roughness values that play a part in this low friction. Although they go as far back as the 1970s, some researchers and surgeons are of the opinion that ceramic-on-ceramic prosthetics may be the 21st century solution to hip replacements. Ceramic prosthetics is considered
especially suitable to younger, highly active individuals. They are designed with longevity and reliability in mind. Ceramic-on-ceramic replaces the metal-on-plastic prosthetics, which has been the *traditional approach*. While European manufacturers have been the primary source for ceramic joints, they are now manufactured in the U.S., as well.

Two issues arose with ceramic-on-ceramic ball bearings in both the 1980s and the 1990s. One issue was a ‘squeaking’ sound, which many patients found highly bothersome. However, irrespective of the noise, the prosthetic continued to perform well. A second problem was that of shattering, but since a substantial improvement in the manufacturing this problem has apparently abated. Initially believed to occur rarely (approximately 1%) in ceramic-on-ceramic THR, recent studies have shown that noise (squeaking, grinding, rubbing, or other audible sounds from the hip) occurs more frequently than originally reported, and is experienced by 10% to 17% of patients with a ceramic-on-ceramic bearing surface. The causes and implications of squeaking have yet to be determined, but are likely to be multifactorial; acetabular modular implant design-specific factors, component orientation and malposition, instability, and femoral component design have all been implicated.

Ceramic is the hardest implant material used in the body, and has the lowest wear rate of all, to almost immeasurable amounts (1000 times less than metal-on-polyethylene, about 0.0001 millimeters each year). Consequently, there is usually no inflammation or bone loss, nor systemic distribution of wear product in the body. New ceramics offer improved strength and more versatile sizing options. However, the main issue related to ceramic materials is the intrinsic brittleness.
The hardness of ceramics hamper plastic deformation under loads, and when cyclic loads are applied over the ceramic components, microscopic imperfections such as pores or inhomogeneity of the material can act as stress risers leading to the propagation of cracks with potential component failure. At present, there is no consensus about the best strategy to address revision surgery in patients with failure of ceramic implant.

Revision surgery for fractured ceramic components should be carried out urgently to reduce the risk that ceramic particles further damage the metal taper. Rest and avoidance of weight bearing until surgery are advisable with the aim to reduce the diffusion of ceramic particles and damages to the neck of the stem and to the metal cup. An additional possibility in the use of ceramics is that of ceramic-on-plastic or polyethylene. As ceramics tend to be a harder component than metal and scratch-resistant, they provide a good partner for plastic parts. Ceramic-on-plastic are also a better combination than metal-on-plastic and have a significant reduction in wear rate. Manufacturers have introduced a Vitamin E stabilizer in these components, which functions as a natural antioxidant and possibly assists with the component’s longevity. Perhaps, the primary issue with ceramic-on-plastic prosthetics is that they tend to be more expensive to produce.

Component fracture in ceramic-on-ceramic hips is another cause for concern for many surgeons and patients. The fracture rates of ceramic joints have been dramatically reduced since the introduction of third and fourth-generation ceramics with the new material processing methods. As these artificial hip joints have been found to perform well in the younger patient (45 to 55 years), some surgeons have chosen to replace the diseased joints of even younger patients with this material combination.
Results from an interesting case study in 2009, involving an unusually young patient, were reported by Capello and Feinberg and involved ceramic-on-ceramic joints implanted in a 13-year-old child with bilateral end-stage arthritis of the hip. Seven and eight years post-operatively the patient had no pain, no limp, and could walk long distances. The radiographs showed no implant loosening, osteolysis or wear. This is a very encouraging result, however, it was stated that the patient was still very young (20 years of age at the time of report) and, therefore, the need for revision surgery will be more than likely.

More recent research offers an additional opinion. Although conventional ultra-high molecular weight polyethylene has achieved great success as a bearing surface for THA, osteolysis caused by the wear debris has become one of the leading causes of failure and reoperation. As an alternative to conventional polyethylene bearings, metal-on-metal, metal or ceramic on highly cross-linked polyethylene, and ceramic-on-ceramic have become popular in the past years. Ceramic bearings are attractive because of hardness and scratch resistance, thus have far-reduced volumetric wear debris in comparison with other types of bearings. However, the higher cost, the squeaking sound, and the prosthesis fracture make the choice controversial.

**Metal Components**

A third form of hip joint construction is that of metal-on-metal. These are generally composed of a cobalt chromium alloy, a titanium alloy and even stainless steel, all exceedingly tough components. It can be manufactured to form very thin components. There are theoretical benefits to using metal-on-metal bearings compared to metal-on-polyethylene bearings. These include
the use of large-diameter heads that can reduce the rate of dislocation. Thinner components also enable bone conservation and more physiological femoral loading.

One of the strengths of metal-on-metal is that they can be manufactured in the widest range of sizes required for the prosthesis. Large ball heads provide increased range of motion and greater stability, which can significantly reduce the risk of hip dislocation, a crucial factor in the long-term success of an implant. However, unlike the ceramic components, the metal-on-metal bearings have been revealed to be far more problematic. By 2006, metal-on-metal components had begun to be associated with large cysts, which were revealed to be soft tissue and bone destruction in further surgical procedures. This has been noted in several areas within the literature.

The Arthritis Society, which is a coordinating group for support and research, raised concerns relative to post-operative total hip surgery complications. In a 2014 report authored by three physicians, Tamer Malak, David Beard and Siôn Glyn-Jones, there was further evidence that the highest failure rates for the THA are those utilizing metal-on-metal components. The future of metal-on-metal devices is unclear. However, their use is on the decline. The British Orthopedic Association (BOA) and the Medicines and Healthcare Products Regulatory Agency (MHRA) have issued guidance on how to follow up patients with metal-on-metal hip replacement. Physicians in the United Kingdom also suggest an annual monitoring of the hip using imaging and measurement of metal levels in the blood to determine whether a revision is needed in people with metal-on-metal hip replacement prostheses who have symptoms, or who have a certain type of metal-on-metal hip replacement,
including stemmed metal-on-metal THRs with a larger femoral head (36 mm diameter or more).

Recently, inflammatory granulomatous pseudo-tumors, which are necrotic cystic soft tissue tumors, have been seen following large-head metal-on-metal hip replacement with one or more implant designs, and have been seen less often following hip replacement. Additional and extensive issues with metal-on-metal components has led to a significant decline in their use. As these components are regulated by the Food and Drug Administration (FDA) it is their responsibility to determine whether metal-on-metal components represent a significant enough risk to discontinue their use, or develop a different type of metal for use in THA surgery. In the European Union and other countries there is a host of agencies capable of consulting and developing new materials for metal-on-metal components. If these agencies are not consulted, then there is the risk of a low rate of innovation for the procedure.

While the FDA has recalled some metal-on-metal devices, this does not necessarily translate into the need for a revision procedure. Any patient who has a metal-on-metal prosthesis should always consult with their surgeon before making any decisions for a revision. The disadvantages of metal-on-metal joints include their high cost, patient hypersensitivity to metal, lack of long-term clinical trials and release of metal ions (cobalt, chromium and titanium), which have been detected both in blood and in urine, and both in new and in old designs. Abnormal levels of these ions have also been observed in relation to metal-to-polyethylene joints, but these variations are much lower.
Huo, et al. reported that the most controversial point regarding the biological response of new surfaces was in relation to metal-to-metal surfaces. They reported that increasing numbers of studies involving metal-to-metal joints had presented potential adverse effects and they discussed whether these effects could be involved both in cases of total hip arthroplasty with large-diameter metal-to-metal surfaces and in cases of resurfacing. The most common problem has been the biological response of macrophages and lymphocytes, which may be related to poor implant positioning, thereby resulting in increased wear and consequent release of metal ions. Harkess and Crockarell reported that flexing or scratching the implant could break its protective surface covering and corrosion could accelerate the process of failure due to fatigue. The results from corrosion can be seen as formation of rubble or stains on the implant surface.

Many individuals will naturally ask themselves which components are right for me? This question is to be answered by the surgeon who will assess patients prior to surgery and in consultation decide on which prosthetic is the best fit for their specific requirements. Many factors influence a surgeon’s choice of bearing surface for a patient, including patient characteristics (such as age, activity level, health and bone stock), familiarity with an implant or bearing surface, implant availability, implant femoral head size required and product performance. Characteristics of the implant, surgeon and patient choice all influence the long-term outcomes of THAs. The choice of materials used for the bearing surface of the implant is an important decision that is determined by the orthopedic surgeon and that can influence revision rates.

According to the American College of Rheumatology there have been cases of cobalt poisoning due to the use of metal hip prostheses. Cobalt poisoning
from hip prosthesis is rare but debilitating. It is caused when the metal wears and introduces cobalt into the bloodstream. This is a known risk with metal-on-metal implants, but newer data are showing that it is also a risk with metal-on-polyethylene implants. According to Dr. Bunning, associate medical director at MedStar National Rehabilitation Hospital in Washington, D.C., it is important for rheumatologists to recognize the symptoms of cobalt toxicity, including cardiomyopathy and thyroid issues, in patients who have prosthetic joints.

Cobalt toxicity can lead to devastating effects, but if it is caught early enough and revision surgery is performed to remove the metal prosthetic, damage can be reversible. Three different case studies of cobalt toxicity after hip replacement surgery were presented within 10 days of each other in early 2014. The remarkable nature of these case studies is that hip pain was not a prominent feature according to Dr. Bunning. The patients did present with similar symptoms, and all were found to have excessively high serum cobalt levels. Two of the cases involved metal-on-polyethylene implants, and one involved a metal-on-metal implant. The diagnoses of cobalt poisoning and subsequent revision surgery occurred in varying degrees of time for each patient, which led to differing outcomes.

Additional concerns regarding metal-on-metal prosthetic hip replacements have been raised because of research conducted by the Canadian Institute for Health Information (CIHI) in 2013. The Institute’s research indicated the need for much earlier revision procedures because of using metal-on-metal prosthetics. CIHI’s study, based on almost 60,000 total hip replacements in Canada (excluding Quebec) reported between 2003 and 2011, looked at the effect of several factors, including the different bearing surface materials used and on the risk of patients needing to have their implants replaced.
early in a revision surgery (within five years of the initial replacement surgery). Patients with a specific type of metal-on-metal hip replacement (specifically, large-diameter modular) were found to be 1.6 times more likely to require surgery within five years to replace the implant than patients who received the most common type of metal-on-plastic implant.

The Canadian Institute for Health Information analysis also found that patients with large-diameter modular metal-on-metal implants had a 5.9% chance of having an early revision surgery, compared with only a 2.7% chance for those with the most common type of metal-on-plastic implant. The data revealed that patients whose hips were replaced with a metal-on-metal implant were most likely to be male and younger than age 55. Studies on revisions and metal-on-metal hip implants done in other countries such as the United Kingdom and Australia have had similar findings. Though repeat surgical procedures are more common with a specific type of metal on-metal implant, these implants may still be preferable for some patients.

Dr. Eric Bohm, an orthopedic surgeon from the Concordia Hip and Knee Institute reported that metal-on-metal hip replacement implants were generally considered to be the most suitable implants for younger, more active patients who are traditionally at higher risk of repeat surgery due to the wear and tear they place on the implant. The goal of hip replacement implants is to improve the quality of life for individuals affected by chronic hip pain and to promote increased physical function. The orthopedic team and patient decided a surgical approach and type of hip prosthesis based on certain patient factors, such as age, activity level and anatomy. Although the use of metal-on-metal implants has declined since its peak in
2007–2008, these implants have been linked with recent safety alerts. However, results show that they represented less than 10% of the implants used in total hip replacements.

The most-used materials were metal-on-plastic (73%). The findings matter because patients whose artificial hips need early replacement undergo a long recovery and rehabilitation period that affects their quality of life. As well, the associated health care costs of revisions are more expensive than those of the initial hip replacement; patients undergoing revision typically stay in hospital an average of 17% longer than patients undergoing their initial surgery, and typical procedure costs in the hospital for revision are about 45% more than for the initial surgery (not including physician fees and rehabilitation costs).

**Total Hip Arthroplasty Surgical Procedure**

One of the key markers of success for the THA procedure is how long the individual benefits from their prosthetic before requiring a revision. The primary reason for the need to undergo a THA continues to be degenerative arthritis. The enthusiasm for minimally invasive surgery has declined recently in favor of surgery performed safely through smaller incisions, and with the goal of achieving an ideal implant orientation and longevity. Computer-assisted surgery (CAS) for total hip replacement has gained popularity and is performed in many centers. The advantages and results of CAS have been difficult to assess, and there does not appear to be any significant advantage to CAS at this time. This section highlights aspects of anesthesia and varied modalities of the THA procedure.¹,⁹-²⁰.
General Anesthesia

The modern era of anesthesia began in the 1960s, with the development of new drugs and the availability of new monitoring techniques and equipment. As more information became available to the anesthetist as to what was happening to the patient and in the anesthetic delivery system, anesthetists began to look more closely at safety and refinement of techniques. Surgery was extended to increasingly complex procedures on patients who might previously have been denied operations on the basis of age or illness. Anesthesia also led the way in analysis of critical incidents (the study of close calls), a process now being extended to other areas of medical care.

Anesthesia is the use of medicine to prevent the feeling of pain or another sensation during surgery or other medical procedures that might be painful. Given as an injection or through inhaled gases or vapors, different types of anesthesia affect the nervous system in various ways by blocking nerve impulses and pain.

Currently, in hospitals and surgery centers, highly trained professionals use a wide variety of safe, modern medications and extremely capable monitoring technology. An anesthesiologist administers and manages anesthetic medications that numb an area of the body or to help patients fall and stay asleep. In addition to administering anesthesia medications before the surgery, the anesthesiologist will perform the functions highlighted below.

• Monitor major bodily functions (such as breathing, heart rate and rhythm, body temperature, blood pressure, and blood oxygen levels) during surgery.
• Address any problems that might arise during surgery. Manage any pain that might occur after surgery.
• Keep patients comfortable as possible before, during, and after surgery.

A specially trained nurse anesthetist, who works with the anesthesiologist and surgeon, may assist in giving the patient anesthesia, although the anesthesiologist will be the one to manage the anesthesia and make all major anesthesia-related decisions during the operation.

General anesthesia acts primarily on the brain and central nervous system to make the patient unconscious and unaware. It is administered through the patient's circulatory system by a combination of inhaled gas and injected drugs. After the initial injection, anesthesia is maintained with inhaled gas anesthetics and additional drugs through an intravenous (IV) line.

A recent analysis of U.S., patient data that included 382,236 patient records undergoing primary hip or knee arthroplasty showed that approximately 11% were performed solely under neuraxial, 14.2% under combined neuraxial-general, and 74.8% under general anesthesia. This analysis showed that despite a trend toward regional anesthesia, the majority of surgeries in the U.S., are carried out using solely general anesthesia. While traditionally viewed as a means to provide surgical procedures, increasing evidence suggests that the choice of anesthesia significantly impacts on perioperative outcomes and thus may be viewed as a major component in an attempt to optimize patient care.

Anesthetists adjust the doses of the anesthesia-inducing drugs individually on a patient-by-patient basis. The drugs are generally titrated to a measurable end-point of some kind. Subconscious hearing is preserved.
during most anesthetics. Fortunately, memory is strongly impaired with small doses of anesthetics, so most people don't remember much from just before they go to sleep until awhile after they actually wake up. During most anesthetics, there is no way to be certain that the patient is asleep. Brain monitoring can be helpful especially if patients are at high risk of awareness, for example if the anesthetic requires paralysis of the muscles, in which case the patient can't move even if they wanted, or if the patient had an episode of awareness in the past. Drug administration is part of the art of anesthesia.

**Spinal Anesthesia**

Regional anesthesia involves injection of a local anesthetic (numbing agent) around major nerves or the spinal cord to block pain from a larger but still limited part of the body. The patient will likely receive medicine to help relax or sleep during surgery. One form of regional anesthesia is spinal, which is often used for lower abdominal, pelvic, rectal, or lower extremity surgery. This type of anesthetic involves injecting a single dose of the anesthetic agent directly into the spinal cord in the lower back, causing numbness in the lower body.

In patients with hip fractures, clinical trials noted a beneficial outcome in patients receiving regional anesthesia. Here a small (25g by 3-inch) needle goes in the back and ends up in the cerebrospinal fluid (CSF) where about 3 ml of 0.5% plain bupivacaine is injected, and patients find that within 10 to 15 minutes they can't feel or move their legs or anything from the waist down. Recovery usually occurs 4 to 8 hours later.
Spinal anesthetics are good for operations on the pelvis and lower limbs, particularly in the elderly. Unfortunately, CSF leaks out of a hole in the dura, and in young people and generally following day surgery a post-spinal headache can occur. Spinal anesthetics are much more common in the elderly, such as surgery for fractured hips. Basic monitoring is used and the patient needs an intravenous infusion drip during a spinal anesthetic procedure.

Very recent research (2015) suggests that spinal anesthesia may become the gold standard for total hip replacement surgery. The research by Basques, et al. is one of a series of studies that have demonstrated that regional anesthesia is more advantageous than general anesthesia for total hip arthroplasty patients. Previous studies have shown a multitude of advantages including decreased cost, complications, infections and improved pain control.

A randomized study comparing forty patients found that total costs per case were almost cut in half in the spinal group in comparison to the general anesthesia group. This was a result of both less cost for anesthesia and less cost for recovery. In the same study, there was no relevant difference in anesthesia times. Patients in the general anesthesia group were admitted to the post anesthesia care unit (PACU) with a higher pain score and needed more analgesics than patients in the spinal group. Spinal anesthesia has also demonstrated fewer complications in comparison to general anesthesia. A meta-analysis of ten independent trials found a significant decrease in deep vein thrombosis (DVT), pulmonary embolisms (PE), surgical time, and blood transfusion. Another study similarly found a 25% decrease in intra-operative blood loss, 50% reduction of intraoperative transfusion, and 20% lower total transfusion requirement.
General anesthesia has been associated with a higher risk of surgical site infection as well as perioperative hyperglycemia in comparison to spinal anesthesia. Study results have indicated that patients who received spinal anesthesia had better outcomes, regardless of preoperative medical comorbidities. The most novel observation is the higher overall adverse event rate of 23.5% for patients undergoing general anesthesia compared to 19.7% for those undergoing spinal anesthesia.

The association of general anesthesia with any adverse event is consistent with the results of several previous studies that have shown a benefit of neuraxial anesthesia relative to general anesthesia in terms of the risk of complications in orthopedic patients. However, the largest study to date that compared operating room times, length of stay, adverse events, and readmission between patients who had undergone elective primary total hip arthroplasty with general anesthesia and those who had undergone elective primary total hip arthroplasty with spinal anesthesia, further supported the advantages of spinal anesthesia in these patients. In addition, it was found that general anesthesia was associated with an increased predicted probability of any adverse event among all studied ranges of medical comorbidity. Spinal anesthesia has been previously associated with improved postoperative outcomes compared with general anesthesia in medically complex patients undergoing total joint arthroplasty; however, studies also indicated that these benefits may also extend to patients with fewer medical comorbidities.

Several studies have shown the relative benefits of neuraxial anesthesia compared with general anesthesia, such as decreased blood loss and need for transfusion, decreased rates of thromboembolic events, and reduced rates of surgical site infection. Most of these findings are from small, single-
institution studies. There is a need for large, multicenter studies that directly compare perioperative outcomes between neuraxial and general anesthesia in patients undergoing total hip arthroplasty.

In a 2009 U.S. study, the conclusions are the same. Regional anesthesia is generally preferred over general anesthesia in the U.S. The merits of regional anesthesia are many. Regional anesthesia provides optimal surgical conditions and analgesia extending into the postoperative period. The motor block achieved by spinal anesthesia is unsurpassed by any other technique. The modest reduction in arterial blood pressure contributes to reduced surgical blood loss. Regional analgesia may also result in reduced postoperative nausea and vomiting, less respiratory and cardiac depression, and decreased risks of thromboembolisms. Regional anesthesia has the advantage of blunting stress response in surgery and decreasing morbidity and mortality in high-risk surgical patients.

Another conclusion was reached in 2015. A benefit of regional anesthesia is the ability of the patient to self-position. Being awake or, at the most, slightly sedated, may prevent complications related to malpositioning of the head, eyes, and upper extremity, and resulting in blindness, brachial plexus pathology, or pressure sores.

In another study conducted in the United Kingdom a similar conclusion was reached. Besides other advantages, spinal anesthesia was associated with less cost and lower postoperative pain scores. A commonly used agent for the central neuroaxial block was reported to be bupivacaine with adjuvants like clonidine and fentanyl. In high-risk patients, surgery can be performed with femoral and sciatic nerve blocks, which can be continued in the postoperative period with in situ catheters for postoperative analgesia.
The same conclusion was reached from yet another United Kingdom study during 2016. This systematic review and meta-analysis confirmed that neuraxial anesthesia was either equivalent or favored over general anesthesia for patient-important outcomes of total hip or total knee arthroplasty. Surgical durations were not lengthened, yet hospital length of stay was reduced when neuraxial techniques were used. Although the evidence is limited to suggest that use of neuraxial anesthesia is associated with improved perioperative outcomes, there are no meta-analysis results supporting that outcomes are better when general anesthesia is used.

**Removal of Ball Joint**

To facilitate the installation of the prosthesis the surgeon must first remove the ball joint. This procedure is called a *femoral head ostectomy*. The hip joint is a ball and socket configuration, much like the knee, elbow, and shoulder. The technique of removing the ball joint is a procedure or technique that was developed in the early part of the 20th century. Surgeons originally developed the technique for the treatment of hip dysplasia and osteoarthritis as hip replacement surgery had not yet been developed. Hip dysplasia means that either the joint is the wrong shape or the hip socket is not in the proper position to cover and support the femoral head. This condition in turn will cause wear and tear on the cartilage and labrum (a piece of fibrocartilage or rubbery tissue which is attached to the rim of the socket and whose purpose is to keep the ball joint in place).

If a person’s hip joint is out of place or too shallow it will wear out much faster than if they had a normal shape. A good analogy is the treads on a car tire. When these wear out, the tires can no longer function properly and they fail to support the upper mechanism. Since physicians do not yet know how
to regrow cartilage, when it wears out in a person’s joints then the only option is to replace the joint, which is what is done now. Prior to the surgical option however a physician will likely recommend the following nonsurgical strategies:

- Physiotherapy to ease the pain and increase functionality
- Analgesics or anti-inflammatories to provide pain relief
- Hot and cold packs to reduce inflammation and pain
- Exercise as can be tolerated (especially swimming)
- Acupuncture for pain relief (or other modalities such as massage therapy)
- Weight reduction if the person is overweight

The benefits of this procedure are that it corrects the deformity, will realign the joints into their proper positions, reduce symptoms such as pain, and prevent further joint degeneration. The restoration of normal alignment of the hip’s ball joint will also increase functionality, a person’s activity level and overall life satisfaction. Moreover, if the removal of the ball joint early on still leads to continued degradation, then the person can have the full hip replacement surgery. But, this procedure on its own has demonstrated positive results for adults with osteoarthritis and hip dysplasia.

The primary reason for the removal of the ball joint as explained above is to realign the hip so that it moves properly, thus enabling the person’s lower extremities to also function properly. When the hip joint is out then subsequently other joints will be thrown into dysfunctional patterns; the back, leg, and foot muscles and joints will overcompensate for the misalignment of the hip joint. These joints and muscles will then be subject to extreme stress, dysfunctionality and injury. Some of the dysfunctionalities
people report include the inability to abduct (to move the muscles outwards) the lower extremities, constant or intermittent pain, hip stiffness and limb shortening.

The primary goals of a femoral osteotomy are to change the contact point across what is called the *articular cartilage* during weight bearing. When people have arthritic changes in their body but no deformity, then something called the *vagus-extension osteotomy* moves that contact point of weight-bearing forces to a new location on the femoral head. This, in turn, will alleviate the pressure across the degenerated area of articular cartilage; and, thus, the area of damaged cartilage will begin to move through a reparative process as new collagen is created. However, as with all procedures there are some contraindications when the procedures would not be advisable, such as when there is the presence of infection, limitations in hip motion (which make realignment difficult), advanced osteoarthritis and inflammatory osteoarthritis.

**Artificial Joint Attachment**

The artificial joint attachment is exactly as it sounds; it is when a person has a damaged joint and a new one is inserted in its place. Arthritis and other diseases, injuries, or causes can damage joints. Arthritis or simply years of use may cause the joint to wear away. This can cause pain, stiffness, and swelling. Diseases and damage inside a joint can limit blood flow, causing problems in the bones, which needs blood to be healthy, grow, and repair themselves. A new joint (or prosthesis) can be made of plastic, metal, or ceramic parts, as explained in earlier sections.
It may be cemented into place or not cemented, so that bone will grow into it. Both methods may be combined to keep the new joint in place. A cemented joint is used more often in older people who do not move around as much and in people with weak bones. The cement holds the new joint to the bone. An uncemented joint is often recommended for younger, more active people and those with good bone quality. It may take longer to heal, because it takes longer for bone to grow and attach to it. New joints generally last at least 10 to 15 years. Therefore, younger patients may need to have the same damaged joint replaced more than once.

Of course, there are risks with any surgery. Risks of joint surgery will depend on the health of joints before surgery and the type of surgery done. Many hospitals and physicians have been replacing joints for several decades, and this experience results in better patient outcomes. Joint replacement is usually a success in most people who have it. When problems do occur, most are treatable. Possible problems include those highlighted below.

**Infection**

Areas in the wound or around the new joint may get infected. It may happen while the patient is still in the hospital or after he/she goes home. It may even occur years later. Minor infections in the wound are usually treated with drugs. Deep infections may need a second operation to treat the infection or replace the joint.

**Blood Clots**

If the blood moves too slowly, it may begin to form blood clots. If pain and swelling develop in the legs after hip or knee surgery, blood clots may be the
cause. The physician may determine medication is needed to thin the blood or may request special stockings, exercises, or boots to help the blood circulate faster. If swelling, redness, or pain occurs in the patient’s legs after leaving the hospital, the patient should be advised this is an emergency and to contact his/her physician.

*Loosening of the New Joint*

The new joint may loosen, causing pain. If the loosening is bad, another operation may be needed to reattach the joint to the bone.

*Dislocation*

Sometimes after hip or other joint replacement, the ball of the prosthesis can come out of its socket. In most cases, the hip can be corrected without surgery. A brace may be worn for a while if a dislocation occurs.

*Wear*

Some wear can be found in all joint replacements. Too much wear may help cause loosening. The surgeon may need to operate again if the prosthesis comes loose. Sometimes, the plastic can wear thin, and the surgeon may just replace the plastic and not the whole joint.

*Nerve and Blood Vessel Injury*

Nerves near the replaced joint may be damaged during surgery, but this does not happen often. Over time, the damage often improves and may disappear. Blood vessels may also be injured.
The onset of infection after joint replacement is one of the most serious risks of this procedure. Prosthesis-related infection is a serious complication for patients after orthopedic joint replacement, which is currently difficult to treat with antibiotic therapy. Consequently, in most cases, removal of the infected prosthesis is the only solution to cure the infection. It is, therefore, important to understand the comprehensive interaction between the microbiological situation and the host immune responses that lead to prosthesis infections. Evidence indicates that prosthesis infections are biofilm-correlated infections that are highly resistant to antibiotic treatment and the host immune responses. Even though the hospital and surgical team will take every necessary precaution to avoid the onset of infection, sometimes people are still affected. Some of the reasons why infections set in can be attributed to the following factors.

Air Quality:

It is imperative that the surgery and recovery take place in a sterile field. Operating rooms rely on air filtration systems to remove the presence of any bacteria that could affect this field. Still, the transport of materials and staff moving in and out of the operating room can increase the possibility of an infection.

Incomplete Skin Disinfection:

The surgical staff and patient must be completely disinfected. And, the surgical instruments must be sterile. The intrusion of even the smallest microbe or bacteria can alter this situation.
Impaired Immune System:

If the patient’s immune system is compromised for any reason this can also increase the possibility of infection.

Pathogens:

Pathogens exist in the hospital and one of the most obvious and well-known of these is the *staphylococci or staph infection*.

As mentioned previously, there are two ways of attaching the new, artificial joint: 1) cemented joint prosthesis, and 2) cementless joint prosthesis. In the first instance, a fast-drying bone cement is used as an adhesive to adhere the prosthesis, and in the second, a process called a *press-fit* prosthesis is used, which allows the bone to grow onto to it and adhere to it over time.

According to The Arthritis Society the advantages of using the cement process are:

- Bone cement allows a surgeon to affix prosthetic joint components to a bone that is slightly porous from osteoporosis.
- A small amount of antibiotic material can be added to the bone cement, helping to decrease the risk of post-surgical infection.
- The bone cement dries within 10 minutes of application, so the surgeon and patient can be confident the prosthetic is firmly in place.

The disadvantages of using the cement process are:
• A breakdown of the cement can cause the artificial joint to come loose, which may prompt the need for another joint replacement surgery (revision surgery).
• The cement debris can irritate the surrounding soft tissue and cause inflammation.
• While rare, the cement can enter the bloodstream and end up in the lungs, a condition that can be life-threatening. This risk is greatest for people who undergo spinal surgeries.

The future of joint prostheses is still unknown but The Arthritis Society believes research indicates a reason to be hopeful. For example, recent research has been done with components made of highly porous metals such as tantalum. Initial studies indicate tantalum may facilitate a strong bond between bone and prosthesis in a relatively short timeframe. This research is still in the very early stages and more clinical study needs to be done.

**Damaged Cartilage Removal**

The importance of healthy cartilage in the body cannot be overstated. It is a firm, whitish connective tissue that appears in many parts of the body and in particular, in our ball and socket joints (but elsewhere too). In addition to being found between bones (such as elbows, hips, knees, shoulders and ankles), it is found at the ends of the ribs, between the vertebrae in the spine, in our ears and nose, and in the bronchial tubes. There are three types of cartilage: 1) Elastic cartilage, 2) Fibrocartilage, and 3) Hyaline cartilage. Cartilage performs two key functions: 1) Smooth movement of joints, and 2) Shock absorption.
Cartilage can become damaged by the occurrences of: 1) Injury, 2) Wear and tear over time, and 3) Onset of arthritis or other degenerative condition. An interesting fact of cartilage is that it contains no nerve endings, and therefore, it is unlikely that damaged cartilage could cause someone pain. However, when cartilage disappears then the joints will rub against each other causing inflammation, and that will cause pain. The medical term for removal of damaged cartilage is excision. Physicians will likely order an MRI or an arthroscopic examination to determine if the cartilage is damaged. The MRI (magnetic resonance imaging) is a high-powered scan that provides tiny snapshots of various parts of the body. In the arthroscopic examination, a tube-like instrument is inserted into the joint itself to determine the extent of the damage.

Cartilage restoration techniques are the bridge between conservative forms of symptom relief and hip replacement surgery. However, as with all procedures this technique is not appropriate for everyone with hip pain and/or dysfunction.

*The Microfracture Technique*

Microfracture, an older technique, is still widely used for cartilage repair, but is often being replaced by procedures that last longer and can restore, rather than repair, cartilage. Surgeons clean and smooth the cartilage tear edges and pierce holes in underlying bone, forming a blood clot rich in stem cells and growth factors. Over time, the clot remodels into fibrocartilage, which is less supple and durable than the original hyaline cartilage. This is a good procedure for people under 50 years of age and with a healthy weight.
Osteochondral Autograft

The osteochondral autograft procedure sounds very much like its name; it is a graft of healthy cartilage over damaged cartilage. This is a procedure that benefits people under 50 years of age and with limited damage.

Synthetic Scaffold Resurfacing

The synthetic scaffold resurfacing procedure soaks a synthetic graft in a solution of stem cells. They are then placed into the damaged area where they eventually stimulate new growth. This procedure is best for younger people who are also highly active.

Incisions

The traditional hip replacement approach requires surgeons to cut muscles and other soft tissue at the back of the hip to access the hip joint. First, the surgeon cuts the fascia lata, a wide piece of fibrous soft tissue at the top of the outer thigh, and the large gluteus maximus muscle that attaches to it. Next, the surgeon must cut the external rotators of the hip, which are small, short muscles that connect the top of the femur to the pelvis. These muscles provide hip stability, preventing the femur from dislocating out the back of the hip socket (posterior dislocation). These muscles are repaired and reattached at the end of the surgery.

The surgical incision begins 2–4 cm lateral to the anterior superior iliac spine of the pelvis. It is then carried distally and laterally for about 8–12 cm at 20 degrees from the sagittal plane of the patient toward the lateral aspect of the patient’s ipsilateral knee. The lateral femoral cutaneous nerve (LFCN) is identified, transposed medially and protected.
As with all aspects of THA there have been significant advancements in the use of incisions. The use of the standard incision is generally divided into discussions on the use of mini incisions or standard incisions, which are described below.

Mini-incision versus Standard-incision THA

The consequences of introducing mini-incision (MI) into total hip arthroplasty (THA) are still a debatable topic in all orthopedic forums. Despite a large amount of existing papers, there are hardly any well-designed trials capable of giving a conclusion, based on high-level evidence, on whether MI THA is superior to standard incision (SI) THA. MI is here defined as the use of a 10 cm or even smaller incision to complete the total hip joint replacement.

Advantages of MI THA were reported as less soft tissue trauma (smaller skin incision and less muscle damage), reduced blood loss and fewer blood transfusion requirements. Postoperative benefits that have been demonstrated in some studies include less pain, shorter hospital stay, quicker return to function and a better cosmetic appearance. However, many studies suggest that MI THA introduces additional risks due to its limited visibility of anatomical landmarks and vital structures. Some have shown that MI THA is more prone to complications, mainly due to component malpositioning with an increased risk of dislocation, in addition to an increased risk of neurovascular complications and excessive skin trauma. Another drawback seems to be the learning curve, which tends to be longer for surgeons with little experience of hip prosthetic surgery.

For quite a long time, comparison of MI versus SI THA has been addressed by several randomized control studies and several meta-analyses, but their
findings are still inconsistent. Moskal, et al. in their meta-analysis concluded that short-term recovery favored MI over SI THA. Li, et al. indicated that MI THA was not superior to SI THA in early postoperative recovery, hip function, and complication rates. In addition, Smith, et al., showed that MI THA was associated with a significantly increased risk of transient palsy of the lateral femoral cutaneous nerve but with no significantly better outcome. The pooled results with significant heterogeneity from the present meta-analysis of 14 randomized controlled trials using a random-effects model suggested that MI THA may reduce just blood loss compared with SI THA in general. Specifically, posterior MI was revealed to have reduced significantly surgical duration, blood loss, and length of hospital stay but had no significant impact on pain compared with posterior SI in the subgroup meta-analysis, indicating that posterior MI is advantageous over SI as an alternative approach for patients undergoing THA. No obvious differences were observed between MI and SI in overall meta-analysis or in subgroup analyses regarding radiological and complication outcomes.

With respect to any benefits of the mini incision versus the standard incision the opinion rendered was that current evidence suggests the differences between mini incision and standard total hip replacement are of little clinical importance with respect to surgical time and blood loss. There was a statistically nonsignificant trend toward a shorter length of hospital stay, although studies were inconsistent and the differences were small. Differences in disease-specific outcome measures varied among studies but there was generally little difference between the groups.

The number of reported complications in both groups was small and there was no significant difference between groups. However, there was a tendency toward increased infections and nerve injuries while there were
decreased fractures and deep venous thromboses in the mini-incision group. There were no major differences in the short-term revision rate or surrogates for long-term outcome measures, although no studies have yet been able to report long-term revision rates or outcomes. Overall, there is no strong evidence either for or against mini-incision compared with standard incision total hip replacement based on the short-term measures currently available.

**Minimally Invasive Surgical Procedures**

In recent years, surgical procedures have become less invasive as researchers and surgeons develop new ways of providing the total hip arthroplasty procedure with new techniques and instruments. With minimal soft tissue trauma, the patient is subjected to far less pain and discomfort because of the procedure. This also provides the patient with a far shorter recovery time, and the ability to return to an active life as quickly as possible. Specific advantages to the minimally invasive procedures are less blood loss, shorter surgical time, fewer post-surgical risks and reduced recovery time. However, just as with traditional or standard procedures, there is a need to ensure all procedures can be provided safely. Several factors must be considered when selecting anesthesia, including those outlined below.\(^1,5,7-14\)

**Patient Experiences and Preferences**

Patient experiences and preferences should be addressed prior to planning hip surgery and type of anesthesia, and clinicians should consider whether patients ever had anesthesia before. Additionally, questions should be asked such as whether they had a reaction to the anesthesia? How did other members of their family react to anesthesia? What kinds of experiences have
they had in the operating room before? Have they ever had surgery prior to hip surgery? Do they have a specific preference and, if so, why?

Current Health and Physical Condition

The clinician should consider the patient’s overall condition. Are they overweight? Do they have any other medical conditions? What is their medical history? Is this their first hip replacement? Are they in good condition; do they exercise on a regular basis? What is the patient’s emotional wellbeing? Do they present as anxious or nervous about the procedure?

Prescription Medications

Whether the patient is currently taking any prescription medications should be asked. Also, are they taking any alternative remedies such as an herbal remedy, a homeopathic remedy, or a Chinese medicine? Are they taking any nutritional supplements; could these interact with the anesthesia? Do they have any allergies; have they ever had an allergic reaction to a medication?

Risks of Surgery

Risks vary, depending on a person’s overall health and selection of anesthesia, and may include breathing difficulties, allergic reactions and nerve injury. It is the responsibility of the surgeon and anesthesiologist to discuss all possible risks with their patients.

The Health Team

The skills and preferences of the surgical and anesthesia team play an important role in the selection of anesthesia. The advantages to regional
anesthesia may include less blood loss, less nausea, less drowsiness, improved pain control after surgery, and reduced risk of serious medical complications, such as heart attack or stroke that may occur with general anesthesia, although these complications are rare. However, as with all medical interventions and procedures there can be side effects. Side effects from regional anesthesia may include headaches, trouble urinating, allergic reactions, and rarely nerve injury. The entirety of these issues will be discussed with the anesthesia team prior to the surgical procedure.

Prior to surgery the patient is taken to the anesthesia area, which is generally adjacent to the operating room (OR). Usually several of the surgical staff are there including the anesthetist and anesthesia assistant. The anesthetist will then use specific equipment to measure the patient’s heart rate, blood pressure and blood oxygen level. An intravenous (IV) cannula will be inserted into the back of the person’s hand or arm to facilitate the flow of drugs and any other fluids into the person’s body. While the IV cannulation cannot be avoided, topical anesthesia may be applied to the area of cannulation to accommodate patient anxiety or concern with venipuncture.

The anesthetist remains in the operating room during the entire procedure and closely watches the patient, and adjusts the anesthetic as required. If the patient is awake or having sedation, the anesthetist remains close by to ensure the person is relaxed and comfortable.

It is possible to lose blood during and after an operation. The physician will order a blood transfusion which can come from a blood donor, or blood from the patient which they have store beforehand.
The latest technological advancements in minimally invasive surgical procedures, novel materials leading to better performance and enhanced durability as well as advanced designs of joint stability and functionality, have made these implants attractive to more and younger adults, particularly those who want to maintain an active lifestyle. One of the concerns raised in a recent study on the minimally invasive approach (MIA) is that not all orthopedic surgeons are necessarily trained in the technique. This is an imperative since it requires a high degree of skill. The technique is perhaps more technically demanding than the lateral approaches used today due to the somewhat limited surgical exposure. It should be reserved for specially trained surgeons who possibly will treat many patients and who need to maintain expert skills.

The minimally invasive procedure involves approaches using smaller incisions combined with traditional approaches, as well as alternate surgical approaches employing smaller incisions or sometimes two incisions. Single incision techniques for minimally invasive surgery include the anterior (front) approach. So, this technique uses one small incision on the front of the upper thigh. The technique is sometimes called the true anterior approach to distinguish it from the anterior-lateral approach discussed earlier, which accesses the hip nearer the side of the thigh rather than at the front.
The posterior-lateral and anterior-lateral approaches are traditional approaches described above using smaller incisions and special instruments to facilitate the procedure through these incisions. Two-incision techniques use one opening nearer the front of the thigh to insert the socket part of the implant, and a separate small incision toward the back of the thigh to insert the stem of the implant. Another opinion on the standard versus minimally invasive surgery for total hip replacement is that despite the absence of a clear difference between minimally invasive and standard hip replacement, there are important implications. Strong claims exist for or against well-conducted single incision minimally invasive surgery based on small individual studies that are not justified.

Despite the multitude of papers on minimally invasive surgery, there is still a need for well-conducted studies with adequate sample sizes and follow-up. With respect to the use of specific types of incisions some of the current research suggests single incision laparoscopic surgery might be the wave of the future. Scarless surgery is the Holy Grail of surgery and the very *raison d'être* of minimal access surgery was the reduction of scars and thereby pain and suffering of the patients. The work of Muhe and Mouret in the late 1980s paved the way for mainstream laparoscopic procedures and it rapidly became the method of choice for many intraabdominal procedures. Single-incision laparoscopic surgery is a very exciting new modality in the field of
minimal access surgery, which works to further reduce the scars of standard laparoscopy and towards scarless surgery.

**Health Risks Of Total Hip Replacement**

Adverse events associated with hip replacement surgery (THR or resurfacing arthroplasty) may occur because of complications at the time of surgery, or may occur years afterward. Complications that may lead to hip replacement revision surgery include prosthesis instability, dislocation, aseptic loosening, osteolysis (bone reabsorption), infection and prosthesis failure; and other complications of surgery include those discussed in this section.10,15,18,21-30,45

**Infection**

The risk of infection is present with any surgical procedure. As the number of hip replacement procedures increase over time (especially as new techniques are developed), there will undoubtedly be an increase in the number of patients who experience an infection because of these surgeries. With respect to infection, it is valuable to suggest that while it is generally not a situation one would welcome, some infections are more serious than others. It is also crucial that the infection is diagnosed as quickly as possible and treated aggressively.

A host of technical and operative improvements have seen the rates of infection associated with joint replacement reach historic lows. However, the increasing number of operations being performed means that the absolute number of such infections remains significant. Diagnosis may be challenging and delaying appropriate treatment can lead to reduced joint function and the need for more complex, perhaps multiple, procedures. Individual centers
tend to see small numbers of such cases, and in the absence of large clinical trials the management tends to vary.

Early diagnosis, selection of an appropriate surgical strategy, accurate identification of the responsible microorganisms and construction of an appropriate antibiotic regimen are essential elements of any management strategy. Such care coordination is best delivered by a multidisciplinary team composed of orthopedic and plastic surgeons, microbiologists, infectious disease physicians, specialist nurses, physiotherapists and occupational therapists. Each treatment plan must be developed in consultation with the patient, considering their aims and realistic goals.

The mechanism of the infection, whether by intraoperative contamination or delayed 'hematogenous' infection, has no bearing on the selection of treatment. Indeed, different mechanisms of infection lead to similar lesions. Both the acute infection that develops within a few days after intraoperative contamination and the delayed hematogenous contamination are initially confined to the soft tissues, so that there is no need to change the prosthesis or debride the bone. Conversely, chronic infection involves both the soft tissues and bone. Under these circumstances, the bone must be debrided and the prosthesis changed irrespective of whether the patient has septic 'hematogenous' contamination with the gradual development of chronic osteitis despite systemic antibiotic therapy.

Prosthetic joint infections are classified as early (occurring within 3 months of implantation), delayed (3–12 months after implantation) and late (more than 12 months after implantation). Early and delayed infections are thought to be due to organisms introduced at the time of surgery, whereas late infections are more likely to be hematogenously acquired. Infecting
organisms form microcolonies on the prosthesis surface, which in turn elaborate exopolysaccharides that coalesce, forming a biofilm. Once formed, organisms within the biofilm are protected from host immune responses and may demonstrate a reduced susceptibility to antibiotics because of changes in metabolic processes and poor diffusion.

Early infections may present with a persistently leaking wound or the acute onset of fever, pain, swelling, effusion and erythema at the implant site. Untreated infections may form chronic sinuses. Bacteremia and a systemic sepsis syndrome may occur. Late infections may present more insidiously with worsening joint pain and sometimes an effusion and restriction of movement. Sinuses may also develop. There may be radiological evidence of loosening but in the absence of a sinus it can be difficult to distinguish infection from aseptic loosening. Radiological loosening occurring relatively soon within the projected lifespan of a prosthetic joint may be suggestive of infection. Late infections occasionally present with an acutely inflamed joint that may be associated with systemic features of sepsis.

Key risk factors for prosthetic joint infection include previous joint arthroplasty, a surgical site infection not involving the joint prosthesis, the presence of malignancy, and a National Nosocomial Infection Surveillance System risk score of 1 or 2. Other suggested risk factors include advanced age, diabetes mellitus, previous native joint infection, use of alcohol or drugs, liver disease, obesity, cardiac or renal disease, poor nutrition, skin disease and pre-existing joint disease (particularly rheumatoid arthritis). Those patients undergoing revision of an existing prosthetic joint are at greater risk than those undergoing primary joint replacement. An increased infection risk has been linked with the use of metal-on-metal bearings in THA. Metallosis-related local soft-tissue damage and increased rates of
revision associated with this type of implant may be contributing factors. Another risk factor that needs consideration is that of hospital stay duration. Prolonged stays in hospital can be associated with risk of infection staphylococcus \emph{aureus}, otherwise known as a staph infection.

The goal of management is not only to eradicate the infection but also to preserve the function of the hip by protecting both bone stock and muscle function. If an acute infection is suspected blood cultures and a joint aspirate should be taken before antibiotics are administered. The latter should not delay the timely administration of antibiotics if severe systemic sepsis is present.

The diagnosis of infection is made by a combination of clinical, histological and biopsy or intra-operative microbiological criteria. Surgical samples or aspirates are more likely to be culture-negative if the patient has received any antibiotics in the preceding 3 months. Where possible, antibiotics should be withheld until all diagnostic microbiological tests have been completed. It is not clear how long a patient should be off antibiotics prior to a diagnostic procedure or joint revision but many clinicians recommend fourteen days. Clearly, administration of pre-operative antibiotics may have to be accepted in those cases where sepsis or deteriorating local disease demands immediate antibiotic therapy.

Specialists in infectious diseases who contribute to the management of patients with an infected arthroplasty should be aware that systemic antibiotics have only limited access to scar tissue and to tissues that have lost their blood supply because of implantation of the prosthesis. Adjuvant local treatment with antibiotics may be used under these conditions. The decisions regarding treatment will be affected by a series of factors. These
include: comorbidity, age, personal expectations, and allergies to any antibiotics or other materials. For some patients, surgical intervention is the appropriate response to the presence of infection. There is a range of options including prosthetic removal, joint fusion, joint revision, and in extreme cases even limb amputation.

Effective treatment requires a combination of an appropriate surgical strategy with suitable antibiotic therapy in most cases. This is most effectively delivered through multidisciplinary teams as suggested earlier, involving specialists involved in the surgery and rehabilitation process. Where infections are long-standing or complicated, it may be appropriate to consider referral to surgeons or teams with expertise in managing such cases. This can be of benefit to both the patient and the referring surgeon. The importance of selecting the appropriate surgical strategy for the individual patient cannot be overemphasized. This will be influenced by their comorbidities, life expectancy, and personal expectations and goals, and these should be explored carefully. Some individuals will have experienced multiple operations, prolonged discomfort and immobility with the psychological comorbidity that entails. One of the well-recognized treatment protocols for joint infection following THA is known as DAIR - Debridement, Antibiotics, Implant, and Retention.

Debridement is the process of removing the infected components and replacing them with new modular components and/or liners, but retaining the prosthesis. This procedure is followed by prolonged antibiotic treatment, which will (hopefully) enable the individual to retain their prosthesis. Some studies have shown a rate as high as 82% for joint retention with the DAIR protocol. The use of antibiotics is highly variable and there is no single treatment protocol. The physicians establish the specific antibiotic and length
of treatment. There are three specific protocols for antibiotic treatment; 1) directly into the prosthetic by injection, 2) oral and 3) intravenous options. The high infection rates associated with prosthetic joint implantation in the 1970s have fallen dramatically because of improvements in patient selection and preparation, surgical technique, theater design, prophylactic antibiotics and anesthesia.

According to a report published by the University of Manitoba for the Concordia Joint Replacement Group one of highest risks of the THA procedure is that of infection, which can lead to the necessity of a revision of the procedure. The leading reasons for early revision were infection, instability, stiffness and patella maltracking or instability. The primary warning signs of an infection are persistent fever (higher than 100°F orally), shaking chills, increasing redness, tenderness, or swelling of the hip wound, drainage from the hip wound and increasing hip pain with both activity and rest.

In accordance with all these factors, there is yet another factor involved in possible infections for patients undergoing THA procedures. The procedure requires an absolute sterile field, and even the smallest intrusion can cause a problem for the patient. The air quality must be tested prior to the operation and hospitals filter the air so that it is ultra-clean, as well as disinfecting the patient and, of course, sterilizing all the instruments. It has been reported that many bacteria can cause prosthesis-related infections, such as S. aureus, including methicillin-resistant strain (MRSA), coagulase-negative staphylococci (CNS) (i.e., S. epidermidis, S. haemolyticus, S. hominis, S. warneri), Propionibacterium acnes, P. aeruginosa, Haemophilus influenzae, Providencia, Enterococci, Streptococcus viridans, Escherichia coli,
Citrobacter, Lactobacillus, Acinetobacter, Serratia marcescens, Klebsiella pneumoniae, and Corynebacterium.

The evidence for the use of specific antibiotics in the setting of prosthetic joint infection is limited. Most studies have examined the treatment of staphylococcal infection. Experimental data support the use of regimens based on rifampicin, as this is an agent with excellent oral bioavailability that achieves high concentrations in biofilms. Used alone, resistance emerges rapidly through a single point mutation in the DNA-dependent RNA polymerase. Animal and clinical data have demonstrated its effectiveness in combination therapy with ciprofloxacin (another agent of high oral bioavailability) or fucidin. It has also been used in combination with trimethoprim and doxycycline. Notably, MRSA isolates demonstrating quinolone resistance have been successfully treated with rifampicin and linezolid or rifampicin and daptomycin. The duration of linezolid therapy is limited by a high risk of hematological and neurological side effects. Linezolid alone is probably as effective as teicoplanin; indeed, it appears to be more effective at the initial clearance of MRSA, but is less well tolerated. Experimental evidence suggests that when used alone, teicoplanin is not as effective as vancomycin in producing a reduction in viable MRSA counts. It could be combined with another agent such as rifampicin, particularly in those instances in which a prosthetic device has been retained; or it may be used at a high dose. Trough levels of >20 mg/L are recommended, requiring at least 600 mg per day in most individuals.

Co-trimoxazole has been shown to be effective in the treatment of MRSA in vitro and anecdotal data and a prospective study suggest it is effective clinically. No randomized trials have specifically assessed its role in joint infection and treatment failure has been associated with settings in which
the bacterial burden is high, emphasizing the importance of thorough operative debridement.

Daptomycin is a novel cyclic lipopeptide with activity against MRSA, glycopeptide-intermediate *S. aureus* and glycopeptide-resistant enterococci. *In vitro* studies demonstrate an efficacy equivalent to that of vancomycin and it demonstrates synergy with rifampicin against vancomycin-resistant enterococci and MRSA.

The evidence supporting any specific antibiotic regimen for the treatment of gram-negative joint infection is lacking. The combination of ceftazidime and ciprofloxacin has been successful in the treatment of *Pseudomonas aeruginosa* infection, and the use of ciprofloxacin may be associated with a better outcome when treating any susceptible gram-negative organism. Often, clinicians will treat many gram-negative prosthetic joint infections with a suitable intravenous agent for 4–6 weeks (for example ceftriaxone, ertapenem or meropenem) according to identification and susceptibility of the organism causing infection and, where indicated, continue with an oral agent.

Prosthesis-related infections after joint replacement are disastrous for patients because, in most cases, removal of the infected prosthesis is the only way to cure the infection. It becomes very important to prevent prosthesis infection. The pathogenesis of prosthesis-related infections could be explained by the interactions of three basic factors, *i.e.*, the number of invading bacteria and their virulence, the host’s immune responses, and the properties of the implant materials.
Deep Vein Thrombosis

The Canadian Society for Vascular Surgery provides the following, helpful information on deep vein thrombosis. Deep venous thrombosis (DVT) means formation of a blood clot in the deep veins of the legs. Veins return blood back to the heart. In the legs, there are superficial veins (close to the skin) and deep veins (between the muscles). When the blood clots in these deep veins, it is called a deep vein thrombosis.

Deep vein thrombosis is a major health concern. If not treated, the blood clots can get larger or break off and go to the lungs. When this happens, it is called a pulmonary embolism. The chance of dying from pulmonary embolism is over 25%. The most common symptoms of DVT are calf pain and swelling. It is well established that patients with these symptoms may not have a DVT and that patients with a DVT may have few symptoms. The first presentation might be of a pulmonary embolism. These symptoms include shortness of breath, chest pain, and palpitations.

Years after a DVT, as many as 20% of patients may develop post-thrombotic syndrome. This syndrome includes leg swelling, heaviness, pain and skin changes. These results from obstructed deep veins in the leg causing pressure-related complications. The most commonly used test for DVT is the duplex ultrasound. In this test, the veins of the leg can be directly visualized and assessed for the presence of clot. Other tests are only rarely used, and include CT scans, MRI, and contrast venography. In some settings, a physician may order a blood test called a D-dimer test. If this is negative, then it is unlikely that the patient has a DVT; however, a positive (or high value) has multiple causes hence further tests would be required to make the diagnosis of a DVT.
Long periods of immobility are usually considered to be the cause of DVT. Immobility causes blood flow in the veins to be slow. Slow-flowing blood is more likely to clot than normal-flowing blood. A surgical operation over 1-1.5 hours is the most common cause of a DVT, because the patient’s legs are still while under anaesthesia with the patient’s muscles temporarily paralysed. Blood flow in the leg veins can become very slow, making a clot more likely to occur. Certain types of surgery (particularly operations on the pelvis or legs) increase the risk of DVT even more. Any illness or injury that causes immobility increases the risk. This includes having a leg in a hard plaster cast after a fracture. People who are admitted to intensive care units are considered at increased risk of DVT. This is due to several reasons but partly because they are very ill and because they are immobile (they may even be kept asleep by anaesthetic medications).

Total hip arthroplasty (THA) is considered a major risk factor for venous thromboembolism (VTE). Without chemoprophylaxis, the incidence of deep vein thrombosis (DVT) in THA patients is 40% to 60%. Routine chemoprophylaxis (aspirin, warfarin, and low-molecular-weight heparins) for such patients is recommended, but there are concerns regarding bleeding, hematoma formation, and prolonged wound drainage. According to the recent guidelines of the American College of Chest Physicians (ACCP), pharmacologic thromboprophylaxis has been performed for patients undergoing major surgery. The results of numerous randomized clinical trials and meta-analyses have indicated that the routine use of both low-dose unfractionated heparin (LDUH) and low-molecular-weight heparin (LMWH) reduces the risk of both asymptomatic and symptomatic VTE resulting from general surgical procedures by at least 60%.
Another factor that might affect the development of postoperative DVT is venous hemodynamics. In a series of 110 patients undergoing total knee replacement surgery, McNally and associates measured venous blood flow using strain-gauge prethysmography before surgery, after surgery, and after discharge from hospital. They found that there was a significant reduction in the mean venous capacitance and mean venous outflow affecting only the treated leg. The reduction of both parameters was maximal on postoperative day 4, and the values of both parameters increased after day 4 until completion of the study period.

**Case Presentation:**

A 69-year-old woman had a cemented hip replacement 15 years previously, which initially fared well but then gradually failed because of aseptic loosening. She developed pain in her hip and was scheduled for a revision total hip replacement. A formal venous thromboembolism (VTE) risk assessment was undertaken before surgery per the Hospital’s policy for all orthopedic admissions. The risk assessment identified 2 conflicting issues. First, the patient had a particularly high risk of VTE, having had an above-knee deep vein thrombosis after her primary hip replacement and now required a major surgery, namely a revision hip arthroplasty. Second, she had a greater than usual risk of bleeding after surgery because of her obesity and the need for a large soft-tissue exposure, long-term aspirin, and supplementary bone graft from her iliac crest.

The surgeon was faced with a common orthopedic problem, providing effective VTE prophylaxis without causing an equally important problem of surgical bleeding. The surgeon weighed the conflicting risks of bleeding and VTE. Because the patient had a higher risk of bleeding, it was decided to delay the pharmacological prophylaxis until the day after surgery.

Mechanical prophylaxis was instituted as early as possible. The patient was given well-fitting graduated compression stockings on arrival in the hospital and was encouraged to wear these for 6 weeks. In the operating room, mechanical foot compressors were applied to the opposite leg and activated throughout the procedure. At the end of the procedure, the foot compressor was applied to the operated leg as well. Compression was continued until the patient started to mobilize. The device was then removed only when the patient was tentatively mobilizing but was reattached by the nurse or physiotherapist immediately afterward. By the fifth day, the patient was mobilizing well and was discharged.
Anticoagulant therapy is the primary form of treatment for DVT. Patients with objectively diagnosed DVT should receive therapeutic anticoagulation for a minimum of 3 months. Whether a patient ought to receive extended treatment needs to be evaluated on an individual basis, depending mainly on risk factors determined by characteristics of the thrombotic event and patient-related factors. In specific patient groups (i.e., pregnant women, cancer patients, and elderly patients), treatment of DVT is more challenging than that in the general population and additional issues need to be considered in those patients.

For several years, the standard of care treatment of acute VTE was the subcutaneous application of low molecular weight heparin (LMWH) or fondaparinux, followed in time by the oral intake of a vitamin K antagonist (VKA). This regimen is highly effective for the prevention of recurrent VTE. However, the treatment with a VKA requires close monitoring due to a narrow therapeutic range and a relatively high rate of bleeding complications. In addition, the acute treatment of VTE requires parenteral anticoagulation with subcutaneous injections of LMWH or fondaparinux due to the delayed onset of action of VKA.

Venous thromboembolism is a disease that may often recur with a 5-year recurrence risk of up to 20–25%. Extended thromboprophylaxis is effective in preventing recurrence of VTE, but it is also associated with a substantially increased risk of major bleeding. Whether a patient should receive extended thromboprophylaxis thus needs to be evaluated on an individual basis, mainly depending on risk factors determined by characteristics of the thrombotic event and by patient-related factors.
The benefits of anticoagulation must be weighed against the risk of bleeding and personal preferences. Therefore, an individualized treatment approach should be pursued. In line with this approach, a risk assessment model was published for the identification of patients with unprovoked VTE in whom an only limited duration of anticoagulation can be considered as relatively safe. Venous thromboembolism is a frequent and potentially life-threatening event. To date, different agents are available for the effective treatment of acute VTE and the prevention of recurrence. DOAC seem to have a more favorable risk-benefit profile compared to VKA.

Based on individual patient characteristics and laboratory parameters, patient-specific treatment modalities should be tailored and clinical decision-making should be guided by current guidelines, risk assessment scores, and data from randomized controlled trials. Special attention must be paid to the question whether extended anticoagulation for secondary VTE prophylaxis is indicated. An interesting piece of research suggests that patients treated with aspirin rather than warfarin demonstrates some promise. In a meta-analysis of randomized trials, aspirin reduced the risk of asymptomatic DVT and pulmonary embolism by about one-third in patients undergoing elective orthopaedic surgery. Aspirin may be more effective in the reduction of proximal DVT than warfarin. Compared to heparin, aspirin causes a decrease in non-pulmonary embolism deaths and thus, shows a tendency to decrease the overall death rate.

**Pulmonary Embolism**

A pulmonary embolism (PE) is a blockage in the pulmonary artery, which is the blood supply to the lungs. Because the blockage (most commonly a blood clot) prevents oxygen from reaching the tissues of the lungs, it is a
potentially life-threatening event. This blockage – usually a blood clot – is potentially life threatening because it can prevent blood from reaching the lungs. The symptoms of a pulmonary embolism can sometimes be difficult to recognise because they can vary between individuals. However, the main symptoms include chest pain, of a sharp, stabbing pain that may be worse when the patient breathes in, shortness of breath, which can come on suddenly or develop gradually, coughing, which is usually dry, but may include coughing up blood or mucus that contains blood, and feeling faint, dizzy or passing out.

A PE is often caused by a blood clot travelling up from one of the deep veins in the legs to the heart and lungs. It is commonly related to a DVT, which was discussed previously. The diagnosis of a PE can be a challenge as its symptoms are also common to many other conditions. However, it is imperative to obtain an accurate diagnosis as treatment isn’t always easy, and the treatments can cause side effects.

Fortunately, there are several tests to help determine whether the person has a PE, or the clinicians can rule out other causes for these symptoms. One of the most common tests, the standard X-ray can be helpful in the diagnostic process. Approximately 50% of people who develop a PE are already in the hospital. One of the primary reasons for the development of the condition is because the person has been laid up for some time (highly inactive) and this inactivity leads to problems in their calf muscles. Whether a person is in hospital they can help themselves by 1) not smoking, 2) eating a balanced diet that is low in fat with plenty of fruit and vegetables, 3) maintaining a healthy weight, and 4) getting plenty of regular exercise.
If a person is already in hospital, then their health team may suspect a PE if the person is over age 60, already has DVT, and has a history of blood clots. Tests that can be performed in addition to an X-ray include:

- Blood tests
- D-dimer tests, which may show the presence of a clot or a thrombosis
- If blood tests results indicate high levels of D-dimer, it suggests that pieces of blood clot are loose in the bloodstream and may have become lodged in the pulmonary artery.
- Computerized tomography pulmonary angiography (CTPA) is a procedure where the person is injected with a special dye before having a computerized tomography (CT) scan. The dye makes it easier to see the blood vessels in their lungs during the scan.
- A ventilation and perfusion scan is used to examine the flow of air and blood in the lungs.

Pulmonary embolisms are treated with anticoagulant medication. These stop the blood clot from getting bigger while the person’s body slowly reabsorbs it, and reduce the risk of further clots from developing. If someone is diagnosed with a pulmonary embolism, they are usually given regular anticoagulant injections for about five days at the beginning. They might also be prescribed an anticoagulant tablet called warfarin to take for several months.

Some research suggests the use of warfarin should come with a warning. Warfarin is a vitamin K antagonist. Vitamin K is an essential substrate of liver enzymes responsible for the final synthesis of clotting factors II, VII, IX, and X. Warfarin inhibits the maturation of these factors in the coagulation cascade. Excessive intake of dietary vitamin K, which is mainly
contained as phylloquinone in green vegetables, reduces the anticoagulant effect of warfarin. Warfarin should be used cautiously in patients taking aspirin or other non-steroidal anti-inflammatory drugs, because of the increased risk of gastrointestinal bleeding. Warfarin also interacts with several commonly used medications, including antibiotics, proton pump inhibitors, and cholecystaramine.

The anticoagulant effect of warfarin can either be counteracted or potentiated because of alterations in intestinal absorption or metabolic clearance. If a person is prone to clots, or this is a part of their family’s medical history, it might be wise to engage in some prevention strategies. Some of the prevention strategies include to: 1) take warfarin, 2) consider wearing compression stockings or using compression devices (compression stockings fit tightly around the lower legs and encourage blood to flow more quickly around the body. Compression devices are inflatable and work in a similar way, expanding at regular intervals to squeeze the legs and encouraging the flow of blood), 3) avoid long periods of inactivity, and 4) live a healthy lifestyle by not smoking, eating a healthy diet such as eating plenty of fruits and vegetables.

Unfortunately, PE is a distinct problem for people who have undergone the THA. In a 2009 study, the factors associated with an increased risk for the diagnosis of PE included revision THA, female gender, dementia, obesity, renal and cerebrovascular disease. An increased association with PE was found among patients with the diagnosis of Adult Respiratory Distress Syndrome (ARDS), psychosis (confusion), and peripheral thrombotic events. These findings may be useful in stratifying the individual patient’s risk of PE after surgery.
In a study of an estimated total of 6,901,324, primary and revision THA and TKA (total knee arthroplasty) procedures were identified in the National Hospital Discharge Survey (NHDS) between 1990 and 2004. Comorbidity factors identified were cerebrovascular and renal disease, obesity, and dementia. Factors that have been suggested to increase the risk for obese patients to develop PE after lower extremity arthroplasty include slow mobilization time, potential under-dosing of anticoagulants, and the ineffectiveness of mechanical compression devices. Peripheral venous thromboembolism, pulmonary complications, ARDS or pulmonary insufficiency after surgery, and psychosis were associated with the highest increase in risk for in-hospital PE. While it is not possible to say with certainty if the complications studied predated the diagnosis of PE, this information is useful to the clinician to anticipate treatment of these associated complications. It becomes apparent that many complications studied are associated with prolonged immobilization and thus may increase the risk of pulmonary embolism.

**Blood Clot Formation**

Historically, hip replacement surgery has been an operation prone to clot formation in the veins of the legs (thrombosis). If these clots dislodge, they migrate through the veins and right heart (right atrium and right ventricle) to the lungs, a complication known as pulmonary embolism. The symptoms the patient may notice depend on the size of the clots: small clots may produce no symptoms or a transient cough, while larger clots are usually associated with chest pain and shortness of breath. If the clots are very large they may compromise the pulmonary circulation and can be life threatening. However, the risk of serious pulmonary embolism has declined substantially in the past three decades, reflecting advances in the
understanding of the formation of clots and its prevention, and numerous improvements in anesthesia, surgical techniques, and patient care.

Patients who are operated on with regional anesthesia will not regain active motion of the lower extremities for a variable period after surgery. This inactivity can be remedied by the use of intermittent pneumatic compression devices. These devices provide a mechanical means of increasing venous flow, by the intermittent inflation of air-filled cuffs placed around the legs. Once the patient recovers motor activity, he or she should be strongly encouraged to "pump" ankles, feet, and toes to augment the venous blood flow. However, this activity may or may not be performed by the patient due to pain, sleep, etc. and under these circumstances, pneumatic compression of the calves is most beneficial. This is just another positive advancement in the field of medicine, which will ameliorate these kinds of risks.

There is also good news on the horizon via genetic research. Recent advances in molecular genetics can identify patients with a genetic predisposition to clot formation. In the future, rapid-screen genotype tests may become part of the preoperative patient evaluation, identifying those patients at highest risk for clot formation. The National Blood Clot Alliance believes the issue of blood clots is not taken seriously enough. They support and publish research to assist doctors and patients with diagnosis and treatment. In addition, they publish free resources.

The National Blood Clot Alliance suggest that prospective or current patients ask their physician the following questions:

• What is my risk of experiencing blood clots after surgery?
• What is your plan to prevent the occurrence of blood clots after surgery?
• Will I need compression stockings? Will they be provided?
• What type of physical therapy will begin after surgery? How frequently (how many visits per week) should I expect?
• Should I contact the therapist prior to surgery to arrange?
• What are some exercises that I can do prior to surgery to strengthen my muscles?
• What type of anticoagulant medicine are you planning to prescribe for me? How long do you anticipate that I will be on this medicine?
• What kind of blood tests are required for this medicine and how frequently do I need to be tested?
• Can I do the test at home, or do I need to go to your office or lab?
• What are the common side effects?
• Do I need to make sure to take this medication at the same time each day? How much grace time do I have with medication timing?
• Are there any medicines, herbs or supplements that I should not take when I am on this medication?
• Do I need to change my diet while I take this medication? Are there any foods that I need to add to my diet, or to make sure that I don’t eat?
• What is the expected expense to me related to this medication? Is it typically paid for by insurance?

**Bleeding**

A wound hematoma is when blood collects in a wound. It’s normal to have a small amount of blood leak from the wound after any surgery. Usually this stops within a couple of days. But occasionally blood may collect under the skin, causing a swelling. This can discharge by itself, causing a larger but temporary leakage from the wound usually a week or so after surgery, or it may require a smaller second operation to remove the blood collection.
Drugs like aspirin and antibiotics can increase the risk of hematoma after surgery.

Hematoma is usually the most common complication associated with major surgical interventions and patients underground THA are certainly at risk. The condition is associated with damage or injury to the blood vessels around the site of surgery or may also be linked to poor post-operative patient care. In most cases, hematoma is linked with surgical inefficiency. However, there are certain medications like blood thinners which can increase the risk of hematoma. Blood thinners like aspirin; prevent the blood from getting clotted, which in turn make the surgical incision more prone to develop a hematoma.

Hematoma formation is a well-known complication following total hip arthroplasty (THA). While most hematomas are, small and reabsorb on their own, some can become large enough to cause immediate consequences such as sciatic nerve palsy, excessive pain, swelling and persistent wound drainage. On occasions return to the operating room for evacuation of hematoma may be needed.

Risk factors for hematoma formation following total knee arthroplasty were recently reported by Galat, et al. This study found that bleeding disorders were associated with hematoma formation and reoperation for evacuation of hematoma. Furthermore, it was found that reoperation for hematoma was associated with a significantly increased risk of periprosthetic joint infection (PJI). Risk factors for hematoma formation following THA and the effects of this complication on the outcome of THA remain unknown. A hematoma that is large enough to require surgical attention is a complication that occurs in
0.41% of patients undergoing THA, a prevalence that is comparable to that of PE in orthopedic patients.

It appears that formation of hematoma requiring surgical intervention is a serious event. The above investigation also found that patients developing hematoma lost significantly more blood during surgery, both as estimated by the surgeon and calculated per the CBL equation, which relates perioperative Hb, Hct, blood transfusions and body surface area.

Greater operative CBL was found to be an independent risk factor for hematoma formation in multivariate analysis. This, in turn, correlates with the significantly greater need for allogenic blood transfusions FFP and Vitamin K perioperatively in the hematoma group. Need for FFP and Vitamin K, however, could be a consequence of hematoma formation rather than being a pre-operative risk factor.

Allogenic transfusion itself has also been associated with adverse outcomes after THA, including increased risk of developing pneumonia and a greater 90-day mortality. This data suggests that patients who require pre-operative anticoagulation remain at a higher risk of bleeding complications perioperatively even when anticoagulants are stopped prior to surgery, and should therefore be managed intensely during surgery to prevent greater blood loss, and should be watched closely post-operatively for wound related problems. The following is a detailed case study of a 61-year-old woman with a hematoma following THA.
Case Study:

A 61-year-old woman had the third operation of revision hip arthroplasty for displacement of the cup from a previous total hip arthroplasty that had been performed when she was 43 years old.

The previous implant was removed and a new implant was inserted through a posterolateral approach. In her previous two surgeries, there were no problems with unexpected bleeding. In the blood tests before this current operation, there were no abnormal values including coagulation tests: APTT was 27.1 sec, and PTINR was 0.87. The operation lasted 500 minutes and the total bleeding during the surgery was 3060 grams. Before leaving the operating room, no problems related to the surgery were noted. In her hospital room, the outflow from the drain was 1110 grams at the postoperative time of 8 hours. Her blood pressure did not decrease, and she did not have DIC.

At postoperative day 3, an outflow from the drain was 250 grams, and the drain was removed. After removing the drain tube, the surgical wound was not inflamed, the patient was not in pain, and her blood tests showed normal values. But, at postoperative day 7, suddenly, she complained of severe thigh pain and her thigh was swollen. The orthopedic team suspected that postoperative bleeding had continued, but her blood hemoglobin was 6.7 g/d which was almost the same value as her previous test. Based on these findings, treatment was not provided.

At postoperative day 18, her thigh pain naturally disappeared. At postoperative days 23 and 27, she complained of severe thigh pain and her thigh was swollen again. It was thought that the cause of the thigh pain and swelling was arterial bleeding and tested for this complication with computed tomography using a contrast medium. Active bleeding was not observed; however, a hematoma around the hip joint was visualized by this method. Thus, the hematoma was punctured and 150 grams of uncoagulated bloody liquid was aspirated. Because the thigh pain was gradually relieved, no further treatment was done. Her thigh remained slightly swollen. She was transferred to a rehabilitation hospital.

At the rehabilitation hospital, the hematoma enlarged gradually and she again complained of thigh pain. Therefore, a doctor at the rehabilitation hospital punctured the hematoma and about 50 mL of uncoagulated bloody liquid was aspirated. Because the bloody liquid continued to flow from the puncture needle hole, she was admitted back to the hospital. It was still thought that the cause of the thigh pain and swelling was an arterial bleed, but this was not observed by computed tomography using a contrast medium.

The plan was to perform angiography to see if she had a transcatheter arterial embolization. Before the angiography at postoperative day 115, we completely removed the hematoma with a 2-cm surgical skin incision. About 1,000 grams of uncoagulated lightly colored bloody liquid was removed. During the surgery, it was easy to confirm internal bleeding, but we did not find any active bleeding. Three days later, the hematoma had enlarged gradually and the thigh pain returned.
Considering the previous case, acquired coagulation factor deficiency and tested factor activity was suspected. Coagulation factor activity was 49% (normal value 70%~140%). As a countermeasure to the bleeding due to coagulation factor deficiency, we decided to give her coagulation factor for five days after surgical removal of the hematoma. We completely removed the hematoma via the same 2 cm surgical skin incision. Five days later, the hematoma enlarged slightly, but she did not have thigh pain. Thus, after surgery she had a blood transfusion of 12 units, fresh frozen plasma in all for three days after she had the blood product factor for five days. At the time when administration of blood product was completed, her factor activity was 200% (normal value 70%~140%). Because the hematoma did not enlarge and she did not have thigh pain, she left the hospital and went home. Until now, we have not seen a recurrence of the hematoma.

**Nerve Injury**

The femoral nerve is the largest branch of the lumbar plexus, arising from the dorsal divisions of the ventral rami of the second, third and fourth lumbar nerves. The nerve originates in the abdomen within the psoas major and descends postero-laterally through the pelvis to approximately the midpoint of the inguinal ligament. It then passes deep to this ligament and enters the femoral triangle, lateral to the femoral vessels. After entering the triangle, the femoral nerve divides into several branches to the hip and knee joints and provides several cutaneous branches to the anteromedial side of the thigh. The terminal cutaneous branch of the femoral nerve, the saphenous nerve descends through the femoral triangle, lateral to the femoral sheath containing the femoral vessels. The femoral nerve supplies motor innervation to the iliacus, pectineus, sartorius and quadriceps femoris muscles.
Determining the incidence of femoral nerve injury is difficult, partially because of under diagnosis. A review of the literature reports an incidence rate ranging from 0.1% to 2.4% following primary THA (mean 0.8%) and 0.3% to 2.3% following revision THA (mean 1.1%). These numbers are very like those reported in other research.

Nerve injury is a recognized complication of total hip replacement (THR). The clinical incidence of nerve damage following primary THR is reported to range between 0.17% and 3.7%, rising to 7.5% in revision procedures. In the majority of these cases, a full recovery is never achieved. A total of 80% of patients who sustain a neuropathy have persistent neurological dysfunction of motor weakness, paresthesia or neuropathic pain. This results in a negative impact on the post-operative rehabilitation of patients and reduced patient satisfaction.

Symptoms and signs of femoral neuropathy may vary depending on both severity and location of the injury, but are characterized typically by groin or thigh pain, weakness of the iliopsoas, paralysis of the quadriceps femoris, loss of the knee jerk and sensory loss over the anteromedial aspect of the lower extremity and swelling or hematoma in the wound or in the inguinal region. Patients are often able to stand and walk on flat surfaces with the usual postoperative assistive devices; however, most patients will have trouble with climbing stairs. The residual functional disability, instability and pain associated with nerve injuries may be incomplete or prolonged. Any persistent postoperative motor and sensory abnormalities may impair the rehabilitation process and adversely affect patient satisfaction.

The higher incidence of femoral neurologic injuries in females versus males has been postulated to result from female’s reduced muscle mass, different
local vascular anatomy and shorter limbs. Experimental models have shown that neural injury will occur if the nerve is elongated more than 6 percent of its length. Given this limit, smaller individuals with shorter limbs, and thus shorter nerves, have less of a tolerance for absolute neural retraction than do much larger individuals. This factor may help to partially explain the differences in prevalence observed between genders.

There has been some disagreement in the literature regarding the evaluation of the role of surgical approach in the development of femoral neuropathy following THA. Navarro et al prospectively compared 1000 consecutive primary and revision THA cases for neurologic injury when performed through the trans trochanteric or posterior approach and concluded that anatomical variation and the complexity of the reconstruction, but not the surgical approach was associated with femoral neurologic injury. Johansen, et al. and Weale et al. also concurred that incidence of neurologic injury was unrelated to surgical approach.

Revision of a failed implant has been associated with an increased risk of injury to the femoral nerve after THA. This increased risk may be due to the more extensive and difficult dissection required with revision procedures and perhaps, in some patients, to uncertainty regarding the location of major neurological and vascular structures when a previous operative exposure has been performed. In addition, tethering by scar tissue may predispose the nerve to stretch with retraction, dislocation of the hip, or limb-lengthening. During isolated revision of the acetabular component through a posterior approach, retraction of the intact femoral component anteriorly may increase the risk of compression of the femoral nerve.
It is often difficult to establish a diagnosis of nerve injury following THA. It is recommended that the following be considered: The neurological status should be examined and recorded on the first post-operative day and repeated during the first post-operative week. Some authors recommend the routine use of electro diagnostic testing however this has not been substantiated. Post-surgical care should include attention to the clinical recognition, accurate diagnosis and assessment of severity of nerve damage that may occur as a complication of the surgery. If femoral nerve damage is indicated and requires surgery (such as those caused by hematomas), early surgical decompression may be recommended to prevent further nerve compression and irreversible damage. However, the treating surgeon should determine this decision. The surgeon should also provide realistic recovery outcomes to the patient. If femoral nerve damage is indicated but surgery is not required, conservative management is the cornerstone treatment of the neuropathy. An electromyogram at six weeks and at three months should be performed. If by three months, there is no improvement, magnetic resonance imaging may be of assistance.

Here is research that identifies the use of inferior retractors as one cause of nerve damage following THA. In over 50% of cases, a clear cause is not identified. Concerns have been expressed regarding the ability of retractors to cause nerve damage. Following evidence of damage to the femoral and obturator nerves on EMG studies, Weale, et al. hypothesized that retractors placed around the acetabulum were responsible for these injuries. Despite this, the anatomical relationship between retractor placement and these nerves has not been elucidated.

Nerve injury is a recognized complication of THR and in most cases results in a poor functional outcome. Weale, et al. hypothesized that anterior and
inferior retractors placed around the acetabulum were responsible for subclinical damage to the femoral and obturator nerves. The striking proximity of the acetabular retractors to these nerves demonstrated in this study supports this hypothesis and raises the strong possibility that the routine placement of acetabular retractors may play a significant role in the etiology of nerve damage following THR.

This research highlights the high incidence of ‘sciatic nerve palsy’ after THA. Sciatic nerve palsy related to hip replacement surgery (HRS) is among the most common causes of sciatic neuropathies. The sciatic nerve may be injured by various periprocedural mechanisms. The precise localization and extension of the nerve lesion, the determination of nerve continuity, lesion severity, and fascicular lesion distribution are essential for assessing the potential of spontaneous recovery and thereby avoiding delayed or inappropriate therapy.

Adequate therapy is in many cases limited to conservative management, but in certain cases early surgical exploration and release of the nerve is indicated. Nerve-conduction studies and electromyography are essential in the diagnosis of nerve injuries. In postsurgical nerve injuries, additional diagnostic imaging is important as well, to detect or rule out direct mechanical compromise. Especially in the presence of metallic implants, commonly applied diagnostic imaging tests generally fail to adequately visualize nervous tissue. Several potential intraoperative or periprocedural mechanisms of HRS including direct sharp or blunt trauma, compression by surgical material (i.e., clips, wires, sutures, or extrusion of cement) or by intraneural or perineural hematoma, vascular compromise, stretching through excessive lengthening of the leg, or heat of polymerizing cement.
may injure the sciatic nerve. In many cases the responsible injury mechanism cannot be specifically determined by any diagnostic test.

Case Study 1:

A 56-year-old female suffered from right sided plegia of the extensors of the foot and toes (MRC muscle strength grade 0/5), and a mild paresis of the flexors of the foot (MRC muscle strength grade 4/5) immediately following ipsilateral HRS 4 months ago. MRN revealed constriction of the peroneal portion of the sub trochanteric sciatic nerve by a cerclage. Consequently, surgical exploration of the right sciatic nerve was performed. The constriction of the peroneal portion of the sciatic nerve by a cerclage, resulting in a depression and partial cut of the nerve, surrounded by extensive interfascicular scar tissue was validated. The peroneal division of the sciatic nerve was released by removal of the cerclage, and the neuroma was excised, because of severe scarring. Direct adaption without tension was not possible, thus interposition of a sural nerve graft was necessary.

Case Study 2:

A 78-year-old male, suffered from severe paresis of the extensors of the left foot and toes (MRC muscle strength grade 1/5), immediately following an ipsilateral HRS 24 months ago. MRN revealed compression of the peroneal portion of the left sciatic nerve by a small susceptibility prone foreign body. Besides signs of denervation of the peroneally innervated muscles at the lower leg, signs of denervation of the long head of the biceps femoris muscle and slightly of the tibialis posterior muscle and the gastrocnemius muscle indicated accompanying affection of the tibial division of the sciatic nerve as well. Since recovery of the sciatic nerve was unlikely to occur two years after HRS, surgery was not indicated.

This research identified some of the risk factors involved with nerve injuries related to THA. A patient undergoing THA should be warned of the risk of nerve injury as a complication of the procedure. Risk factors include diabetes...
mellitus, thyroid disease, hypertension, hyperlipidemia, hereditary sensory and motor neuropathy, anemia, and malignancy, especially with a history of cisplatinum chemotherapy. Patient age and preexisting neuropathies such as diabetes, alcoholism, and spinal stenosis adversely affect nerve recovery. Poor nutrition, smoking, and corticosteroid use also diminish the chance of neurologic recovery. Once the nerve injury occurs, some evidence of dysfunction usually persists but dysesthetic pain most highly predicts major disability.

In the largest reported series of nerve injuries associated with THA, no patient with dysesthesias had satisfactory recovery of function. Coexisting spinal stenosis, especially with a positive history of back and leg pain without weakness before the surgery, may be a risk factor for symptomatic nerve injury associated with THA. Pritchett reported 21 patients with spinal stenosis in whom foot drop developed after THA. Spinal imaging studies are recommended with subsequent lumbar decompression.

Here is another analysis of perioperative nerve injury (PNI) after total hip arthroplasty. In addition to surgical risk factors for PNI, we also found that the risk for PNI was greater for younger patients and females. The association between female gender and increased risk for PNI has been reported previously. However, it is unclear if this association is confounded by a higher prevalence of developmental hip dysplasia (another potential risk factor) within females. The underlying etiology of PNI in females (versus males) is unknown. Some investigators have postulated that the higher incidence of PNI in females may be attributed to reduced muscle mass, vascular anatomic variations, or potentially shorter limbs.
Fracture or Dislocation

A periprosthetic fracture is a broken bone that occurs around the components or implants of a total hip replacement. It is a serious complication that most often requires surgery. Although a fracture may occur during a hip replacement procedure, most periprosthetic fractures occur after a patient has spent years functioning well with a hip replacement. Fortunately, these fractures are rare. However, because more patients are having hip replacement surgery, the number of periprosthetic fractures is expected to increase.

The dislocation of a total hip endoprosthesis is an emotionally traumatizing event that should be prevented if possible. Preoperative risk assessment should be performed and the operation should be performed with optimal technique, including the best possible physical configuration of implant components, soft-tissue balance, and an adequately experienced orthopedic surgeon.

The analysis of the register data showed that THA dislocation is one of the main reasons for revision surgery. Currently, approximately 8 to 12% of the annually performed hip surgeries are revision procedures; of these, 11 to 24% are performed to treat THA dislocation. In the international literature and registers, data on the annual rate of THA dislocations after primary THA vary between 0.2% and 10%. With THA dislocation, it is important to distinguish whether the triggering event constituted an adequate trauma or a rather an everyday and controlled movement. The latter is suggestive of inadequate tissue tension or component mispositioning. Information about when the implantation was performed helps to distinguish between early
dislocation, *i.e.*, within the first 6 months, and late dislocations which are frequently due to material failure.

Depending on the mechanical cause, 3 dislocation directions can be observed, even though dislocation direction and component positioning are not necessarily related:

- Cranial dislocation
  - Excessive inclination of the cup, abductor insufficiency, polyethylene wear.
  - Dislocation along with adduction of the extended hip joint.

- Dorsal dislocation
  - Insufficient ante version or retroversion of the cup, joint hyperlaxity, primary or secondary impingement.
  - Dislocation with internal rotation and adduction of the flexed hip joint or with deep flexion.

- Anterior dislocation
  - Excessive combined antetorsion of stem and cup, joint hyperlaxity, primary or secondary impingement.
  - External rotation and adduction of the extended hip joint.

One of the key factors contributing to joint stability is the muscular and capsular guidance for the replaced hip joint. Accordingly, a higher dislocation incidence of between 5% and 8% annually was observed in patients with neuromuscular conditions, such as cerebral palsy, muscle dystrophy and dementia, but also with Parkinson’s disease. For the population of patients older than 80 years of age, an increased risk of dislocation has been
described and attributed to sarcopenia, loss of proprioception and the increased risk for falls. Likewise, non-compliance is more prevalent in these patient populations, as dislocation-promoting hip movements, such as deep flexion or internal rotation of the flexed hip joint, are not strictly avoided. Consequently, dislocation may result even in the absence of procedure-specific mistakes.

Prior fractures or surgical procedures involving the hip significantly increase the risk of dislocation. Dislocation rates of up to 50% after prior femoral neck fractures have been reported in the literature. Revision total hip replacements after previous dislocation, periprosthetic fractures, and septic or aseptic loosening are associated with dislocation rates of up to 28% due to at times significant soft-tissue trauma, extensive scarring, heterotopic ossification, and acetabular or femoral bone loss. During the preoperative risk assessment, the surgeon should pay attention to patient-specific risk factors and highlight these during the informed consent discussion.

The alignment of the implants during hip replacement surgery is of special importance for the stability of the artificial joint. Even though both acetabular and femoral cup positioning is guided by individual anatomic requirements, the dislocation-stable cup position with an inclination of 40 ± 10° and an ante version of 10 to 20° as published by Lewinnek is internationally considered desirable. In a study, Wines, et al. asked surgeons to intraoperatively estimate the alignment of the acetabular and femoral components and compared these estimations with postoperative CT scan measurements.

It was found that when surgeons estimated intraoperatively an acetabular component ante version between 10° and 30°, only 45% of components
were within this target range. In case of the femoral component alignment, the surgeons intraoperatively estimated the ante torsion in 93% of cases between 15° and 20°, while CT scan measurements ranged from 15° retro torsion to 45° ante torsion and 71% of prosthesis stems were in the target range. While a component position which increases the risk of THA dislocation is a procedure-related factor and can potentially be avoided, it is influenced by intraoperative positioning, the patient-specific anatomical situation, periarticular contractures, mispositioning of the lumbosacral junction, and obesity as well as considerably by the surgeon’s experience. Studies have shown that with increasing volume of procedures performed by a surgeon, the risk of THA dislocation significantly drops.

Dislocation following total hip replacement can be extremely traumatizing for patients. They lose confidence in their artificial joint, completely move away from the aim of a forgotten joint, and may reproach the surgeon for this outcome. Thus, dislocation prophylaxis is essential. Apart from preoperative risk assessment, this includes proper surgical technique with optimized alignment of the components, soft-tissue balancing and head-neck ratio, as well as adequate surgical experience. Treatment of instability after total hip replacement should follow a standardized algorithm.

This research offers similar opinions with respect to fractures and dislocations in post-operative patients undergoing THA. Instability after total hip replacement (THA) occurs infrequently and leads in most cases to hip dislocation. In rare cases, instability presents as transient subluxation. A patient reports a sound or click and often has a sense of giving way or apprehension. Dislocation and subluxation of the hip after THA normally occur in the first three postoperative months, but cases of late instability are not uncommon.
Two cases were reviewed of patients who presented with apparent eccentric polyethylene wear and pain, after contemporary THA. In both situations, the acetabular component was positioned in excessive abduction. After direct lateral radiograph confirmed femoral head subluxation and examination under fluoroscopy with the leg internally rotated confirmed reduction, revision surgery was offered. Both patients underwent revision surgery to reposition the cup, and in both cases pain-free ambulation, without recurrent subluxation, was achieved after recovery.

Case Study:

A 64-year-old male presented with generalized hip pain and associated clicking five years after a right, non-cemented total hip arthroplasty (THA) performed for osteoarthritis through a posterior approach. Symptoms were present for 6 months and were not associated with trauma. Review of the implants used at the time of surgery confirmed that the femoral head size correctly matched the acetabular inner diameter size.

Physical examination demonstrated an antalgic gait to right side, and the patient used a crutch on his left side. There was an audible clunk with ambulation, but this could not be reproduced on physical exam. Supine radiographs showed superior eccentric placement of the femoral head within the acetabular polyethylene and excessive acetabular component abduction.

Prior radiographs were not available for comparison. Radiographs in internal rotation showed the head to be concentrically reduced, and revision surgery was offered.

Prosthetic Failure

One of the risks of this surgical procedure is the failure of the prosthesis to function adequately. There is also the possibility of improper placement of the prosthesis during the procedure. Two other health concerns can be bone reabsorption (osteolysis) and aseptic loosening. Per a 2012-13 Canadian
A research study the most common reason for revision for both hip and knee replacements continue to be aseptic loosening (26.3% for hip, 22.5% for knee). Improper placement of the prosthesis and the resulting biomechanical disturbances within the hip joint (excessive elongation or shortening of the extremity or improper rotation of the implant) are responsible for failure of hemiarthroplasty. Inadequate calcar seating, insufficient residual femoral neck length, insufficient metaphyseal fill, and errors in sizing the prosthesis are all associated with early failure of the hemiarthroplasty.

In case of implant breakage, the broken stem can be extracted in two ways, either endofemoral or transfemoral. Endofemoral extraction can be accomplished anterogradely (using special extraction instruments) or retrogradely (when anterograde approach fails). A retrograde technique requires establishment of a standard retrograde femoral nailing portal and intramedullary rods to push the broken stem proximally. Sometimes, a broken implant can be pushed distally to act as cement restrictor. However, endofemoral approach is tedious and time consuming. Special instruments (like extraction hook, hollow mill, carbide drill, extraction cork screw) are needed when using this approach and such a technique always carries a risk of cortical perforation.

The transfemoral approach includes sliding trochanteric osteotomy, extended trochanteric osteotomy, or distal fenestration of the femoral cortex to remove the broken implant. However, transfemoral approach requires bypassing the osteotomy by the new longer femoral stem with at least two canal diameters. Other methods like metal cutting ones have the risk of metallosis. Augment calcar with bone graft to restore the limb length (vertical offset) in cases of calcar resorption.
Research has examined ceramic head fractures. Ceramic head fracture is a catastrophic event and several cases of fractured heads are reported in scientific databases. Most these manuscripts are case reports and retrieved analysis of fractured heads. The remaining studies reported on the incidence of fractured ceramic heads in retrospective case-series on the mid to long term outcomes of COC hip prostheses. A trauma was involved in the generation of fractures in 7 reports. Only two papers specifically focused on risk factors for ceramic head fractures. Koo, et al., found 5 head fractures among 367 COC hip prostheses using third generation 28 mm heads]. All fractured components were short-neck heads and in all cases the fracture involved the circumferential portion of the head near to the edge of the head bore.

Researchers have postulated that using 28 mm heads the distance between the corner of the head bore and the outer surface of the ceramic head is smaller in comparison with the medium and long neck designs, thereby facilitating the propagation of cracks. These findings agree with the work of Callaway, et al. in which a greater risk of fracture was also identified for second generation 28 mm short-neck heads. On the contrary, in two manuscripts it was hypothesized that long neck designs could facilitate head fractures because the increased distance between the edge of the head bore and the outer surface of the head itself increases the tensile stresses at the taper-bore junction. However, reported data were not sufficient to support this theory.

Based on the available literature, the only factor associated to the risk of ceramic head fracture is the use of short neck 28 mm heads. It has also been supposed that chipping because of misalignment of the liner during insertion into the cup could be the cause of failure in many instances.
McAuley, et al. tested this hypothesis by using a laboratory model and demonstrated that misalignment of the liner during impaction into the acetabular component does significantly increase the risk of liner fractures. Based on the paper cup malposition on the axial plane and misalignment of the liner during insertion was found to be the only two relevant factors affecting the risk of liner fractures.

Unfortunately, for patients who cope with prosthetic failure, the outcome may not be a positive one. Revision surgery for fractured ceramic components can be troublesome, and could be associated with poor results. In fact, it has been speculated that the presence of sharp ceramic fragments retained in the artificial joint space could act as an abrasive paste affecting the performance of the new articular coupling. Besides, concerns exist about the reimplantation of a new head on a previously used morse taper because of the presumed higher risk of new fracture due to fretting corrosion of the morse taper.

At present, there is no consensus about the best strategy to address revision surgery in patients with failure of ceramic implant. Revision surgery for fractured ceramic components should be carried out urgently to reduce the risk that ceramic particles further damage the metal taper. Rest and avoidance of weight bearing until surgery are advisable with the aim to reduce the diffusion of ceramic particles and damages to the neck of the stem and to the metal cup.

**Summary**

Total hip replacement arthroplasty is a surgical procedure performed on millions of people around the world. It has, in fact, become one of the most
common surgical procedures. The procedure is performed when a person’s hip has become so severely damaged (most usually by osteoarthritis), that the hip no longer functions. Several factors must be taken into consideration before the surgeon decides that the replacement is necessary.

Pain management strategies would always be considered the first thing to do – especially conservative strategies such as ice packs and anti-inflammatory medication to bring down the inflammation, as well as varied rest periods, limiting certain activities, and providing pain medications. The physician might also recommend the individual attend sessions with a physical therapist. Physical therapy has been proven to be a helpful and ameliorative strategy in the management of arthritic conditions.

While pain is definitely an important consideration, the surgeon will want to know how the patient functions. It is functional limitations to the person’s life that will guide the surgeon more than anything else. Activities of daily living the person can and cannot perform are considered, such as dressing, bathing, house-cleaning, cooking, and socializing with others. If the person is of working age, it is crucial to determine whether they can continue at their job even once accommodations have been made.

If the clinician goes ahead and recommends surgery, the patient can undergo a standard procedure, or the widely used minimally invasive procedure. This latter procedure has become incredibly popular world-wide and is often considered the preferred choice; the patient generally has a reduced recovery time and a lower chance of post-operative risks such as infection.
However, as with all surgeries there are risks. The most common are: infection, deep-vein thrombosis, pulmonary embolism, and prosthetic failure. Of these, prosthetic failure is the most emotionally and physically damaging to the patient. Another devastating risk is that of nerve injury, which is a life-altering situation, as the opportunity for re-implantation of a prosthetic no longer exists and treatment for nerve injuries are still undeveloped.

Because of its prominence around the world, total hip replacement surgery is one of the most widely studied of all surgical procedures. The research has resulted in excellent outcomes especially with the use of new techniques, medications, and materials used in the procedure. This review of Total Hip Arthroplasty is by no means all-inclusive, and is a brief review of the primary topics.

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Completing the study questions is optional and is NOT a course requirement.
1. The native acetabular cartilage and subchondral bone plate _______________ during hemiarthroplasty.
   a. are reformatted
   b. are replaced
   c. lack screw holes
   d. *are preserved

2. If the bipolar head of a hemi-prosthesis has worn down the acetabular cartilage and protrudes into the subchondral bone plate, it could be misinterpreted
   a. *as an acetabular cup in a reamed acetabulum from total hip arthroplasty.
   b. as having a slightly greater than hemispheric shape.
   c. as lacking screw holes.
   d. as a bipolar head that is smooth, rather than textured.

3. Because of its durability and performance, __________________ has been the leading artificial hip component material chosen by surgeons since hip replacement surgeries were first performed.
   a. polyethylene
   b. ceramic
   c. *metal-on-polyethylene
   d. plastic

4. True or False: Polyethylene is a plastic material that is often used in the THA procedure by itself.
   a. True
   b. *False

5. A good fit is essential to successful outcome of the total hip replacement surgery but
   a. hardware-fitting issues are expected because hospitals do not always have the correct size in stock.
   b. the lack of a wide array of options makes this inconsistent.
   c. *a poor fit should never happen.
   d. operating room exigencies make it difficult.
6. The metal-to-polyethylene surface used in total hip arthroplasty
   a. is an effective procedure but it is also the most expensive procedure.
   b. is technically the most difficult to implant.
   c. performs better than products using cross-linked polyethylene.
   d. *allows immediate load-bearing.

7. The most common type of polyethylene failure is
   a. external fracturing at the bone-implant junction.
   b. external wear.
   c. caused by the presence of free radicals.
   d. *internal wear at the metal-plastic interface.

8. True or False: The most common type of polyethylene failure caused by internal wear at the metal-plastic interface more frequently occurs in the superolateral portion of the component.
   a. *True
   b. False

9. Abrasive wear of the metal-plastic interface is exemplified by
   a. *a harder surface producing grooves on the softer surface.
   b. cyclical loading giving rise to fissures.
   c. softer material releasing fragments that adhere to the harder material.
   d. All of the above

10. One of the major advantages of ceramic components is their characteristic of being
    a. *scratch resistant.
    b. fracture-proof.
    c. ceramics do not shed material.
    d. All of the above

11. Daily activities act as __________ on the joint prosthesis leaving dynamic stresses on the prosthesis and the cement.
    a. corrosive forces
    b. lubrication
    c. *cyclic forces
    d. static forces
12. Although they date back to the 1970s, some researchers and surgeons are of the opinion that _______________ prosthetics may be the 21st century solution to hip replacements.

   a. *cubic-on-cubic
   b. metal-on-plastic
   c. ceramic-on-polyethylene
   d. metal-on-ceramic

13. One issue with ceramic-on-ceramic prosthetics is

   a. the scratches that form because of material hardness.
   b. they lack versatility with sizing options.
   c. inflammation, which causes bone loss.
   d. *the "squeaking sound" they may make.

14. True or False: The consensus among experts on the best strategy to address revision surgery in patients with failure of ceramic implant, is to replace the implant with metal-on-polyethylene components.

   a. True
   b. *False

15. Although conventional ultra-high molecular weight polyethylene has achieved great success as a bearing surface for THA, ____________ caused by the wear debris has become one of the leading causes of failure and reoperation.

   a. hip dysplasia
   b. *osteolysis
   c. osteoporosis
   d. osteoarthritis

16. Metal-on-metal hip joint components is/are generally composed of

   a. a cobalt chromium alloy.
   b. a titanium alloy.
   c. stainless steel.
   d. *All of the above
17. Fracture of the ______________ constitutes a dramatic long-term complication of total hip surgery.

a. socket component  
b. acetabulum  
c. *femoral stem  
d. femoral head

18. True or False: The incidence of femoral stem fractures is a rare event because of improvements with modern femoral stems.

a. *True  
b. False

19. A hip replacement procedure known as a hemi-prosthesis means

a. the entire hip was replaced at surgery.  
b. the acetabulum was replaced at surgery.  
c. *the femoral half of the joint was replaced at surgery.  
d. a bipolar design was used.

20. The acetabulum refers to

a. the entire hip.  
b. the thigh bone.  
c. the femoral half of the joint.  
d. *the hip socket.

21. The onset of infection after joint replacement is one of the most serious risks of this procedure, and in most cases, ______________ is the only solution to cure the infection.

a. irradiation  
b. antibiotic treatment  
c. *removal of the infected prosthesis  
d. hip resurfacing
22. _______ prosthetics are considered especially suitable to younger, highly active individuals.
   a. *Ceramic
   b. Metal
   c. Plastic
   d. Irradiated polyethylene

23. Friction tests using different viscosities of carboxy-methyl cellulose (CMC) solution show that _________________ joints operate close to full-fluid film lubrication with very low friction factors (0.002 at physiological viscosities).
   a. metal-on-ceramic
   b. *ceramic-on-ceramic
   c. metal-on-plastic
   d. ceramic-on-polyethylene

24. An infection inside or near the prosthesis would likely necessitate
   a. a hip resurfacing.
   b. *a revision (a new prosthesis).
   c. use of a bipolar design.
   d. irradiation of the area and material.

25. True or False: Ceramic wear is the biggest obstacle to prosthesis longevity.
   a. True
   b. *False

26. The main issue related to ceramic materials is
   a. its tendency to wear.
   b. the scratches that form because of material hardness.
   c. it sheds material into the body over time.
   d. *its intrinsic brittleness.
27. A rare but debilitating risk of metal-on-metal implants is

a. nerve injury.
b. infection.
c. *cobalt poisoning.
d. deep-vein thrombosis.

28. Patients undergoing primary hip or knee arthroplasty use a general anesthesia approximately ________ of the time for the surgery.

a. half
b. 14.2%
c. *74.8%
d. 11%

29. True or False: Because of polyethylene’s light weight, researchers and surgeons uniformly believe that polyethylene prosthetics are the 21st century solution to hip replacements.

a. True
b. *False

30. In patients with hip fractures, clinical trials noted a beneficial outcome in patients receiving

a. *regional anesthesia.
b. general anesthesia.
c. inhaled gas as an anesthesia.
d. a combination of neuraxial-general anesthesia.

31. The _____________ is a piece of fibrocartilage or rubbery tissue which is attached to the rim of the socket and whose purpose is to keep the ball joint in place.

a. *labrum
b. articular cartilage
c. acetabulum
d. vagus-extension
32. Prior to the surgical option however a physician will likely recommend the following non-surgical strategies:
   a. Re-growing cartilage.
   b. Hip resurfacing.
   c. *Appropriate exercise, such as swimming.
   d. All of the above

33. A joint may be cemented into place or not cemented: A cemented joint is used more often
   a. with people who need the joint to heal more quickly.
   b. in active people.
   c. in younger people.
   d. *in older people.

34. Osteochondral Autograft (a procedure where healthy cartilage is grafted over damaged cartilage) is a procedure that benefits
   a. people who need the joint to heal more quickly.
   b. *people under 50 years of age and with limited damage.
   c. older people with limited cartilage remaining.
   d. active people with little or no cartilage remaining.

35. True or False: Mini-incision (MI) total hip arthroplasty (THA) is superior to standard incision total hip arthroplasty.
   a. True
   b. *False

36. The most common symptoms of deep vein thrombosis are
   a. shortness of breath and chest pain.
   b. palpitations and chest pain.
   c. infection and a fever higher than 100°F orally.
   d. *calf pain and swelling.
37. Excessive intake of dietary vitamin K in green vegetables, reduces the anticoagulant effect of

a. phylloquinone.
b. non-steroidal anti-inflammatory drugs.
c. *warfarin.
d. cholecystaramine.

38. Patients who are operated on with regional anesthesia will not regain active motion of the lower extremities for a variable period after surgery but this inactivity can be remedied by

a. compression socks.
b. administration of non-steroidal anti-inflammatory drugs.
c. the use of warfarin.
d. *the use of intermittent pneumatic compression devices.

39. Reoperation for hematoma was associated with a significantly increased risk of

a. hip dysplasia.
b. *periprosthetic joint infection (PJI).
c. cobalt poisoning.
d. osteolysis.

40. The most common reason for revision for both hip and knee replacements may continue to be

a. hip dysplasia.
b. periprosthetic joint infection (PJI).
c. *aseptic loosening.
d. osteolysis.
CORRECT ANSWERS:

1. The native acetabular cartilage and subchondral bone plate ________________ during hemiarthroplasty.
   
   d. are preserved

   “The native acetabular cartilage and subchondral bone plate are preserved during hemiarthroplasty, and they can often be recognized on coronal reformatted CT images of a hemi-prosthesis.”

2. If the bipolar head of a hemi-prosthesis has worn down the acetabular cartilage and protrudes into the subchondral bone plate, it could be misinterpreted
   
   a. as an acetabular cup in a reamed acetabulum from total hip arthroplasty.

   “… if the bipolar head of a hemi-prosthesis has worn down the acetabular cartilage and protrudes into the subchondral bone plate, it could be misinterpreted as an acetabular cup in a reamed acetabulum from total hip arthroplasty.”

3. Because of its durability and performance, __________________ has been the leading artificial hip component material chosen by surgeons since hip replacement surgeries were first performed.
   
   c. metal-on-polyethylene

   “Polyethylene is a plastic material that is often used in the THA procedure, but not by itself. The components made from plastic are used in combination with metal and ceramic components. Because of its durability and performance, metal-on-polyethylene has been the leading artificial hip component material chosen by surgeons since hip replacement surgeries were first performed.”

4. True or False: Polyethylene is a plastic material that is often used in the THA procedure by itself.
   
   b. False

   “Polyethylene is a plastic material that is often used in the THA procedure, but not by itself.”
5. A good fit is essential to successful outcome of the total hip replacement surgery but

   c. a poor fit should never happen.

   “A good fit is essential to successful outcome of the total hip replacement surgery. Given the modular nature of these hip devices and the wide array of options, a poor fit should never happen.”

6. The metal-to-polyethylene surface used in total hip arthroplasty

   d. allows immediate load-bearing.

   “The metal-to-polyethylene surface is still the one most used in total hip arthroplasty. Its advantage is that it is inexpensive, is technically easier to implant, allows immediate load-bearing, surgeons have wide experience with this method, and present-day acetabula made of cross-linked polyethylene will bring better future results than seen with older types of polyethylene.”

7. The most common type of polyethylene failure is

   d. internal wear at the metal-plastic interface.

   “Although polyethylene failure may occur because of external fracturing or wear, the most common type of polyethylene failure is internal wear at the metal-plastic interface.”

8. True or False: The most common type of polyethylene failure caused by internal wear at the metal-plastic interface more frequently occurs in the superolateral portion of the component.

   a. True

   “Although polyethylene failure may occur because of external fracturing or wear, the most common type of polyethylene failure is internal wear at the metal-plastic interface. This wear occurs more frequently in the superolateral portion of the component.”
9. Abrasive wear of the metal-plastic interface is exemplified by

   a. a harder surface producing grooves on the softer surface.

   “There are three types of wear at the metal-plastic interface: 1) abrasive wear, in which the harder surface produces grooves on the softer surface, 2) adhesive wear, in which the softer material releases fragments that adhere to the harder material, and 3) fatigue, in which cyclical loading gives rise to fissures, particles or delamination and the material goes beyond the elastic regime, thus causing plastic rupture.”

10. One of the major advantages of ceramic components is their characteristic of being

   a. scratch resistant.

   “One of the major advantages to this specific surface is its characteristic of being scratch resistant. Although they can fracture just as other components, ceramics tend to have an extremely low fracture rate of 0.5%. Another advantage is utilizing the technique of ceramic-on-ceramic ball bearings in the replacement procedure which allows for a lower rate of wear reduction, and offers the patient a longer rate of success with the new joint.”

11. Daily activities act as ___________ on the joint prosthesis leaving dynamic stresses on the prosthesis and the cement.

   c. cyclic forces

   “The daily activities of the human body act as cyclic forces on the joint prosthesis leaving dynamic stresses on the prosthesis and the cement.”

12. Although they date back to the 1970s, some researchers and surgeons are of the opinion that ________________ prosthetics may be the 21st century solution to hip replacements.

   a. ceramic-on-ceramic

   “Although they go as far back as the 1970s, some researchers and surgeons are of the opinion that ceramic-on-ceramic prosthetics may be the 21st century solution to hip replacements.”
13. **One issue with ceramic-on-ceramic prosthetics is**

d. the “squeaking sound” they may make.

“One issue was a ‘squeaking’ sound, which many patients found highly bothersome. However, irrespective of the noise, the prosthetic continued to perform well. A second problem was that of shattering, but since a substantial improvement in the manufacturing this problem has apparently abated.”

14. **True or False: The consensus among experts on the best strategy to address revision surgery in patients with failure of ceramic implant, is to replace the implant with metal-on-polyethylene components.**

b. False

“... there is no consensus about the best strategy to address revision surgery in patients with failure of ceramic implant.”

15. **Although conventional ultra-high molecular weight polyethylene has achieved great success as a bearing surface for THA, ___________ caused by the wear debris has become one of the leading causes of failure and reoperation.**

b. osteolysis

“Although conventional ultra-high molecular weight polyethylene has achieved great success as a bearing surface for THA, osteolysis caused by the wear debris has become one of the leading causes of failure and reoperation.”

16. **Metal-on-metal hip joint components is/are generally composed of**

a. a cobalt chromium alloy.
b. a titanium alloy.
c. stainless steel.
d. All of the above [correct answer]

“A third form of hip joint construction is that of metal-on-metal. These are generally composed of a cobalt chromium alloy, a titanium alloy and even stainless steel, all exceedingly tough components.”
17. Fracture of the ______________ constituted a dramatic long-term complication of total hip surgery.

c. femoral stem

“... fracture of the femoral stem constitutes a dramatic long-term complication of total hip surgery, most notably with older hip replacement designs.”

18. True or False: The incidence of femoral stem fractures is a rare event because of improvements with modern femoral stems.

a. True

“The use of high-strength materials including forged cobalt chrome, titanium alloy and high-nitrogen stainless steel, as well as further development of stem design and stem geometry, have led to a reduction in the incidence of this complication, and the occurrence of fracture with modern femoral stems is now a very rare event.”

19. A hip replacement procedure referred to as a hemi-prosthesis means

c. the femoral half of the joint was replaced at surgery.

“In general, a hip replacement is either a hemi-prosthesis or a total prosthesis, depending on whether the femoral half or the entire joint was replaced at surgery. The two main subtypes of hemi-prostheses are unipolar and bipolar in design.”

20. The acetabulum refers to

d. the hip socket.

“The implanted joint consists of a ball component (metal or ceramic) that replaces the femoral head, and a socket component (metal cup that may include a polyethylene, ceramic or metal insert or liner) that replaces the acetabulum (hip socket).”
21. The onset of infection after joint replacement is one of the most serious risks of this procedure, and in most cases, _________________ is the only solution to cure the infection.

c. removal of the infected prosthesis

“The onset of infection after joint replacement is one of the most serious risks of this procedure. Prosthesis-related infection is a serious complication for patients after orthopedic joint replacement, which is currently difficult to treat with antibiotic therapy. Consequently, in most cases, removal of the infected prosthesis is the only solution to cure the infection.”

22. _________________ prosthetics are considered especially suitable to younger, highly active individuals.

a. Ceramic

“Ceramic prosthetics are considered especially suitable to younger, highly active individuals.”

23. Friction tests using different viscosities of carboxy-methyl cellulose (CMC) solution show that _________________ joints operate close to full-fluid film lubrication with very low friction factors (0.002 at physiological viscosities).

b. ceramic-on-ceramic

“A well-positioned ceramic-on-ceramic hip, tested under the loads and motions expected during the standard walking cycle, performs exceptionally well in terms of friction, lubrication and wear. Friction tests using different viscosities of carboxy-methyl cellulose (CMC) solution show that these joints operate close to full-fluid film lubrication with very low friction factors (0.002 at physiological viscosities).”

24. An infection inside or near the prosthesis would likely necessitate

b. a revision (a new prosthesis).

“An infection inside or near the prosthesis would likely necessitate a revision (a new prosthesis).”
25. True or False: Ceramic wear is the biggest obstacle to prosthesis longevity.

b. False

“Polyethylene wear is the biggest obstacle to prosthesis longevity.”

26. The main issue related to ceramic materials is

d. its intrinsic brittleness.

“New ceramics offer improved strength and more versatile sizing options. However, the main issue related to ceramic materials is the intrinsic brittleness.”

27. A rare but debilitating risk of metal-on-metal implants is

c. cobalt poisoning.

“According to the American College of Rheumatology there have been cases of cobalt poisoning due to the use of metal hip prostheses. Cobalt poisoning from hip prosthesis is rare but debilitating. It is caused when the metal wears and introduces cobalt into the bloodstream.”

28. Patients undergoing primary hip or knee arthroplasty use a general anesthesia approximately ________ of the time for the surgery.

c. 74.8%

“A recent analysis of U.S., patient data that included 382,236 patient records undergoing primary hip or knee arthroplasty showed that approximately 11% were performed solely under neuraxial, 14.2% under combined neuraxial-general, and 74.8% under general anesthesia.”
29. True or False: Because of polyethylene’s light weight, researchers and surgeons uniformly believe that polyethylene prosthetics are the 21st century solution to hip replacements.

b. False

“Although they go as far back as the 1970s, some researchers and surgeons are of the opinion that ceramic-on-ceramic prosthetics may be the 21st century solution to hip replacements.”

30. In patients with hip fractures, clinical trials noted a beneficial outcome in patients receiving

a. regional anesthesia.

“In patients with hip fractures, clinical trials noted a beneficial outcome in patients receiving regional anesthesia.”

31. The _____________ is a piece of fibrocartilage or rubbery tissue, which is attached to the rim of the socket and whose purpose is to keep the ball joint in place.

a. labrum

“... labrum (a piece of fibrocartilage or rubbery tissue which is attached to the rim of the socket and whose purpose is to keep the ball joint in place).”

32. Prior to the surgical option however a physician will likely recommend the following non-surgical strategies:

c. Appropriate exercise, such as swimming.

“Since physicians do not yet know how to re-grow cartilage, when it wears out in a person’s joints then the only option is to replace the joint, which is what is done now. Prior to the surgical option however a physician will likely recommend the following non-surgical strategies: ... Exercise as can be tolerated (especially swimming).”
33. A joint may be cemented into place or not cemented: A cemented joint is used more often
d. in older people.

“It may be cemented into place or not cemented, so that bone will grow into it. Both methods may be combined to keep the new joint in place. A cemented joint is used more often in older people who do not move around as much and in people with ‘weak’ bones. The cement holds the new joint to the bone. An uncemented joint is often recommended for younger, more active people and those with good bone quality. It may take longer to heal, because it takes longer for bone to grow and attach to it.”

34. Osteochondral Autograft (a procedure where healthy cartilage is grafted over damaged cartilage) is a procedure that benefits
b. people under 50 years of age and with limited damage.

“Osteochondral Autograft: This procedure sounds very much like its name, it is a graft of healthy cartilage over damaged cartilage. This is a procedure that benefits people under 50 years of age and with limited damage.”

35. True or False: Mini-incision (MI) total hip arthroplasty (THA) is superior to standard incision total hip arthroplasty.
b. False

“The consequences of introducing mini-incision (MI) into total hip arthroplasty (THA) are still a debatable topic in all orthopedic forums. Despite a large amount of existing papers, there are hardly any well-designed trials capable of giving a conclusion, based on high-level evidence, on whether MI THA is superior to standard incision (SI) THA. MI is here defined as the use of a 10 cm or even smaller incision to complete the total hip joint replacement.”
36. The most common symptoms of deep vein thrombosis are
d. calf pain and swelling.

“Deep vein thrombosis is a major health concern. If not treated, the blood clots can get larger or break off and go to the lungs. When this happens, it is called a pulmonary embolism. The chance of dying from pulmonary embolism is over 25%. The most common symptoms of DVT are calf pain and swelling.”

37. Excessive intake of dietary vitamin K in green vegetables, reduces the anticoagulant effect of
c. warfarin.

“Warfarin is a vitamin K antagonist. Vitamin K is an essential substrate of liver enzymes responsible for the final synthesis of clotting factors II, VII, IX, and X. Warfarin inhibits the maturation of these factors in the coagulation cascade. Excessive intake of dietary vitamin K, which is mainly contained as phylloquinone in green vegetables, reduces the anticoagulant effect of warfarin.”

38. Patients who are operated on with regional anesthesia will not regain active motion of the lower extremities for a variable period after surgery but this inactivity can be remedied by
d. the use of intermittent pneumatic compression devices.

“Patients who are operated on with regional anesthesia will not regain active motion of the lower extremities for a variable period after surgery. This inactivity can be remedied by the use of intermittent pneumatic compression devices. These devices provide a mechanical means of increasing venous flow, by the intermittent inflation of air-filled cuffs placed around the legs.”

39. Reoperation for hematoma was associated with a significantly increased risk of
b. periprosthetic joint infection (PJI).

“Furthermore, it was found that reoperation for hematoma was associated with a significantly increased risk of periprosthetic joint infection (PJI).”
40. The most common reason for revision for both hip and knee replacements may continue to be

c. aseptic loosening.

“One of the risks of this surgical procedure is the failure of the prosthesis to function adequately. There is also the possibility of improper placement of the prosthesis during the procedure. Two other health concerns can be bone reabsorption (osteolysis), and aseptic loosening, which is the failure of the bond between an implant and bone in the absence of infection.”

References Section

The References below include published works and in-text citations of published works that are intended as helpful material for your further reading.


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health.com/surgery/type/cemented-vs-cementless-alternatives-joint-replacement


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