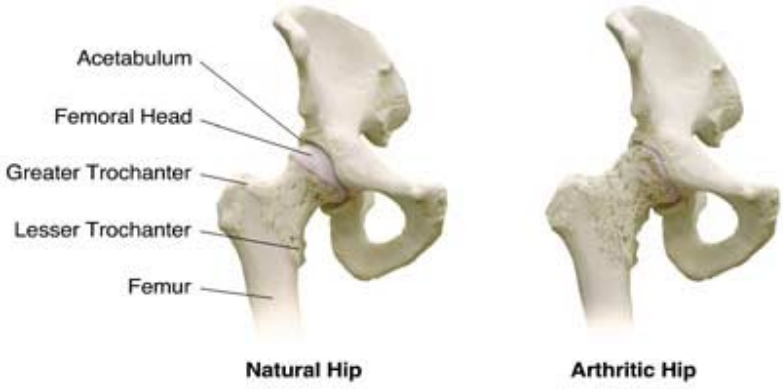
Hip Anatomy

Anatomy

The hip is one of the largest weight-bearing joints in the body. When it's working properly, it lets you walk, sit, bend, and turn without pain. To keep it moving smoothly, a complext network of bones, cartilage, muscles, ligaments, and tendons must all work in harmony.

The hip is a very stable ball-and-socket joint: A ball (femoral head) at the top of the thighbone (femur) fits into a rounded socket or cup-like cavity (acetabulum) in your pelvis. Bands of tissues called ligaments form a capsule connecting the ball to the socket and holding the bones in place.

A layer of smooth tissue called cartilage cushions the surface of the bones, helping the ball to rotate easily in the socket. Fluid-filled sacs (bursae) cushion the area where muscles or tendons glide across bone. The capsule surrounding the joint also has a lining (synovium) that secretes a clear liquid called synovial fluid. This fluid lubricates the joint, further reducing friction and making movement easier.



Damaged Hip

Injury or disease can damage your hip in several ways, resulting in a broken or deteriorated bone, irritated bursae, or worn cartilage. Damaged cartilage leads to various forms of arthritis

MIS Hip Procedure

This new procedure allows your surgeon to place your new hip through a smaller incision without cutting the muscles and tendons around the hip.

Clinical experience shows that this procedure can allow a surgeon visibility and space to operate and yet not cut the muscles. This approach may lead to faster rehabilitation. It also keeps an important hip structure intact (the posterior capsule), which may help provide increased joint stability.

Some of the potential patient benefits of the MIS Hip Procedure are:

- A single incision
- Less tissue trauma
- Spares muscles and tendons, allowing for the possibility of a faster recovery
- Shorter hospital stay
- Smaller scar

Over 10,000 primary total hip replacement procedures have been performed using this innovative surgical technique. Reports suggest that it helps provide successful outcomes with less muscle damage and more rapid rehabilitation for people receiving hip replacement.

Hip Replacement Considerations

Thigh Pain

A primary goal of hip replacement is to reduce pain. Though most patients experience some pain during recovery from surgery, they find that the long-term relief is a welcome liberation from the pain caused by diseased hip joints.

However, hip replacement patients can experience pain if their implants are too rigid, “pinching” against the more flexible bone that supports them. Zimmer hip stems have several design features to minimize pain and stiffness.

Leg Length

Zimmer offers a variety of sizes and options to help surgeons match each patient’s natural leg length as closely as possible. Each hip system comes in a range of sizes, measured in precise millimeters.

Most patients' hip joints have an approximate 130° neck angle. However, for those patients with slightly different anatomies, Zimmer offers both "offset" and "short neck" hip stems to adjust for unique anatomies.

Bone Preservation

Bone is living tissue and like most living things, needs stimulation to stay healthy.

A challenge in hip implant design is not to let the implant do all the work. If the implant overly shields the bone from stress ("stress-shielding"), bone can be resorbed or broken down by the body, resulting in bone loss for the patient.

On the other hand, if the bone is required to take on too much stress, abnormal growth can occur – called "adaptive remodeling."

Zimmer implants are designed to provide a balance between stable fit and natural stress loading.

Bone Loss (Osteolysis)

In addition to inadequate stress loading, bone can also be lost through a process known as osteolysis.

Here's what happens:

As the hip stem's hard metal head rubs against the softer polyethylene cup in the hip socket, the friction can degrade the polyethylene over time, causing small wear particles to break off in the body. The body's immune system rejects this foreign debris, attacking it much like it would attack an infection.

Unfortunately, since the polyethylene debris typically settles around the site of the implant, the immune system may start attacking the surrounding bone tissue. This is known as osteolysis – literally, "eating away" of the bone. As the patient loses bone tissue in his or her hip, the implant may become loose and no longer function properly. Many orthopedic surgeons identify osteolysis as the number one cause of hip implant failure.

Zimmer implants have several design features that specifically address the issue of osteolysis:

- Build-up in the upper (proximal) area of the hip stem to effectively fill the bone and reduce potential tracks for debris.
- Oxygenless packaging of implants, introduced in 1994, virtually eliminates all oxygen from the package during sterilization so oxidation (and possible subsequent aging) cannot occur. The absorber continues to remove oxygen from the package during its shelf life. These features lead to reduced debris degeneration.

Stability

Zimmer hip implant designs are the result of detailed analyses of hundreds of patient x-rays for maximum stability and optimal bone/implant fit. The goal is to maximize the patient’s range of motion while at the same time minimizing the possibility for dislocation.

Lifetime of Implant

The longevity of a prosthetic hip (how long it will last) varies from patient to patient. It depends on many factors, such as a patient's physical condition and activity level, body weight and the surgical technique. A prosthetic joint is not as strong or durable as a natural, healthy joint, and there is no guarantee that a prosthetic joint will last the rest of a patient's life. All prosthetic hips may need to be revised (replaced) at some point.

Revision Surgery

Some patients require a second revision implant due to loosening, trauma, infection or chronic dislocation.

A common challenge with revision patients is the loss of bone due to too much stress shielding of the implant or osteolysis caused by wear of the polyethylene insert.

Zimmer offers a full line of revision hip implants designed to preserve as much remaining bone as possible and minimize the need for yet another surgery.

Preparing for Joint Replacement Surgery

Three Weeks Before Surgery

This information is intended to be an overview of activities that you may experience during joint replacement surgery. It is not intended to replace any instructions provided by your physician, and we would encourage you to discuss this information with your physician.

- **Store frequently used items in easy to reach cabinets, such as cleaning supplies and canned foods**. Avoid very high or very low shelves as these may require you to use a step stool or kneel.
- **Make and freeze meals or stock up on frozen dinners before surgery so that meal preparation is easier and requires less effort**. You may want to make a list of items you will need to prepare meals and go to the supermarket. You should plan on making enough meals for one week or so.
- **Contact friends/family for support**. Friends/family may be needed to assist with activities such as driving and moving items in your home for safety. The Arthritis Foundation also has a support network that can provide emotional support. You can contact your local chapter or go to the Arthritis Foundation web site for more information.
- **Check the safety of your home to prevent falls or tripping** . Move long electrical and telephone cords against the wall, remove rugs, and place a non-skid mat in your bathtub. You may want to prepare a bed in the downstairs level of you home to reduce climbing stairs. Have an elevated chair or high seated chair with arms in every room if possible.

Two Weeks Before Surgery

- **Anti-inflammatory medications** Your physician may not want you to take any aspirin or non-steroidal anti-inflammatory medications (Advil, Ibuprofen, Motrin, etc.) for the 14 days before surgery. You may be able to take Tylenol or medicines with acetaminophen. Be sure to discuss this with your physician.

- **Purchase or borrow the special equipment your physician recommends** . This may include an elevated commode and small devices such as a grabber. You can find these items at most hospital supply sections of large drug stores or in mail order catalogs from department stores. Practice using the items at home.

Your Hip Surgery

There are many ways to treat the pain caused by arthritis. One way is total hip replacement surgery. The decision to have total hip replacement surgery should be made very carefully after consulting your doctor and learning as much as you can about the hip joint, arthritis, and the surgery.

In total hip replacement surgery, the ball and socket that have been damaged by arthritis are removed and replaced with artificial parts made of metal and a durable plastic material. We call these artificial parts "implants," or "prostheses."

Two Types of Hip Fixation

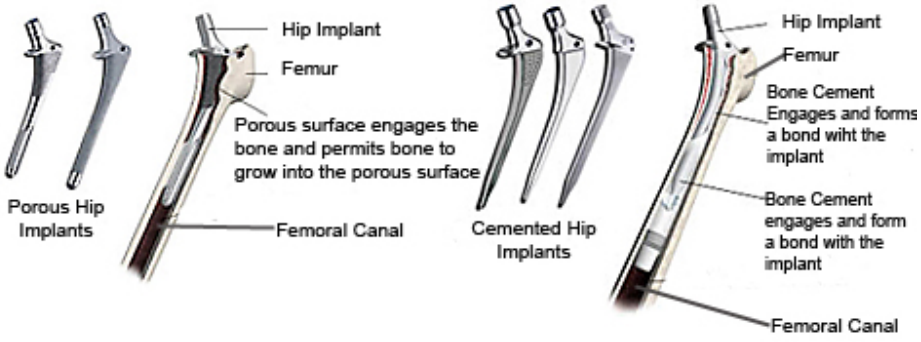
There are two main types of fixation philosophies-cemented and porous. Both can be effective in the replacement of hip joints. The physician (and the patient) will choose the best solution that is specific to the patient's needs.

Cemented Hip Implants

The cemented hip implant is designed to be implanted using bone cement (a grout that helps position the implant within the bone). Bone cement is injected into the prepared femoral canal. The surgeon then positions the implant within the canal and the grout helps to hold it in the desired position.

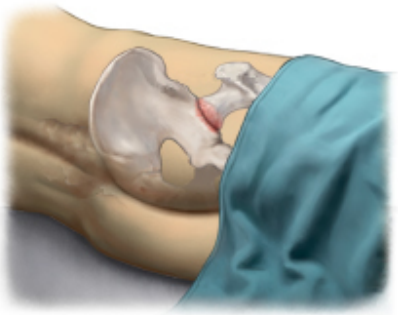
Porous Hip Implants

The porous hip implant is designed to be inserted into he prepared femoral canal without the use of bone cement. Initially, the femoral canal is prepared so that the implant fits tightly within it. The porous surfaces on the hip implant are designed to engage the bone within the canal and permit bone to grow into the porous surface. Eventually, this bone ingrowth can provide additional fixation to hold the implant in the desired position.



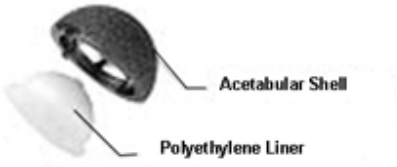
During Surgery

The patient is first taken into the operating room and given anesthesia. After the anesthesia has taken effect, the skin around the upper thigh is thoroughly scrubbed with an antiseptic liquid. An incision of appropriate size is then made over the hip joint.



Replacing the Socket Portion of the Joint

One type of implant that replaces the socket consists of a metal shell that is lined with a strong plastic liner.



Removing the Surface of the Socket

The leg is maneuvered until the femoral head is dislocated from the socket.

A special reamer is then used to remove the damaged cartilage and bone surface from the acetabulum, and to shape the socket so it will match the shape of the implant that will be inserted.

Inserting the Implant

The shell portion of the socket implant may be attached either by using a special kind of epoxy cement for bones, or by pressing the implant into the socket so that it fits very tightly and is held in place by friction. Some implants may have special surfaces with pores that allow bone to grow into them to help hold the implant in place. Depending on the condition of the patient's bone, the surgeon may also decide to use screws to help hold the implant in place.

When the shell portion of the socket implant is in place, the plastic liner is locked into place inside the shell.

Replacing the Ball Portion of the Joint

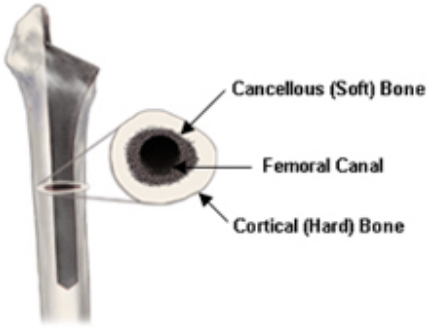
The implant that replaces the ball consists of a long metal stem that fits down into the femur. The metal ball is mounted on top of this stem.

Removing the Ball

A special power saw is used to remove the damaged femoral head.

Clearing and Shaping the Canal

The upper leg bone has relatively soft, porous bone tissue around the center. This part of the bone is called cancellous bone. It surrounds the canal, which mainly contains blood vessels and fatty tissue.



Special instruments are used to clear some of the cancellous bone from the canal, and then to mold the inside walls of the canal to fit the shape of the implant stem.

Inserting the Implant

The stem implant may be held in place by either using the special cement for bones, or by making it fit very tightly in the canal. If cement is used, it is injected into the canal first, and then the implant is inserted into the canal. If cement is not used, the implant is simply inserted into the canal. Like the socket implant, the stem implant may have a special surface with pores that allow bone to grow into them.

On some implants, the stem and ball are one piece. On others, they may be two separate pieces. If the ball is a separate piece, it is usually secured to the top of the stem after the stem has been inserted.

Closing the Wound

When all the implants are in place, the surgeon places the new ball that is now part of the upper leg bone into the new socket that is secure within the pelvic bone. If necessary, the surgeon may adjust the ligaments that surround the hip to achieve the best possible hip function.

When the ligaments are properly adjusted, the surgeon sews the layers of tissue back into their proper position. A plastic tube may be inserted into the wound to allow liquids to drain from the site during the first few hours after surgery. After the tube is inserted, the edges of the skin are sewn together, and a sterile bandage is applied to the hip. Finally, the patient is taken to the recovery room.

Hip Surgery

The following are some ways to incorporate movement after you have had hip replacement surgery. Discuss these techniques with your physicians and orthopedist before attempting them. Your physical therapist may modify some of these techniques depending upon your situation (i.e., age, weight, and procedure). Only do the techniques that are recommended by your physician and/or therapist.

Getting Out of Bed

Step 1 Get out of the bed on the same side as your operated leg. You physician and/or physical therapist will show you how to move your operated leg properly and will assist you the first few times while you're in the hospital.

Step 2 Pivot on your hips using your elbows to help. Keep your body straight with your operated leg kept to the side. Do not twist your leg.

Step 3 Move your unoperated leg around and sit on the edge of the bed keeping your operated leg straight. Hold onto your walker for support and stand. Do not bend forward as you try to stand.

Sitting

Step 1 Sit in firm, straight-backed chairs with high seats and armrests. You should avoid low, overstuffed chairs. Back your walker up until you feel the chair touching the back of your legs.

Step 2 Release your hands from the walker and reach down and hold onto the arm rests. Slowly lower yourself keeping your operated leg straight out in front.

Step 3 Sit then slide back in the chair bending your unoperated leg first. You use this technique when using a toilet with arm rails as well.

Walking

Once you can stand, you will use a walker to help you keep your balance. Initially you will be told to place only a small amount of weight on your operated leg as you walk. As you become stronger, your doctor will tell you when you can increase the amount of weight placed on your operated leg.

Step 1 Place the walker a few inches in front on you and hold on to the walker firmly with both hands. Keep you hip straight and step your unoperated leg into the center of the walker. To protect your hip, avoid rotating your hip or foot.

Step 2 Lean on the walker and let it support your weight. Step forward and through the walker with your operated leg. Be careful not to wrap your leg around the legs of the walker.

Step 3 Lift your walker straight up (if it doesn't have wheels). Be sure to place all four of its legs down before stepping forward again.

Crutches

Once your muscles are strong enough, your physical therapist and/or physician may recommend crutches instead of using a walker. Your therapist will give you guidelines on how far and how long you may walk. When using crutches, put your weight on your palms, not your armpits. Don't twist to turn, take small steps instead. Your physician and/or therapist will tell you how much weight you can put on your operated leg.

Step 1 With the crutches firmly in place, place pressure on your hands, not on your armpits.

Step 2 Move the operated leg and both crutches forward at the same time.

Step 3 Looking up and straight ahead, first step through the crutches with the operated leg followed by your unoperated leg.

Walking Up Stairs with Crutches

With your crutches upright on the floor and firmly planted for support, lift your unoperated leg and place it on the step. Leaning forward on the crutches, lift yourself up. Use the crutches and your unoperated leg to support your weight. Now lift your operated leg up onto the step. You may want to have someone help you the first few times until you become comfortable with stairs.

Walking Down Stairs with Crutches

Place your crutches and your operated leg on the lower step. Use the crutches for balance and lower yourself carefully down onto the step moving the crutches as you move the operated leg. Again, you may wish to have someone assist you the first few times you try this.

Avoid Risky Movements

At first some movements will put too much strain on your new hip joint, which could cause the ball to slip from its socket. A therapist will teach you which movements to avoid. A few of the most risky ones are:

Sitting

Don't let your knee cross the midline of your body.

Rather, sit with both feet on the floor, with your knees six inches apart.

Turning

Don't plant your foot and rotate your new hip inward.

Rather, turn both your feet and your body.

Bending Down

Don't bend all the way over from the waist.

Rather, use a device, such as a long-handled grabber to reach down.

Once You Are At Home

It is very important that you follow your surgeon's instructions. The following suggestions should be discussed with your surgeon before your hospital discharge:

- If you will be using a walker or crutches to assist with walking, ask your doctor how much weight you may put on your operated leg. Remember that you will probably tire more easily than usual. You may want to plan a rest period of 30 to 60 minutes mid-morning and mid-afternoon.
- It is safer and easier to get in and out of chairs using both arms and you should avoid low or overstuffed furniture. To increase your comfort, use a cushion or pillow to raise your body while seated.
- An elevated toilet seat may reduce stress to your hips and knees as you sit and stand.
- A shelf placed in the shower at chest height may reduce having to bend to retrieve items while in the shower.
- A bathtub seat (bench) allows you to sit while bathing for increased safety and comfort.
- A long-handled bath sponge may be used to reach lower legs. Women can also purchase razor extenders to shave their legs.
- Avoid sweeping, mopping, and running the vacuum cleaner. Use long-handled feather dusters for dusting high and low items. Your doctor will tell you when it is okay to sweep, mop, and vacuum.
- You may ride in a car, but you must follow your doctor's instructions for how to get in and out of the vehicle. You can raise the height of the car seat with pillows to protect your hips and knees as well.
- Your doctor will talk with you about when you can drive, typically within four to six weeks after surgery. If you have a car with manual transmission, talk with your doctor about driving limitations. Make sure you can brake the car without discomfort before you attempt to drive in traffic.
- Constipation is a common problem for patients following surgery. This is usually due to your limited activity and any pain medications you may be taking. Discuss your diet with your doctor. It should include fresh fruits and vegetables as well as eight full glasses of liquid each day, unless your doctor tells you otherwise.
- Your doctor will probably give you a prescription for pain pills. Please follow your doctor's instructions concerning these medications.
- Some swelling around the incision is normal. You will find it more comfortable to wear loose clothing to avoid pressure on the incision. Ask your doctor or other qualified health professional about appropriate wound care.

Frequently Asked Questions

Hip Replacement

This page provides a brief introduction to hip replacement. It can help you make a list of questions to ask your doctor, but it is not meant to provide complete information. Check with your surgeon's office about more comprehensive resources and patient education materials.

What causes hip pain?

- Osteoarthritis
- Fractures/dislocations
- Rheumatoid arthritis
- Aseptic bone necrosis / Avascular necrosis

Is there a cure?

Since hip pain results from damage to the joint, there is no “cure.” However there are a variety of treatment options available, ranging from rehabilitation to total hip replacement surgery.

What is a hip replacement?

In a total hip replacement surgery, the painful parts of the damaged hip are replaced with artificial hip parts called a prosthesis, a device that substitutes or supplements a joint. The prosthesis consists of steel components: a socket, ball, and stem. The outer shell of the socket is usually made of metal and the inner shell consists of plastic, or the entire socket may be plastic. When the metal ball is joined with the socket, the new hip can allow for smooth, nearly frictionless movement.

How do I know if I need a hip replacement?

If you have difficulty walking or performing everyday activities such as getting dressed, it may be time to consider hip replacement surgery.

Doctors generally try to delay total hip replacement for as long as possible in favor of less invasive treatments. However in patients with advanced joint disease, hip replacement offers the chance for relief from pain and a return to normal activities.

How do I prepare for hip replacement surgery?

If you and your surgeon decide that total hip replacement is right for you, a date will be scheduled for your surgery. Several things may be necessary to prepare for surgery. For example, your surgeon might ask you to have a physical examination by your primary care physician. This will help to ensure that other health problems you may have, such as diabetes or high blood pressure, will be identified and treated before surgery.

You doctor may suggest that you lose weight and initiate an exercise program. If you smoke, be sure to speak with your doctor about it, as smoking can dangerously increase surgical risks and slow down the healing process.

You should also finish any dental work that may be underway to prevent germs in your mouth from entering the bloodstream and infecting the joint. It is likely that you will need blood during hip surgery, and your surgeon may place an order with the blood bank in

case a transfusion is needed. If you prefer, or if your surgeon feels it is needed, you may want to donate your own blood ahead of time to reduce the risk of your body reacting to the blood transfusion. Read the Surgery Calendar for more information on how to prepare for surgery.

What happens during hip replacement surgery?

On the day of surgery, an intravenous tube will be inserted into your arm to administer necessary medications and fluids during surgery. You will then be taken to the operating room and given anesthesia.

The surgery usually takes two to four hours, although this is dependent upon the severity of the arthritis in your hip. In the operating room, a urinary catheter will be inserted and left in place for one or two days. Compression stockings and pneumatic sleeves will be put on both legs. The procedure is performed through an incision over the side of the hip. The ball-end of the thighbone (femur) is cut and replaced with the new metal ball and stem component. It may be stabilized with or without cement. The damaged surface of the socket is smoothed in preparation for the insertion of the new socket. The ball and socket are then joined. When the surgeon is satisfied with the fit and function, the incision will be cleaned and covered with dressings. You will also find small drainage tubes coming out of the hip to drain fluid from the wound.

You will be sent to the recovery room and as the anesthesia wears off you will slowly regain consciousness. A nurse will be with you, and may encourage you to cough or breathe deeply to help clear your lungs. You will also be given pain medication and will find a foam wedge or pillows placed between your legs to help hold your joint in place. When you are fully conscious, you will be taken back to your hospital room.

How long does the surgery take? What is the recovery time?

In the weeks immediately following surgery, you may need walking aids such as a cane or crutches. Within a few months, however, you should be able to return to normal activities.

For more information, please read, Your Hip Surgery and After Hip Surgery.

How is the implant affixed in the body?

- **Bone Cement**
  A special type of bone acrylic cement may be used to secure some or all of the

implant components to the bone. If used, the bone cement takes about 15 minute to set.

- **Press-Fit**
  In other cases, the implants may be “press-fit” into the bone. Press-fit components may have a special porous coating that allows tissue to grow up to it for fixation.
- **Combination**
  In some cases, your surgeon may choose a combination of cement and press-fit attachment, depending upon the implant components and condition of the pelvic and thigh bone.

The decision as to whether to use a cemented or press-fit component depends upon many factors, including the manufacturer’s intended use of the product, surgeon philosophy and the patient’s condition.

What can I expect after surgery?

When you are back in your hospital room you will begin a gentle rehabilitation program to help strengthen the muscles around your new hip and regain your range of motion. On the day of surgery you may be asked to sit on the edge of the bed and dangle your feet. You will also learn how to protect your new hip while doing daily activities.

As soon as possible, usually within the next 24 hours, your physical therapist will help you start walking a few steps at a time. As you heal you will progress from walker to crutches and then a cane. Before you are dismissed from the hospital, an occupational therapist will also show you how to perform daily tasks at home with your new hip. For example, he or she will instruct you on how to go to the bathroom, how to dress yourself, how to sit or stand, how to pick up objects and many others.

After about two to four days, or when your surgeon determines that you have recovered sufficiently, you will be discharged. You may be transferred to a rehabilitation facility for a few more days, as determined by your surgeon. Upon returning to your home, you will need to continue taking your regular medications and continue exercising as directed by your surgeon or physical therapist. Walking, remaining active and practicing the required exercise are the quickest ways to full recovery. Read the Surgery Calendar to learn more on what to expect after surgery.

How long will a joint replacement last?

Longevity of the prosthetic hip varies from patient to patient. It depends on many factors, such as a patient's physical condition, activity level, and weight, as well as the accuracy of implant placement during surgery. It is useful to keep in mind that prosthetic joints are not as strong or durable as a natural, healthy joint, and there is no guarantee that a prosthetic joint will last the rest of a patient's life.

Today, total hip replacement has become a common and predictable procedure. Many patients enjoy relief from pain and improved function, compared to their status before surgery. As a result, some patients may have unrealistic expectations about what the prosthetic hip can do and how much activity it can withstand. As with any mechanical joint, the ball and socket components move against each other. Natural fluid in the joint space, called synovial fluid, helps to lubricate the implants just as it lubricates the bones and cartilage in a natural joint. Still, the prosthetic components do wear as they roll and slide against each other during movement. As with car tires or brake pads, the rate of wear depends partly on how the hip joint is used. Activities that place a lot of stress on the joint implants, as may be the case with heavier and more active patients, may reduce the service life of the prosthesis. Implant loosening and wear on the plastic portions of the implant can lead to the necessity for revision surgery to replace the worn components, or all of the components. Your doctor will be in the best position to discuss these issues with you, taking into account your particular clinical circumstances, the type of implants used, and your post-surgical lifestyle.

Talk with your doctor about the following points, and how they might affect the longevity and success of your hip replacement:

- Avoiding repetitive heavy lifting
- Avoiding excessive stair climbing
- Maintaining appropriate weight
- Staying healthy and active
- Avoiding "impact loading" sports such as jogging, downhill skiing and high impact aerobics
- Consulting your surgeon before beginning any new sport or activity
- Thinking before you move
- Avoiding any physical activities involving quick stop-start motion, twisting or impact stresses
- Avoiding excessive bending when weight bearing, like climbing steep stairs
- Not lifting or pushing heavy objects

- Not kneeling
- Avoiding low seating surfaces and chairs.

Are there any complications?

Some common complications specific to hip replacement surgery include loosening or dislocation of the implant and a slight difference in leg length.

Your healthcare team will discuss these possible complications with you and the precautions taken against them.

How old is the average patient?

In the U.S., the average joint replacement patient is around 65-70 years old, however patients of all ages have received hip implants.

What activities can I do or not do after receiving a hip implant?

Typically, patients are advised to avoid high impact sports such as jogging, basketball, racquetball, gymnastics, etc.

Safer activities may include walking, golf, swimming, and bicycling.

Your doctor will advise you on safe activities for your particular condition.

Will an implant set off a metal detector?

Patients have reported mixed experiences at airports: some detectors go off and some don't.

You may be provided with a special card to keep in your wallet explaining that you have a hip implant.

What about sex?

Doctors generally allow patients to resume sexual activities as soon as they feel able. In the months following surgery, patients are generally advised to take it easy and modify their positioning to keep pressure off of the joint while it’s healing. As always, it is best to consult with your doctor about what’s safe for your particular condition.

Will a hip implant last a lifetime?

The longevity of a prosthetic hip (how long it will last) varies from patient to patient. It depends on many factors, such as a patient's physical condition and activity level, body weight and the surgical technique. A prosthetic joint is not as strong or durable as a natural, healthy joint, and there is no guarantee that a prosthetic joint will last the rest of a patient's life. All prosthetic hips may need to be revised (replaced) at some point.

Materials Used in Orthopaedic Implants

Overview

As you would expect, orthopaedic implants are very “high tech.” Their designs can be quite complex, and the materials used to make them, called biomaterials, are highly developed. Examples of biomaterials include Titanium, cobalt-chrome, polyethylene, and *Trabecular Metal*™ Material.

In the United States the FDA requires extensive testing before a new material may be used in an orthopaedic implant. The materials most commonly used have a long history of clinical use with great success.

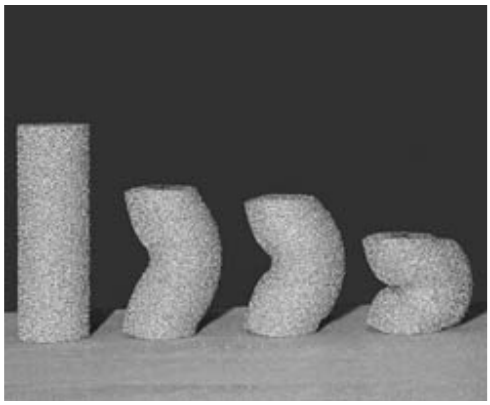
There are many different biomaterials, but there is no single biomaterial that is best for all implants and all patients. The specific requirements of an implant material vary depending on how the implant is designed to be used. Also, like medicine, biomaterials can produce side effects like microscopic debris, increased ion levels in the blood or urine, or inflammation. These are rare, but you should be aware of the possibility. For these reasons, your doctor will evaluate you individually and carefully consider the material that is used to manufacture your implant, along with its design.

The content on biomaterials is intended to answer some of the most common questions about the biomaterials used in orthopaedic implants, but it cannot tell you what material is best for your implant. Only your doctor can tell you that, so be sure to discuss your specific questions with him. If you have more questions for your surgeon about the biomaterials in your implant, be sure to ask during your visits.

Materials Used in Orthopaedic Implants

Importance of Materials

As you go about your daily activities, an implant may encounter mechanical forces that tend to push on it, pull on it, bend it, scrape it, or cause its parts to rub together. These forces can cause the implant to break or wear out over time.



It is also subjected to the many natural chemicals inside your body. Although normal, some of these chemicals may tend to corrode some materials. In order for an implant to perform under these conditions, it must be made from materials that can withstand these forces and chemicals.

Whether an implant is designed to replace a joint, or help repair a fracture, several physical and biological characteristics are important when selecting the material for the implant. For example, an implant must be sufficiently strong, flexible, and resistant to wear. But that doesn't mean the strongest material, or the most flexible material, is the best material.

The ideal implant material would have physical characteristics that match those of the bone it is replacing or reinforcing. After all, orthopaedic implants are attached to your bones, and they must work *with* your bones to restore function. This usually requires a balance of physical characteristics. Your bones, for example, are strong but flexible. This combination helps them withstand forces as high as several times your weight without breaking.

Obviously, physical characteristics are important to orthopaedic materials; but biological characteristics are just as important. When we talk about biological characteristics, we mean the biological effect the material has on the body, as well as the effect the body has on the material.

Materials Used in Orthopaedic Implants

Physical Characteristics—Strength and Flexibility

Strength

Certainly, an orthopaedic implant should be designed to be as strong as possible. Even in everyday activities, you will place high levels of mechanical stress on your bones and

joints. An implant must be able to withstand these stresses day to day without breaking or permanently changing its shape. It should also be designed to withstand the accumulated effect of repeating these stresses.

Flexibility

While strength characteristics of implants are important, they must also be somewhat flexible to avoid shielding of bones from stress (what doctors call “stress shielding”). To understand stress shielding, you have to understand that the human body may tend to reduce or eliminate its own parts when they are not used. Your muscles, for example, can be built up by lifting weights. But when you stop lifting weights, you will eventually begin to lose the extra muscle that you have built up.

Similarly, your bones can remain strong only if they are regularly placed under a reasonable stress. And if they are never stressed, your body will actually begin to lose bone tissue, causing the remaining bone to become weak.

When stress is applied to an orthopaedic implant that is very stiff, the implant absorbs most of the stress. But when stress is applied to a more flexible implant, some of the stress passes through the implant so it can be shared with the surrounding bone. That’s good because your bones need to be stressed. That’s why flexibility is important.

Materials Used in Orthopaedic Implants

Physical Characteristics—Material Resistance to Wear and Corrosion and Biocompatibility

Resistance to Wear

Some of the parts that make up an orthopaedic implant must touch each other or rub together, especially in the case of an artificial joint. Any time two parts rub together, friction is created and the parts may possibly wear over time. When an implant wears, tiny particles of the material are removed from the surface and remain in the tissues that surround the implant. In some patients, these particles may cause a reaction that could lead to inflammation. If the inflammation is severe, or continues for too long, the implant may become loose.

Generally, the harder the material, the more resistant it is to wear. Also, the choice of the two materials that rub together in an implant is important in minimizing wear. Many combinations of materials are used today for implants, including metal on polyethylene, metal on metal, ceramic on ceramic, and ceramic on polyethylene.

Resistance to Corrosion

Some of the normal chemicals that make up the fluids in your body can damage certain materials. Corrosion occurs as these chemicals react with the implant material, creating particles similar to small wear particles. Not only can corrosion weaken the implant, but the particles produced can remain in the tissues that surround the implant. This could eventually lead to implant failure or, in severe cases, damage to the bone.

Biocompatibility

Biocompatibility refers to the way materials interact with your body. Some materials, lead and mercury for example, are naturally harmful when taken into the body, so are not suitable for implanting. Other materials are not suitable to implant because the body fluids cause them to break down, either weakening them, or causing corrosion or other byproducts. Some materials may cause irritation or, rarely, may cause an allergic reaction. If this happens, the implant site may experience some inflammation which may involve swelling, redness and pain. Fortunately, all biomaterials used in medical devices, in the U.S. and in most other countries, must be extensively tested for biocompatibility before they are approved for use.

Because some few people may have an allergic reaction, even to materials that are generally safe for the general public, it is important to tell your doctor about any allergies you may have.

Materials Used in Orthopaedic Implants

Common Materials Used in Orthopaedic Implants

Generally, the most common materials used in orthopaedic implants are metals and a type of plastic called polyethylene. These two material types are combined in most joint implants, that is, one component is made from metal, and one from polyethylene. When properly designed and implanted, the two components can rub together smoothly while minimizing wear.

While some pure metals have excellent characteristics for use as implants, most metal implants are made from a mixture of two or more metals. These mixed metals are called alloys. By combining metals, a new material can be created that has a good balance of the desired characteristics. The most common metal alloys used in orthopaedic implants are stainless steels, cobalt-chromium alloys, and titanium alloys.

Stainless Steel

Stainless steel is a very strong alloy, and is most often used in implants that are intended to help repair fractures, such as bone plates, bone screws, pins, and rods. Stainless steel is made mostly of iron, with other metals such as chromium or molybdenum added to make it more resistant to corrosion. There are many different types of stainless steel. The stainless steels used in orthopaedic implants are designed to resist the normal chemicals found in the human body.

Cobalt-chromium Alloys

Cobalt-chromium alloys are also strong, hard, biocompatible, and corrosion resistant. These alloys are used in a variety of joint replacement implants, as well as some fracture repair implants, that require a long service life. While cobalt-chromium alloys contain mostly cobalt and chromium, they also include other metals, such as molybdenum, to increase their strength.

Titanium Alloys

Titanium alloys are considered to be biocompatible. They are the most flexible of all orthopaedic alloys. They are also lighter weight than most other orthopaedic alloys. Consisting mostly of titanium, they also contain varying degrees of other metals, such as aluminum and vanadium.

Titanium

Pure titanium may also be used in some implants where high strength is not required. It is used, for example, to make fiber metal, which is a layer of metal fibers bonded to the surface of an implant to allow the bone to grow into the implant, or cement to flow into the implant, for a better grip.

Tantalum

Tantalum is a pure metal with excellent physical and biological characteristics. It is flexible, corrosion resistant, and biocompatible.

Polyethylene

Polyethylene is a type of plastic commonly used on the surface of one implant that is designed to contact another implant, as in a joint replacement. You may recognize polyethylene as the material used to make milk cartons. But don’t worry; your implant is not made from recycled milk cartons. The polyethylene used in orthopaedic implants is a much higher grade. In fact, a special type of medical-grade polyethylene was developed specifically for use in orthopaedic implants.

Polyethylene is very durable when it comes into contact with other materials. When a metal implant moves on a polyethylene surface, as it does in most joint replacements, the contact is very smooth and the amount of wear is minimal.

Patients who are younger or more active may benefit from polyethylene with even more resistance to wear. This can be accomplished through a process called crosslinking, which creates stronger bonds between the elements that make up the polyethylene. The appropriate amount of crosslinking depends on the type of implant. For example, the surface of a hip implant may require a different degree of crosslinking than the surface of a knee implant.