**Hip replacement**

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**Hip replacement** is a surgical procedure in which the hip joint is replaced by a prosthetic implant. Hip replacement surgery can be performed as a total replacement or a hemi (half) replacement. Such joint replacement orthopaedic surgery is generally conducted to relieve arthritis pain or fix severe physical joint damage as part of hip fracture treatment. A total hip replacement (total hip arthroplasty) consists of replacing both the acetabulum and the femoral head while hemiarthroplasty generally only replaces the femoral head. Hip replacement is currently the most common orthopaedic operation, though patient satisfaction short and long term varies widely.

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History

The earliest recorded attempts at hip replacement (Gluck T, 1891), which were carried out in Germany, used ivory to replace the femoral head (the ball on the femur).[1]

On September 28, 1940 at Columbia Hospital in Columbia, South Carolina, Dr. Austin T. Moore (1899–1963), an American surgeon, reported and performed the first metallic hip replacement surgery. The original prosthesis he designed was a proximal femoral replacement, with a large fixed head, made of the Cobalt-Chrome alloy Vitallium. It was about a foot in length and it bolted to the resected end of the femoral shaft (hemiarthroplasty). A later version of Dr. Moore's prosthesis, the so-called Austin Moore, developed in Columbia, SC was introduced in 1952 is still in use today, although rarely. Like modern hip implants it is inserted into the medullary canal of the femur. It depends on bone growth through a hole in the stem for long term attachment.

In 1960 a Burmese orthopaedic surgeon, Dr. San Baw (29 June 1922 – 7 December 1984), pioneered the use of ivory hip prostheses to replace ununited fractures of the neck of femur when he first used an ivory prosthesis to replace the fractured hip bone of an 83 year old Burmese Buddhist nun, Daw Punya.[2] This was done while Dr. San Baw was the chief of orthopaedic surgery at Mandalay General Hospital in Mandalay, Burma. Dr. San Baw used over 300 ivory hip replacements from the 1960s to 1980s. He presented a paper entitled "Ivory hip replacements for ununited fractures of the neck of femur" at the conference of the British Orthopaedic Association held in London in September 1969. An 88% success rate was discerned in that Dr. San Baw's patients ranging from the ages of 24 to 87 were able to walk, squat, ride a bicycle and play football a few weeks after their fractured hip bones were replaced with ivory prostheses. Ivory may have been used because it was cheaper than metal at that time in Burma and also was thought to have good biomechanical properties including biological bonding of ivory with the human tissues nearby. An extract from Dr San Baw's paper, which he presented at the British Orthopaedic Association's Conference in 1969, is published in Journal of Bone and Joint Surgery (British edition), February 1970. With modern hip replacement surgery, one can expect to walk immediately post-op.

Modern process

The modern artificial joint owes much to the work of Dr. Sir John Charnley at Wrightington Hospital; his work in the field of tribology resulted in a design that almost completely replaced the other designs by the 1970s. Charnley's design consisted of three parts:

1. stainless steel one-piece femoral stem and head
2. polyethylene (originally teflon), acetabular component, both of which were fixed to the bone using
3. PMMA (acrylic) bone cement

The replacement joint, which was known as the Low Friction Arthroplasty, was lubricated with synovial fluid. The small femoral head (7/8" (22.2 mm)) was chosen for Dr. Charnley's belief that it would have lower friction against the acetabular component and...
thus wear out the acetabulum more slowly. Unfortunately, the smaller head dislocated more easily. Alternative designs with larger heads such as the Mueller prosthesis were proposed. Stability was improved, but acetabular wear and subsequent failure rates were increased with these designs. The Teflon acetabular components of Dr. Charnley's early designs failed within a year or two of implantation. This prompted a search for a more suitable material. A German salesman showed a polyethylene gear sample to Dr. Charnley's machinist, sparking the idea to use this material for the acetabular component. The Ultra High Molecular Weight Polyethylene or UHMWPE acetabular component was introduced in 1962. Dr. Charnley's other major contribution was to use polymethylmethacrylate (PMMA) bone cement to attach the two components to the bone. For over two decades, the Charnley Low Friction Arthroplasty, and derivative designs were the most used systems in the world. It formed the basis for all modern hip implants.

The Exeter hip stem was developed in the United Kingdom during the same time as the Charnley device. This is also a cemented device, but with a slightly different stem geometry. Both designs have shown excellent long-term durability when properly placed and are still widely used in slightly modified versions.

Early implant designs had the potential to loosen from their attachment to the bones, becoming painful typically ten to twelve years after placement. In addition to the devices loosening, erosion of the bone around the implant was seen on x-rays. Initially surgeons believed this was caused by an abnormal reaction in response to the cement holding the implant in place. That belief prompted a search for an alternative method to attach the implants. The Austin Moore device had a small hole in the stem into which bone graft was placed before implanting the stem. It was hoped bone would then grow through the window over time and hold the stem in position. Success was unpredictable and the fixation not very robust. In the early 1980s, surgeons in the United States applied a coating of small beads to the Austin Moore device and implanted it without cement. The beads were constructed so that gaps between beads matched the size of the pores in native bone. Over time, bone cells from the patient would grow into these spaces and fix the stem in position. The stem was modified slightly to fit more tightly into the femoral canal, resulting in the Anatomic Medullary Locking (AML) stem design. With time, other forms of stem surface treatment and stem geometry have been developed and improved.

Initial hip designs were made of a one-piece femoral component and a one-piece acetabular component. Current designs have a femoral stem and separate head piece. Using an independent head allows the surgeon to adjust leg length (some heads seat more or less onto the stem) and to select from various materials from which the head is formed. A modern acetabulum component is also made up of two parts: a metal shell with a coating for bone attachment and a separate liner. First the shell is placed. Its position can be adjusted, unlike the original cemented cup design which are fixed in place once the cement sets. When proper positioning of the metal shell is obtained, the surgeon may select a liner made from various materials.

To combat loosening caused by polyethylene wear debris, hip manufacturers developed improved and novel materials for the acetabular liners. Ceramic heads mated with regular polyethylene liners or a ceramic liner were the first significant alternative. Metal liners to mate with a metal head were also developed. At the same time these designs were being developed, the problems that caused polyethylene wear were determined and manufacturing of this material improved. Highly-crosslinked UHMWPE was introduced in the late 1990s. The most recent data comparing the various bearing surfaces has shown no clinically significant differences in their performance. Potential early problems with each material are discussed below. Performance data after 20 or 30 years may be needed to demonstrate significant differences in the devices. All newer materials allow use of larger diameter femoral heads. Use of larger heads significantly decreases the chance of the hip dislocating, which remains the greatest complication of the surgery.

To date, when currently available implants are used, there is no demonstrable difference in performance of cemented versus uncemented stems, and no significant difference in the clinical performance of the various methods of surface treatment of uncemented devices. Uncemented stems are selected for patients with good
quality bone that can resist the forces needed to drive the stem in tightly. Cemented devices are typically selected for patients with poor quality bone who are at risk of fracture during stem insertion. Cemented stems are less expensive due to lower manufacturing cost, but require good surgical technique to place them correctly. Uncemented stems can cause pain with activity in up to 20% of patients during the first year after placement as the bone adapts to the device. This is rarely seen with cemented stems.

Once an uncommon operation reserved for frail patients with a limited life expectancy, hip replacement is now common, even among active athletes including race car drivers Bobby Labonte and Dale Jarrett, and British Open runner-up, golfer Tom Watson.

**Indications**

Total hip replacement is most commonly used to treat joint failure caused by osteoarthritis. Other indications include rheumatoid arthritis, avascular necrosis, traumatic arthritis, protrusio acetabuli, certain hip fractures, benign and malignant bone tumors, arthritis associated with Paget's disease, ankylosing spondylitis and juvenile rheumatoid arthritis. The aims of the procedure are pain relief and improvement in hip function. Hip replacement is usually considered only once other therapies, such as physical therapy and pain medications, have failed.

**Techniques**

There are several incisions, defined by their relation to the gluteus medius. The approaches are posterior (Moore), lateral (Hardinge or Liverpool),[3] antero-lateral (Watson-Jones),[4] anterior (Smith-Petersen)[5] and greater trochanter osteotomy. There is no compelling evidence in the literature for any particular approach, but consensus of professional opinion favours either modified anterolateral (Watson-Jones) or posterior approach. [citation needed]

**Posterior approach**

The *posterior (Moore or Southern) approach* accesses the joint and capsule through the back, taking piracy and the short external rotators off the femur. This approach gives excellent access to the acetabulum and femur and preserves the hip abductors and thus minimises the risk of abductor dysfunction post operatively. It has the advantage of becoming a more extensile approach if needed. Critics cite a higher dislocation rate, although repair of the capsule, piriformis and the short external rotators along with use of modern large diameter head balls reduces this risk.

**Lateral approach**

The *lateral approach* is also commonly used for hip replacement. The approach requires elevation of the hip abductors (gluteus medius and gluteus minimus) to access the joint. The abductors may be lifted up by osteotomy of the greater trochanter and reapplying it afterwards using wires (as per Charnley),[citation needed] or may be divided at their tendinous portion, or through the functional tendon (as per Hardinge) and repaired using sutures. Although this approach has a lower dislocation risk than the posterior approach, critics note that occasionally the abductor muscles do not heal back on, leading to pain and weakness which is often very difficult to treat.

**Antero-lateral approach**
The *anterolateral approach* develops the interval between the tensor fasciae latae and the gluteus medius.

**Anterior approach**

The *anterior approach* utilises an interval between the sartorius muscle and tensor fascia latae. Dr. Joel Matta has adapted this approach commonly used for pelvic fracture repair surgery in conjunction with a traction table for use when performing hip replacement. When used with older hip implant systems that had a small diameter head, dislocation rates were reduced compared to surgery performed through a posterior approach. With modern implant designs, dislocation rates are similar regardless of the approach and probably more a function of surgeon experience. There is a 10% rate of numbness in the thigh following this approach due to injury to the lateral femoral cutaneous nerve.

**Minimally invasive approach**

The double incision surgery and minimally invasive surgery seeks to reduce soft tissue damage through reducing the size of the incision. However, component positioning accuracy and visualization of the bone structures is significantly impaired. This can result in unintended fractures and soft tissue injury. Surgeons using these approaches are advised to use intraoperative x-ray fluoroscopy or computer guidance systems.[citation needed]

Computer Assisted Surgery techniques are also available to guide the surgeon to provide enhanced accuracy. Several commercial CAS systems are available for use worldwide. HipNav was the first system developed specifically for total hip replacement, and included navigation and preoperative planning based on a preoperative CT scan of the patient. Improved patient outcomes and reduced complications have not been demonstrated when these systems are used when compared to standard techniques.

**Implants**

The prosthetic implant used in hip replacement consist of different parts, the acetabular cup, the femoral component and the articular interface. Options exist for different patients and indications. Correct selection of the prosthesis is important.

**Acetabular Cup**

The Acetabular cup is the component which is placed into the acetabulum (hip socket). Cartilage and bone are removed from the acetabulum and the acetabular cup is attached using friction or cement. Some acetabular cups are one piece, while others are modular. One piece (monobloc) shells are either polyethylene or metal, they have their articular surface machined on the inside surface of the cup and do not rely on a locking mechanism to hold a liner in place. A monobloc polyethylene cup is cemented in place while a metal cup is held in place by a metal coating on the outside of the cup. Modular cups consist of two pieces, a shell and liner. The shell is made of metal, the outside has a porous coating while the inside contains a locking mechanism designed to accept a liner. Two types of porous coating used to form a friction fit are sintered beads or a foam metal design to mimic the trabeculae of cancellous bone. Additional fixation is achieved as bone grows onto or into the porous coating. Screws can be used to lag the shell to the bone.
Femoral Component

The femoral component is the component that fits in the femur (thigh bone). Bone is removed and the femur is shaped to accept the femoral stem with attached prosthetic femoral head (ball). There are two types of fixation: cemented and uncemented. Cemented stems use acrylic bone cement to form a mantle between the stem and to the bone. Uncemented stems use friction, shape and surface coatings to stimulate bone to remodel and bond to the implant. Stems are made of multiple materials (titanium, cobalt chromium and stainless steel) and they can be monolithic or modular. Modular components consist of different head dimensions and/or modular neck orientations; these attach via a taper similar to a Morse taper. These options allow for variability in leg length, offset and version. Femoral heads are made of metal or ceramic material. Metal heads, made of cobalt chromium for hardness, are machined to size and then polished to reduce wear of the socket liner. Ceramic heads are more smooth than polished metal heads, have a lower coefficient of friction than a cobalt chrome head, and in theory will wear down the socket liner more slowly. As of early 2011, follow up studies in patients have not demonstrated significant reductions in wear rates between the various types of femoral heads on the market. Ceramic implants are more brittle and may break after being implanted.

Articular Interface

The articular interface is not actually part of the either implant, rather it is the area between the acetabular cup and femoral component. The articular interface of the hip is a simple ball and socket joint. Size, material properties and machining tolerances at the articular interface can be selected based on patient demand to optimise implant function and longevity whilst mitigating associated risks. The interface size is measured by the outside diameter of the head or the inside diameter of the socket. Common sizes of femoral heads are 28 mm, 32 mm and 36 mm. While a 22.25 mm was common in the first modern prostheses, now even larger sizes are available 38–54+. Larger diameter heads lead to increased stability and range of motion whilst lowering the risk of dislocation. At the same time they are also subject to higher stresses such as friction and inertia. Different combinations of materials have different physical properties which can be coupled to reduce the amount of wear debris generated by friction. Typical pairings of materials include metal on polyethylene (MOP), metal on crosslinked polyethylene (MOXP), ceramic on ceramic (COC), ceramic on crosslinked polyethylene (COXP) and metal on metal (MOM). Each combination has different advantages and disadvantages.

Risks and complications

Risks and complications in hip replacement are similar to those associated with all joint replacements. They can include dislocation, loosening, impingement, infection, osteolysis, metal sensitivity, nerve palsy, pain and death.

Dislocation

Dislocation is the most common complication of hip replacement surgery. At surgery the femoral head is taken out of the socket, hip implants are placed and the hip put back into proper position. It takes eight to twelve weeks for the soft tissues injured or cut during surgery to heal. During this period, the hip ball can come out of the socket. The chance of this is diminished if less tissue is cut, if the tissue cut is repaired and if large diameter head balls are used. Surgeons who perform more of the operations each year tend to have fewer patients dislocate. Doing the surgery from an anterior approach seems to lower dislocation rates when small diameter
Dislocated artificial hip

Osteolysis

Many long term problems with hip replacements are the result of osteolysis. This is the loss of bone caused by the body's reaction to polyethylene wear debris, fine bits of plastic that come off the cup liner over time. An inflammatory process causes bone resorption that may lead to subsequent loosening of the hip implants and even fractures in the bone around the implants. In an attempt to eliminate the generation of wear particles, ceramic bearing surfaces are being used in the hope that they will have less wear and less osteolysis with better long term results. Metal cup liners joined with metal heads (metal-on-metal hip arthroplasty) were also developed for similar reasons. In the lab these show excellent wear characteristics and benefit from a different mode of lubrication. At the same time that these two bearing surfaces were being developed, highly cross linked polyethylene plastic liners were also developed. The greater cross linking significantly reduces the amount of plastic wear debris given off over time. The newer ceramic and metal prostheses do not always have the long term track record of established metal on poly bearings. Ceramic pieces can break leading to catastrophic failure. This occurs in about 2% of the implants placed. They may also cause an audible, high pitched squeaking noise with activity. Metal-on-metal arthroplasty releases metal debris into the body raising concerns about the potential dangers of these accumulating over time. Highly cross linked polyethylene is not as strong as regular polyethylene. These plastic liners can crack or break free of the metal shell that holds them.

Metal sensitivity

Concerns are being raised about the metal sensitivity and potential dangers of metal particulate debris. New publications\[6\][7] that have demonstrated development of pseudotumors, soft tissue masses containing necrotic tissue, around the hip joint. It appears these masses are more common in women and these patients show a higher level of iron in the blood. The cause is unknown and is probably multifactorial. There may be a toxic reaction to an excess of particulate metal wear debris or a hypersensitivity reaction to a normal amount of metal debris.

Metal hypersensitivity is a well-established phenomenon and is common, affecting about 10–15% of the population.\[8\] Contact with metals can cause immune reactions such as skin hives, eczema, redness and itching. Although little is known about the short and long term pharmacodynamics and bioavailability of circulating metal degradation products in vivo, there have been many reports of immunologic type responses temporally associated with implantation of metal components. Individual case reports link hypersensitivity immune
reactions with adverse performance of metallic clinical cardiovascular, orthopedic and plastic surgical and dental implants.[9]

**Metal toxicity**

Most hip replacements consist of cobalt and chromium alloys, or titanium. Stainless steel is no longer used. All implants release their constituent ions into the blood. Typically these are excreted in the urine, but in certain individuals the ions can accumulate in the body. In implants which involve metal-on-metal contact, microscopic fragments of cobalt and chromium can be absorbed into the patient's bloodstream. There are reports of cobalt toxicity with hip replacement patients.[10][11]

**Metal-on-metal hip implant failure rate**

By 2010, reports in the orthopaedic literature have increasingly cited the problem of early failure of metal on metal prostheses in a small percentage of patients.[12] Failures may relate to release of minute metallic particles or metal ions from wear of the implants, causing pain and disability severe enough to require revision surgery in 1–3% of patients.[13] Design deficits of some prosthesis models, especially with heat-treated alloys and a lack of special surgical experience accounts for most of the failures. Surgeons at leading medical centers such as the Mayo Clinic have reported reducing their use of metal-on-metal implants by 80 percent over the last year in favor of those made from other materials, like combinations of metal and plastic.[14] The cause of these failures remain controversial, and may include both design factors, technique factors, and factors related to patient immune responses (allergy type reactions). In the United Kingdom the Medicines and Healthcare products Regulatory Agency commenced an annual monitoring regime for metal-on-metal hip replacement patients from May 2010.[15] Data which is shown in The Australian Orthopaedic Association's 2008 National Joint Replacement Registry, a record of nearly every hip implanted in that country over the previous 10 years, tracked 6,773 BHR (Birmingham Hip Resurfacing) Hips and found that less than one-third of one percent may have been revised due to the patient's reaction to the metal component.[16] Other similar metal-on-metal designs have not fared as well, where some reports show 76% to 100% of the people with these metal-on-metal implants and have aseptic implant failures requiring revision also have evidence of histological inflammation accompanied by extensive lymphocyte infiltrates, characteristic of delayed type hypersensitivity responses.[17] It is not clear to what extent this phenomenon negatively affects orthopedic patients. However for patients presenting with signs of an allergic reactions, evaluation for sensitivity should be conducted. Removal of the device that is not needed should be considered, since removal may alleviate the symptoms. Patients who have allergic reactions to cheap jewelry are more likely to have reactions to orthopedic implants. There is increasing awareness of the phenomenon of metal sensitivity and many surgeons now take this into account when planning which implant is optimal for each patient.

On March 12, 2012, *The Lancet* published a study, based on data from the National Joint Registry of England and Wales, finding that metal-on-metal hip implants failed at much greater rates than other types of hip implants and calling for a ban on all metal-on-metal hips.[18] The analysis of 402,051 hip replacements showed that 6.2% of metal-on-metal hip implants had failed within five years, compared to 1.7% of metal-on-plastic and 2.3% of ceramic-on-ceramic hip implants. Each 1mm increase in head size of metal-on-metal hip implants was associated with a 2% increase of failure.[19] Surgeons of the British Hip Society are recommending that large head metal-on-metal implants should no longer be performed.[20]

On February 10, 2011, the U.S. FDA issued a patient advisory on metal-metal hip implants, stating it was continuing to gather and review all available information about metal-on-metal hip systems.[21] On June 27–28 2012, an advisory panel will meet to decide whether to impose new standards, taking into account the *The*
Lancet findings.[11][22]

Nerve palsy

Post operative sciatic nerve palsy is another possible complication. The incidence of this complication is low. Femoral nerve palsy is another but much more rare complication. Both of these will typically resolve over time, but the healing process is slow. Patients with pre-existing nerve injury are at greater risk of experiencing this complication and are also slower to recover.

Chronic pain

A few patients who have had a hip replacement suffer chronic pain after the surgery. Groin pain can develop if the muscle that raises the hip (iliopsoas) rubs against the edge of the acetabular cup. Bursitis can develop at the trochanter where a surgical scar crosses the bone, or if the femoral component used pushes the leg out to the side too far. Also some patients can experience pain in cold or damp weather. Incision made in the front of the hip (anterior approach) can cut a nerve running down the thigh leading to numbness in the thigh and occasionally chronic pain at the point where the nerve was cut (a neuroma).

Death

Rates of death for elective hip replacements are much less than 1%. [23][24]

Leg length inequality

The leg can be lengthened or shortened during surgery. Unequal legs are the most common complaint by patients after surgery with over lengthening the most common problem. Sometimes the leg seems long immediately after surgery when in fact both are equal length. An arthritic hip can develop contractures that make the leg behave as if it is short. When these are relieved with replacement surgery and normal motion and function are restored, the body feels that the limb is now longer than it was. If the legs are truly equal, the sense of inequality resolves within a month or two of surgery. If the leg is unequal, it will not. A shoe lift for the short leg, or in extreme cases, a corrective operation may be needed.

True leg length inequality may sometimes be caused by improper implant selection. The femoral component may be too large and stick out of the femur further than needed. The head ball selected may sit too proud on the stem. Stiffness in the lower back from arthritis or previous fusion surgery seems to magnify the perception of leg length inequality.

Alternatives and variations of hip replacement

Conservative management

The first line approach as an alternative to hip replacement is conservative management which involves a multimodal approach of medication, activity modification and physical therapy.[25] Conservative management can prevent or delay the need for hip replacement.

Hemiarthroplasty

Hemiarthroplasty is a surgical procedure which replaces one half of the joint with an artificial surface and
leaves the other part in its natural (pre-operative) state. This class of procedure is most commonly performed on
the hip after a subcapital (just below the head) fracture the neck of the femur (a hip fracture). The procedure is
performed by removing the head of the femur and replacing it with a metal or composite prosthesis. The most
commonly used prosthesis designs are the Austin Moore prosthesis and the Thompson Prosthesis. More recently
a composite of metal and HDPE which forms two interphases (bipolar prosthesis) has also been used. The
bipolar prosthesis has not been shown to have any advantage over monopolar designs. The procedure is
recommended only for elderly and frail patients, due to their lower life expectancy and activity level. This is
because with the passage of time the prosthesis tends to loosen or to erode the acetabulum.[26]

**Hip resurfacing**

Hip resurfacing is an alternative to hip replacement surgery. It has been used in Europe for over 17 years and
become a common procedure.

**Viscosupplementation**

Current alternatives also include viscosupplementation, or the injection of artificial lubricants into the joint.[27]
Use of these medications in the hip is off label. The cost of treatment is typically not covered by health
insurance organizations.

Some believe that the future of osteoarthritis treatment is bioengineering, targeting the growth and/or repair of
the damaged, arthritic joint. Centeno et al. have reported on the partial regeneration of an arthritic human hip
joint using mesenchymal stem cells in one patient.[28] It is yet to be shown that this result will apply to a larger
group of patients and result in significant benefits. The FDA has stated that this procedure is being practiced
without conforming to regulations, but Centeno claims that it is exempt from FDA regulation. It has not been
shown in controlled clinical trials to be effective, and costs over $7,000.

**See also**

- Hip examination
- 2010 DePuy Hip Recall
- Femoral Acetabular Impingement
- Abductor wedge

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External links

- Edheads Virtual Hip Surgery + Surgery Photos (http://www.edheads.org/activities/hip/)


Categories: Implants | Pelvis | Prosthetics | Orthopedic surgery

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