Hip: Type of Prosthesis and Implantation Technique

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10.1 Hip Arthroplasty

Hip replacements are among the most common orthopedic procedures.

When a total hip replacement is performed, the arthritic damaged hip joint is removed. The ball-and-socket hip joint is then replaced with an artificial implant.

A total hip replacementimplant has three parts: the stem, which fits into the femur; the ball, which replaces the spherical head of the femur; and the cup, which replaces the worn out hip socket. Each part comes in various sizes to accommodate various body sizes and types (Fig. 10.1).

At present, there is a wide range of prostheses with different new types of articulations such as metal on metal and ceramic on ceramic instead of metal on polyethylene, based on new scientific research and availability of improved metal alloys, which may reduce the wear up to 1/4,000.

The use of exchangeable neck/ball (modular prosthesis) in primary as well as revision surgery has enhanced the surgeons amatory to create a stable prosthesis in most conditions and facilitates future revision surgery.

In some designs, the stem and ball are one piece; other designs are modular, allowing for additional customization in fit.

The stem could be implanted with cemented or uncemented technique.

Over the past 40 years, there have been many improvements in the materials and the methods used to hold the femoral in place. Today, the most common used bone cement is an acrylic polymer called polymethylmethacrylate.

From 1980s, new implant designs were introduced to attach directly to bone without the use of cement. In general, these designs are larger and longer than those used with cement.

From the results of Implants National Registries, it seems to be that the uncemented technique is more indicated for younger patients. However, final decision regarding implant selection should be based on the quality and anatomy of the patient's bone as well as on expected functional demands and expected life span of the patient.

All these issues have an impact on the choice of component fixation and, above all, on the choice of bearing surfaces.

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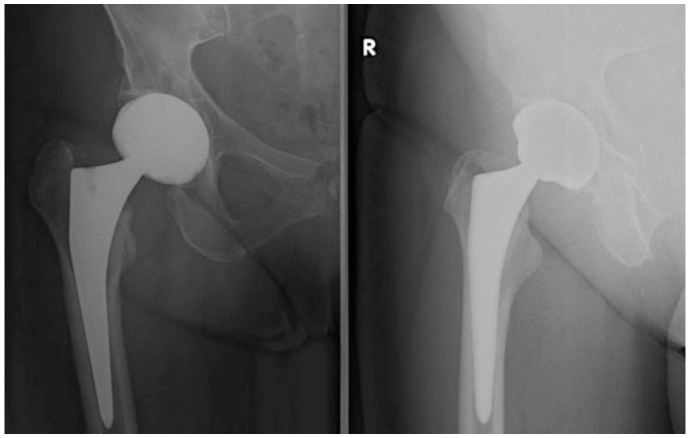

Fig. 10.1 Hip arthroplasty

The patient's bone type/quality, the presence of bone loss on the acetabular or the femoral side as well as the presence of shortening or deformity are all factors that may influence the final decision to opt for cemented or cementless fixation and to determine whether additional augmentation or bone grafting will be required. Several rating systems for bone quality have been reported. The Dorr classification (Fig. 10.2) has the advantage of simplicity and reproducibility and is of practical value in the clinical setting. According to this system, cemented femoral components are often advocated for Type C bone. Severe osteoporosis is associated with increased risk of intraoperative fracture, both femoral and acetabular, necessitating great care in the preparation and insertion of the components. In this setting, the bone quality may be such that the use of cemented component(s) may be preferable to achieve a stable and durable construct.

In the instance of THA after previous proximal femoral fracture or osteotomy where the hardware has been removed, the most distal screw hole should ideally be bypassed by at least two and a half times the diameter of the bone at that level to reduce the risk of periprosthetic fracture. This may then require that a revision-type long-stem femoral component be used in the primary setting.

Developmental dysplasia of the hip poses additional technical challenges. This is particularly seen in Crowe Types III and IV hips in which augmented acetabular reconstruction using metal and/or structural bone graft may be required. In addition, distortion of the femoral anatomy may require the use of either a fully modular femoral component to allow for correction of excessive femoral neck anteversion or even potentially a custom femoral component.

The tribology of materials is the main role in the follow-up of long-term implants. In recent years, technology has led to strong developments in this surgery developing more resistant materials and then determining a lower failure rate.

Nowadays, the aseptic loosening, normally due to the implants' wear, represents more than 75 % of the failures in prosthetic surgery of the hip.

The coupling materials available are as follows:

10.2 Metal on Metal

These are fabricated from a harder cobalt–chromium alloy and thus consist of a metal-on-metal couple. This new combination creates a differential hardness between the two moving parts. This differential hardness determines that the metal is likely to release less particles into the body and wear less over time. In all hip prostheses, the femoral head wears quicker than the acetabular shell (except the metal-on-polyethylene ones (hard-on-soft)). The difference in hardness is a major advantage over the previous

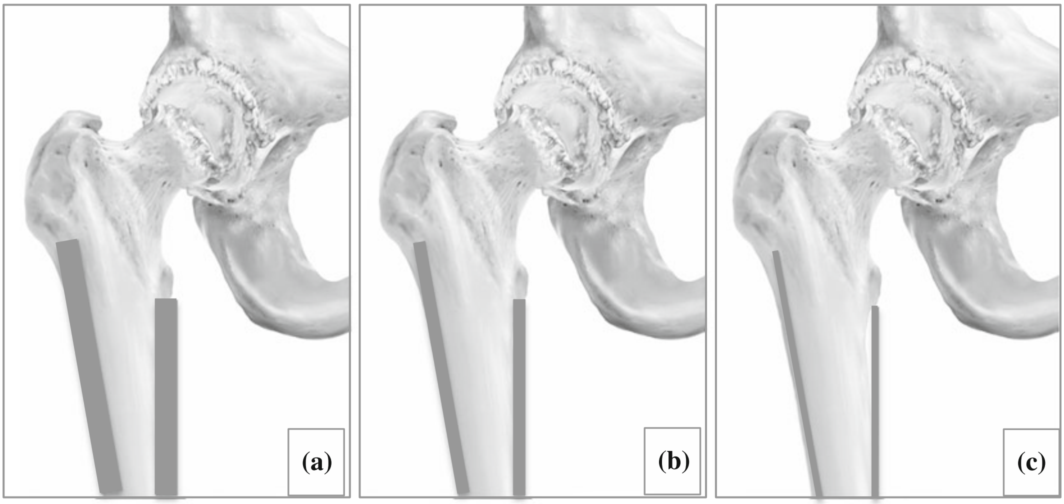

Fig. 10.2 Dorrr femoral bone classification. *Type A narrow canal* with thick cortical walls (champagne flute canal). *Type B* moderate cortical walls. *Type C wide canal* with thin cortical walls (stove-pipe canal)

metal-on-metal prostheses and even more over the metal-on-polyethylene prostheses.

The metal-on-metal bearings are hard without being brittle and they are more resistant to scratching and wearing. There is a debate on the effect of metal ions released by the couple; the potential effect of these ions is not clear yet, but research is being done on that subject.

10.3 Ceramic on Ceramic

Ceramic-on-ceramic (COC) has been an excellent alternative bearing surface for total hip arthroplasties (THA) in young, high-demand patients with end-stage arthritis of the hip.

Ceramic material has been used for THA in Europe for 40 years with variable results.

Hamadouche et al. described minimal wear, a low rate of complications and limited osteolysis with COC THA after 18.5 years of follow-up. On the other hand, the revision rate in Europe and the USA from 1988 till 1996 varied between 3 and 44 %.

Subsequently, new generations of C–o–C BIOLOX-delta bearings were developed, eliminating this risk and presenting the superior tribological properties of ceramics.

As it is demonstrated, the reinforcing mechanism is fully activated within a region of a few micrometers. For the macroscopic performance of the material, it is very important that immediately at the beginning of crack initiation, the reinforcing mechanisms are also activated. Regarding this mechanism, one should keep in mind that the average distance between the reinforcing zirconia particles is approx. 0.3 mm, i.e., similar to the grain size. Thus, the reinforcement is activated immediately when any microcrack is initiated. This is of particular interest for the significant advantage of ZTA (BIOLOX®delta) under severe wear conditions.

10.4 Ceramic–Metal on Polyethylene

Polyethylene acetabular cups coupled with metal or ceramic femoral heads remain the most popular bearing combination in the hip. In the long term, the polyethylene cups wear and the micron and submicron wear particles result in osteolysis and loosening. Particles accumulate in periprosthetic tissues until a critical volume and concentration is reached, which results in osteolysis. Patients have different levels of reactivity to polyethylene particles and particle concentrations in tissues are dependent on access. It is important to reduce polyethylene wear rate in order to extend the osteolysis-free lifetime.

10.5 Hip Resurfacing

Increasing number of total hip replacements in young patients in recent years is accompanied by an increased number of revision operations due to excessive wear of the polyethylene in the young active patient, leading to osteolysis and loosening of the prosthesis. For this reason, there has been extensive research to find alternative bearings with better wear properties to cope with this tremendous devastating problem.

In conventional hip replacement surgery, the femoral head and a portion of the femoral neck are completely removed and replaced with a stemmed prosthesis, which is inserted into the medullary canal of the upper femur.

Hip resurfacing procedure shapes the femoral head and recaps it with a metal surface replacement. This preserved the normal bone of the upper femur and allows normal mechanics and weight-bearing loads across this area. Normal load forces through the bone of the upper femur keep the bone healthy and strong. The acetabulum of the hip joint is also resurfaced.

Surface hip arthroplasty (Fig. 10.3) has become more important in treating younger patients for osteoarthritis in the new century.

The resurfacing technique in the past, namely the Teflon prosthesis of Charnley and metal-on-polyethylene prosthesis of Wagner or Tharies prosthesis, is based on failure of the design and material properties of the implants, rather than failure of the resurfacing concept.

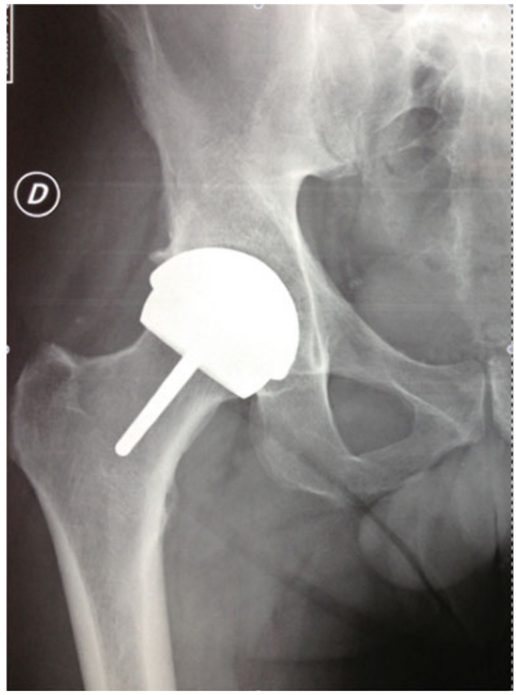

Fig. 10.3 Hip resurfacing

Due to a perfect operation technique, an up-to-date knowledge and fabrication of metal-on-metal articulations, the resurfacing technique is doing extremely well with clinical and radiological follow-up for more than 10 years.

The overall results were consistent with data produced from registry and high specialization centers in that the clinical outcome of large male patients was extremely encouraging, whereas the survival of the smaller joints was less satisfactory.

10.6 Hip Revision

Hip revision surgery, which is also known as revision total hip arthroplasty, is a procedure in which the surgeon removes a previously

Fig. 10.4 Hip revision arthroplasty

implanted artificial hip joint, or prosthesis, and replaces it with a new prosthesis. Hip revision surgery may also involve the use of bone grafts. The bone graft may be an autograft, which means that the bone is taken from another site in the patient's own body, or an allograft, which means that the bone tissue comes from another donor (Fig. 10.4).

Hip revision surgery has three major purposes: relieving pain in the affected hip, restoring the patient's mobility, and removing a loose or damaged prosthesis before irreversible harm is done to the joint. Hip prostheses that contain parts made of polyethylene typically become loose because wear and tear on the prosthesis gradually produces tiny particles from the plastic that irritate the soft tissue around the prosthesis. The inflamed tissue begins to dissolve the underlying bone in a process known as osteolysis. Eventually, the soft tissue expands around the prosthesis to the point at which the prosthesis loses contact with the bone.

In general, a surgeon will consider revision surgery for pain relief only when more conservative measures, such as medication and changes in the patient's lifestyle, have not helped. In some cases, revision surgery is performed when X-ray studies show loosening of the prosthesis, wearing of the surfaces of the hip joint, or loss of bone tissue even though the patient may not have experienced any discomfort. In most cases, however, increasing pain in the affected hip is one of the first indications that revision surgery is necessary.

Other less common reasons for hip revision surgery include fracture of the hip, the presence of infection, or dislocation of the prosthesis. In these cases, the prosthesis must be removed in order to prevent long-term damage.

10.7 Approach to the Hip Joint

The hip joint can be approached in many ways, and therefore, many different exposures have been described. There are advantages and disadvantages to each, and there is a great deal of controversy among hip surgeons as to which is the "best." All surgeons have a favored surgical approach, and it is a testament to the success of the procedure that all of them generally produce good results.

Surgical approaches to the hip joint can be classified in many ways. One simple classification is based on the direction of approach. The common approaches used based on this classification are the anterior, direct lateral, and posterior.

10.8 Anterior Approach (Heuter)

The first hip arthroplasty performed through this approach was by Robert Judet in 1947. Judet referred to the surgical approach as the "Heuter Approach" referring to Heuter Volkmann and the approach for drainage of a tuberculosis hip abscess. The reasons for Judet's choice of this approach for hip arthroplasty are several: (1) The hip is an anterior joint, closer to the skin anterior than posterior. (2) The approach follows the anatomic interval between the zones of enervation of the superior and inferior gluteal nerves lateral and the femoral nerve medial. (3) The approach exposes the hip without detachment of muscle from the bone.

Position The patient is placed supine on a standard operating table or on a Trauma Judet Table.

Technique The skin incision begins 2 cm below the anterior–superior iliac spine and extends distally for approximately 8 cm in a linear fashion between the tensor fascia lata and the Sartorius. This interval can be identified by palpation. The subcutaneous tissue is reflected to the level of the fascia. The Sartorius and tensor fascia lata muscles are identified and the fascia investing these two muscles is split longitudinally. Splitting the anterior fibers of tensor muscle helps protect against injury to the lateral femoral cutaneous nerve. The tensor is separated from the Sartorius by sharp and blunt dissection. The Sartorius is reflected medially, the tensor laterally. Further exposure is straightforward and is usually done by palpating the femoral head and exposing the capsule by blunt dissection. The ascending branch of the lateral circumflex artery and vein do cross the field and must be ligated or cauterized. At the level of the hip joint, the gluteus medius and tensor fascia are further reflected laterally. The attachment of the reflected head of the rectus femoris is observed at the superior aspect of the acetabulum and must be incised. Excising the anterior capsule the hip joint is accessed.

Internervous plane Lies between the Sartorius (femoral nerve) and the tensor fasciae lata (superior gluteal nerve).

Dislocation Extension and external rotation of the hip.

Closure Suturing of the subcutaneous tissue and the skin.

Advantages Preservation of the vascularity, stability following the procedure with less chance of dislocation and good access to the acetabulum are the key advantages of this approach. The approach limits muscle cutting and separation, the extensors and the abductors are kept intact along with the medial circumflex femoral artery and its branches.

Disadvantages The main limitation of this approach is the limited access to the proximal femur. Some encourage using a fracture table to get a better approach to the femur. Injury to lateral cutaneous nerve can occur.

10.9 Direct Lateral Approach (Hardinge)

Direct lateral approach also called as the trans-gluteal approach initially described by first described by McFarland and Osborne in 1954, popularized by Hardinge in the modern age gives good exposure to the hip joint preserving most of gluteus medius minimus and vastus lateralis, and the vascularity. It exposes the femur well with good access to the joint.

Position The patient is placed and supported in the lateral decubitus position; however, the supine position with the greater trochanter lying over the edge of the table is also acceptable.

Technique The skin incision is centered over the greater trochanter and extends approximately 6–8 cm distally along the anterior aspect of the trochanter and down the anterior lateral aspect of the femoral shaft. Proximally, the skin incision extends 6–8 cm in line with the fibers of the gluteus maximus muscle. The iliotibial band is entered and split distally, and the gluteus maximus muscle is split proximally. The gluteus maximus is retracted posteriorly and the tensor fascia lata retracted anteriorly. The deep exposure begins at the anterior margin of the trochanter and extends distally to include the anterior third of the vastus lateralis muscle. Proximally, the incision extends about 4–5 cm past the trochanteric tip and splits the gluteus medius musculature in line with its fibers separating its anterior one-third from the posterior two-thirds. Splitting the gluteus medius muscle more than about 4–5 cm proximal to the tip of the trochanter should be avoided as it may injure the superior gluteal nerve. The interval is developed by subperiosteally releasing the antero-oblique fibers of the gluteus medius from the trochanter in line with the remaining anterior fibers of the more proximally fan-shaped portion of the medius musculature. The anterior third of the vastus lateralis muscle is elevated from the trochanter and proximal femur for a distance of about 5–7 cm. The sleeve of tissue containing this portion of the abductors and the vastus lateralis is then reflected anteriorly and retracted with a narrow Hohmann retractor. This allows ready access to the anterior capsule. The gluteus minimus muscle is detached from the trochanter beginning anteriorly and separated from the capsule to the extent needed for adequate exposure. A curved Hohmann retractor placed over the femoral neck facilitates retraction of the medius and minimus musculature. The capsule is excised anteriorly, placed over the femoral neck, and further release of the lateral and inferior aspect of the capsule is performed as needed.

Internervous plane As the gluteus medius tendon and muscle fibers and the vastus lateralis muscles are split, there is no true internervous plane. However, it is important are split protect the superior gluteal nerve by making the incision distal to the point which it enters the muscle.

Dislocation The hip is dislocated by external rotation and flexion. For this exposure, the leg may be placed in a sterile pocket anteriorly to prepare the femoral canal.

Closure Gluteus minimus is reattached to its insertion. Gluteus medius is closed with a series of interrupted sutures, as is vastus lateralis. The deep fascia and the iliotibial tract are closed similarly.

Advantages This approach gives good access to the hip and yet preserves vascularity, minimizes risk of damage to sciatic nerve, and has low dislocation rates.

Disadvantages There can be damage to gluteal muscle mainly medius, which increase recovery time. Heterotopic ossification may also be a problem.

10.10 Posterior Approach (Moore)

This is the most popular approach for total hip replacement in the USA. The common feature of posterior exposures is the release of the short rotators. Variation is introduced by the manner of developing the exposure dealing with the gluteus maximus muscle and the iliotibial track. The repair of the rotators with capsule is also variably described.

Position The patient is placed and supported in the lateral decubitus position.

Technique The skin incision is along the posterior to the lateral side of the greater trochanter and carried distally about 6 cm along the femoral axis. Proximally, the incision runs slightly curved toward the posterior superior iliac spine (PSIS) to a point approximately 6 cm proximal to the greater trochanter. The fascia lata is incised, and the gluteus maximus fibers are divided by blunt dissection. Retraction of the proximal part of gluteus maximus exposes the greater trochanter, and the overlying trochanteric bursa is either incised or partially excised. Retraction of the posterior fibers of gluteus maximus posteriorly exposes the short external rotators of the hip. The short external rotators are then divided. Piriformis is cut through its tendon lateral to the stay suture. Obturator internus and the gemelli may be divided adjacent to the trochanter if the head and neck are to be sacrificed, as in hip arthroplasty. If this is not the case, divide them 1 cm from their trochanteric insertion in order to preserve the posterior circumflex artery. Internal rotation of the hip facilitates identification and division of the rotators because it stretches them. Elevation and retraction of the short external rotators expose the posterior part of the capsule and the posterior surface of the acetabulum. The posterior part of the joint capsule is incised.

Internervous plane As the gluteus maximus is split through the fibers rather than between muscle planes, it is difficult to find a true internervous plane. However, as the nerve enters, the muscle medial to the split the muscle denervation is unlikely.

Dislocation The hip is dislocated by flexion, adduction, and internal rotation.

Closure At the end of the procedure, the posterior capsular flap is sutured, and then, the external rotators tendons are reinserted to their anatomic insertion on the posterior greater trochanter. A secure repair of the tendons and capsule decreases the risk of hip prosthesis dislocation after a posterior approach.

Advantages This approach provides excellent exposure to both acetabulum and the femoral head and neck, making it easier to surgical procedures well. The approach limits muscle cutting and separation, and the medius and minimus gluteus muscles are kept intact and patients have fast recovery after operation.

Disadvantages The main disadvantage in the past was high rate of dislocations; this problem is seen less nowadays with the use of large diameter femoral heads and with a correct positioning of the acetabular component. Other documented complications seen are damaged to sciatic nerve, which could be either stretching which recover usually, or permanent damage, which will result in a foot drop and damage to inferior gluteal vessels, branches of profunda femoris vessels and rarely femoral vessels, which can lead to blood loss.

10.11 Preoperative Imaging

Plain radiographs are the first-choice modality in the diagnosis of hip arthritis.

The radiographic exam includes an AP pelvic and a lateral view; different lateral views include cross-table lateral, a frog-leg lateral, and a false profile view.

Although in more complex cases of arthritis, secondary to dysplasia, Perthes disease, and slipped capital epiphysiolysis, where hip's anatomy is severely altered, CT and MR imaging are more sensitive imaging methods for the diagnosis of synovitis and/or joint effusion and for the detection of bone marrow edema, erosions, subchondral cysts, and cartilage destruction. Moreover, in some cases, bone scan can be used as additional tool to preoperative planning is an essential step that helps the surgeon to execute a successful operation. The correct placement of both acetabular and femoral components is critical for the optimal functioning of the bearings. For this reason, preoperative templating is an essential tool of a successful hip arthroplasty. It is performed on antero-posterior radiographs of pelvis, which should be taken with the femur rotated internally to reduce the effect of femoral anteversion.

The socket template is positioned first to establish the center of rotation of the reconstruction. For femoral templating, it should be considered both the part inside the bone (the size of the component), and both the part outside the bone, which sets limb length and biomechanical parameters such as the abductor muscle and joint reaction forces. Medializing the hip center of rotation and increasing the horizontal femoral offset can improve clinical outcomes and reduce wear. Modern modular systems allow limb length adjustment and biomechanical improvement for a range of patients.

In the last decades, computed systems have been developed to perform preoperative templating in order to provide a more accurate and easier measurements.

10.12 Imaging in the Follow-up

Despite the increasing popularity of modern imaging techniques such as ultrasound scanning (USS) and MRI, radiography remains the primary imaging method for the regular postoperative evaluation of hip arthroplasty. The zones described by Gruen et al. are among the most quoted assessment tools in conventional total hip arthroplasty (THA). However, the introduction of hip resurfacing arthroplasty (HRA) with metal-on-metal bearings requires a new radiographic evaluation protocol in order to assess the components and surrounding structures. The use of plain hip radiographs in the clinical evaluation of hip arthroplasty has been doubted by some authors due to the limitation of radiography in identifying soft tissue pathology.

However, the importance of radiography in the clinical setting is yet to be investigated.

The radiographic evaluation of the non-cemented acetabular component in HRA is similar to those described for THA. However, the femoral component requires different evaluation criteria to those used to describe a standard THA because there is no component in the femoral canal and the metallic femoral implant overlies, and hence obscures, the junctions between bone cement and cement prosthesis. Lucencies around the short metaphyseal HRA femoral stem can be described as defined by Amstutz et al. The authors divided the femoral zonal system into 3 PEG zones, which correspond to superior, tip and inferior zones around the metaphyseal femoral stem.

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