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The Evolution of Total Hip Arthroplasty (THA)

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Abstract

Introduction

The evolution of Total Hip Arthroplasty (THA) has been dramatic and relentless in the last century. Hip Arthroplasty started as a very simple rudimentary idea of excising the hip joint (excision Arthroplasty), through fusion of the hip, to actual replacement of the joint surfaces with various artificial substances ranging from pig’s bladder, glass, plastic, ivory, ceramic polyethylene (PE) and more recently to metal-on-metal hip replacement. Osteoarthritis of the hip is one of the commonest indications for Total Hip Arthroplasty (THA). Other indications include inflammatory arthritides such as rheumatoid arthritis, avascular necrosis (AVN) of the femoral head, developmental dysplasia (DDH), Perthes’ disease, malignancy, Paget’s disease, as well as femoral neck fractures.

Discussion

THA has become one of the most common operations performed in elective orthopaedic theatres worldwide, because it is a very versatile and satisfying surgical procedure with excellent outcomes in most cases. However, several complications have been observed following THA, which may be linked to the surgical technique, implant, or patient factors. This has led to recent refinements and improvements in the prosthetic implants and equipment used, in addition to the introduction of minimally invasive (MI) and computer-aided (CA) THA, with the aim of increasing the accuracy of implant placement and reducing the risk of complications as well as subsequent failure of the prostheses. However, these new techniques and devices are very expensive and so increase the overall cost of surgery. In addition to that, the long term effects and outcomes of these new techniques and implants are yet to be fully determined, and so more time will be required to carry out further studies in the future.
Introduction

Total Hip Arthroplasty (THA) is one of the most common procedures performed on Orthopaedic elective lists, and is considered to be one of the best medical innovations of our generation\(^1\). The concept of hip Arthroplasty started as a very simple rudimentary idea of excising the hip joint (excision Arthroplasty), through to fusion of the hip, to actual replacement of the joint surfaces with various artificial substances ranging from glass, plastic, pig’s bladder, ivory, ceramic polyethylene (PE) and more recently to actual metal-on-metal hip replacement. There has been a dramatic rise in experimentation with these various elements as a result of the growing human population and the increased diagnosis of arthritides and other hip pathologies, with sometimes disastrous consequences for the patient\(^2\). In addition to that, there is also a recent growing increase in arthroplasties for hip fractures in fit elderly people, in many developed countries like the UK as a result of the NICE (National Institute for Clinical Excellence) guidelines and increased quality of life among the growing elderly population\(^3\).

However, there is a lot of knowledge and good evidence which has emanated from the recent improvement in the techniques and implants used for THA, which provided very good results and outcomes, as well as changing the life of many individuals afflicted with various types of arthritis. Hip replacement has been acclaimed to be a very satisfying operation for patients, with very good long term outcomes in many cases, but new problems and challenges are being constantly observed in many hip registries, as a result of the longevity of the prosthetic implants and the improved quality of healthcare in many developed countries; which leads to increased life expectancy of the individuals; therefore giving more time for the implants to last and perhaps reveal their weaknesses\(^4\).

Historical background

Anthony White (1782-1849) of the London Westminster Hospital, is believed to have performed the first excision arthroplasty of the hip in 1821, but did not make a personal presentation of this procedure (White, 1849)\(^5\). Subsequently, Henry Park (1744-1831), who worked in the Liverpool Royal Infirmary; was among the first surgeons to practice and popularise excision arthroplasty of the hip joint towards the end of the 18\(^{th}\) Century and the
beginning of the 19th century (Park, 1782)⁶. However, John Rhea Barton (1794-1891) in Philadelphia USA, was the first to perform osteotomy on an ankylosed (fused) hip in 1821². He was said to have performed an inter-trochanteric osteotomy without any anaesthesia in only seven minutes²!

Inter-positional arthroplasty is believed to have started in France. Although Auguste Stanislas Verneuil (1823-95) from Paris France, performed soft tissue hip interpositions in 1860; it was Leopold Ollier’s (1830-1900) work in Lyon France that brought the attention of the medical world at the time, to the concept of inter-positional arthroplasty⁷. In 1885, Ollier described the use of adipose tissue in uninfecte hip joints, but this procedure failed because he did not fix the interposed fat to the bone (Ollier, 1885)⁷. A Czech surgeon called Vitezlav Chlumsky (1867-1943) while working in Germany, carried out several experiments with various inter-positional materials which include muscles, celluloid, silver plates, rubber struts, magnesium, zinc, glass, pyres, decalcified bone, and wax among others⁸.

Subsequently in 1891, Berliner Professor Thermistocles Gluck (1853-1942) produced an ivory ball and socket joint, which he fixed to bone with nickel-plated screws⁸. He later experimented with a mixture of plaster of Paris, and powdered pumice with resin in order to provide fixation to bone, with some acceptable results at the time (Rang, 1966)⁸. Towards the end of the 19th century, John Benjamin Murphy (1857-1916) from Chicago described the simple removal of overhanging bone osteophytes (Hip Cheilectomy), in order to alter the symptoms of localised hip osteoarthritis (Murphy, 1915)⁹. Earlier in the 1900s, Murphy (Murphy, 1904)¹⁰ and Eric Lexer (1867-1937) from Germany had described hip interposition with fascia lata (Lexer, 1908)¹¹. A similar procedure was earlier described by Henrich Helferich (1851-1945) for the treatment of temporo-mandibular joint OA¹³. Pig bladder was later suggested as a good inter-positional material by a French surgeon known as Foedre (born 1860), because it was observed to be strong enough to withstand the stresses of mobilisation and joint pressures (1896)¹⁴. William Steven Baer (1872-1931), also popularised the use of pig bladder in the USA¹⁵,¹⁶.

Around the same period, Sir Robert Jones (1855-1933) used a strip of gold foil to cover the surface of the femoral head; and reported that twenty years later, the patient had still retained full mobilisation of the hip joint¹⁷. That was the longest follow-up history reported
at the time. In 1924, Royal Whitman (1857-1946) from the Hospital for Special Surgery in New York, published the first description of hip arthritis surgery by alternative means to fusion in the Annals of surgery\textsuperscript{18}; and since then, several modifications of the procedure were tried with variable results. Later on, the Norwegian-born American surgeon Marius Smith-Petersen (1886-1953) from Boston Massachusetts, who in 1923 suggested the use of synthetic inter-positional arthroplasty with a mould prosthesis\textsuperscript{19}. This was designed to provide bone-implant movement both at the femoral and acetabular sides of the implant. He designed a glass mold to be interposed between the femoral and acetabular surfaces, and also described the anterior approach to the hip which he used for this procedure; and started implanting the devices in 1932. However, he abandoned this procedure because the glass was breaking and there was mixed results among his patients; with many patients requiring revision to remove the broken glass. Smith-Petersen subsequently tried celluloid, Bakelite, as well as Pyrex; and later his dentist suggested Vitallium which had recently been introduced to dentistry at the time. He was able to implant over 500 Vitallium molds over a period of ten years with good results. This provided the first predictable result in transpositional arthroplasty.

The first surgeon to use rubber femoral prosthesis however, was Pierre Delbet (1861-1925) in France. He used a rubber femoral prosthesis in 1919 to perform a hemiarthroplasty. In 1927, Ernest Hey-Groves (1872-1944), in Britain experimented with ivory; producing disastrous consequences. The Judet brothers, Robert (1901-80) and Jean (1905-95); produced a prosthesis which was exceptionally susceptible to wear and failed within a short time, and so it was abandoned\textsuperscript{20}.

Furthermore, in the 1940s resection of the femoral head especially for tuberculosis and other infections was re-advocated by Gathorne Robert Girdlestone (1881-1950), from Oxford in the United Kingdom\textsuperscript{21}. Girdlestone’s excision arthroplasty is still currently used as a last resort after failed THA, and is also known as conversion Arthroplasty (Girdlestone, 1943)\textsuperscript{21,22}. Frederick Roeck Thomas (1907-83) later modified the idea of the Judet brothers by producing a Vitallium prosthesis in the 1950s (Juet and Judet, 1950), in collaboration with Harold Bohlman (1893-1979) from Nebraska, and Austin Moore (1899-1963). The latter implanted the first of this prosthesis in 1940. Bohlman and Moore, later modified this
prosthesis to a fenestrated one to allow for bone in-growth\textsuperscript{23}. These prostheses are still widely used especially in hemiarthroplasty following neck of femur fractures\textsuperscript{23,24}.

In 1938, Philip Wiles (1899-1966), of the Middlesex hospital in London, introduced the first hip replacement using precisely fitted stainless steel components fixed to bone with screws and bolts; but he achieved poor results with this implant\textsuperscript{25}. Edward Haboush (1904-1973) from USA, and Kenneth McKee (1905-1991) from Norwich England developed prostheses in the late 1940s and experimented with acrylic dental cement for fixation of the prosthesis to bone\textsuperscript{26}. McKee later tried the Austin Moore prosthesis, but had a very high failure rate resulting from loosening of the prosthesis\textsuperscript{26}. Peter Ring (born 1922) was another Briton, who experimented with cement-less prosthesis with metal-on-metal articulation in 1964. Some of his implants had surprisingly good outcomes with up to 97% surviving for seventeen years or more\textsuperscript{27}. These prostheses were later abandoned in the 1970s for the Charnley models\textsuperscript{27}.

Finally, it will be a disservice not to properly mention the great work and contribution of Sir John Charnley who drove the evolution of a truly successful operation in Orthopaedics, the modern Total Hip Arthroplasty (THA)\textsuperscript{28}. He worked in Manchester Royal Infirmary, and is considered to be the father of modern THAs. It was Charnley who introduced the low friction Arthroplasty (LFA) in the 1960s\textsuperscript{29}. This consisted of a metal femoral stem which had a small head to reduce the rate of wear on the bearing surface, a polyethylene acetabular component, and acrylic bone cement\textsuperscript{28,29}.

**The concept and evolution of THA**

THA is believed to be one of the most successful operations invented by the medical field. About 700,000 hip and knee replacements are currently carried out in the USA every year, and this trend seems to be rising in the US and many countries\textsuperscript{30}. Osteoarthritis of the hip is one of the commonest indications for THA, which is aimed at providing adequate pain relief and improvement of mobility to the patient. Other indications include inflammatory arthritides such as rheumatoid arthritis, avascular necrosis (AVN) of the femoral head, developmental dysplasia (DDH) especially in young adults, Perthes’ disease, malignancy, Paget’s disease, as well as femoral neck fractures in fit elderly or young patients\textsuperscript{3}. A recent
systematic review of randomised controlled trials (RCTs) comparing the outcomes of THA versus hemiarthroplasty (HA) for displaced femoral neck fractures in fit elderly patients, revealed that although THA has a better patient-based outcomes; however, it has a higher rate of dislocation than HA in these patients.\(^3\)

Rahman and colleagues recently revealed a high success rate in reducing pain and improving hip function following THA in patients with steroid-induced femoral head osteonecrosis or AVN\(^3\). Although THA in patients with DDH prevents special challenges, the functional outcomes have also been found to be excellent; even though a higher rate of mechanical failure has been reported in this group of patients compared to other groups\(^3\). The recovery and rehabilitation of the patient are influenced by post-operative pain; adequacy of analgesia, patient’s motivation, understanding and ability to carry out post-operative restrictions and other recommended exercises in order to achieve full independent walking.\(^3\)

THA basically consists of a metallic stem and prosthetic acetabular cup made of various materials. It also consists of a bearing surface on both the femoral (small or large head) and acetabular surface: these can be soft-on-soft (PE on both the femoral head and the acetabular liner), soft-on-hard (PE acetabular liner versus metallic or ceramic femoral head) or hard-on-hard (H-o-H) bearing surface (metal-on-metal {M-o-M}, or ceramic-on-ceramic {C-o-C}), and the femoral implants can be modular or single stem and neck. In addition to that, both the femoral stem and acetabulum can be cemented or un-cemented (cementless), with the ability to make different hybrid combinations. The un-cemented (cementless) acetabular cup can be press fit or used with screw options, depending on the bone quality and adequacy of the fixation. When the femoral stem is cemented and the acetabulum is un-cemented (cementless), this is called a hybrid THA; and when the femur is un-cemented (cementless) and the acetabulum is cemented, this is called a reverse hybrid THA.

None of these combinations however, have clear advantages or edge over the others; but there are clear indications for cemented or un-cemented (cementless) arthroplasties according to the particular case being treated, presence of osteoporosis, surgeon’s training and preferences, funding, as well as severity of the hip pathology. In a systematic review
comparing cemented versus un-cemented (cementless) THAs, Abdulkarim et al (2013) found that there was no difference in revision rates between the two groups after a long follow-up\(^4\). They however observed that cemented arthroplasties provided better short-term outcomes than the un-cemented hips, but recommended further research to observe other long term complications and survival behaviours of the two types of THA\(^4\). Figures 1-5 show some radiographs of patients who THAs for severe OA of the hip.

**Principles of THA**

The principles of THA depend on the choice of fixation (cemented or cementless), and the desired hip stability. Assessment of hip stability involves component design, component alignment or position, soft tissue tensioning, as well as soft tissue function. There are different types of component designs which depend on the manufacturers, but the important considerations for any design include the primary arc range of the ball and cup, head-neck ratio, and excursion distance; which will determine the jumping distance of the femoral head, risk of impingement and any risk of dislocation\(^35\).

The second important consideration in THA is prosthetic component alignment; the recommended ante-version for the cup should be 15-30°, and the coronal tilt (theta angle) should be 35-45°. For the femoral stem, an ante-version of 10-15° is generally acceptable\(^35\). Soft tissue tension as well as adequate repair of the abductor complex and function are very important to the stability of THAs and will help to minimise the risk of Trendelenberg gait and limping. Pre-operative templating can be used to assess the head offset and neck length, so as to achieve the right soft tissue tensioning and leg length at the end of the procedure. This will help to minimise the problems of limb length inequality, which can make patients very unhappy\(^35\).

**Approaches to THA**

THA is one of the most common elective procedures performed in modern Orthopaedic theatres. There are different approaches to the hip according to the indication as well as the surgeon’s training and preferences. However, each of the approaches has its advantages and disadvantages. The most commonly used and practical approach to the hip for THA is the posterior approach\(^36\). This was popularised by Moore and is also called the Southern
approach. This approach allows for easy, quick and safe access to the hip joint, and does not interfere with the function of the hip abductors. It also allows very good visualisation of the femoral shaft, and so it has become the favoured approach for revision Arthroplasty of the hip\textsuperscript{36}.

Other less commonly used approaches include the anterior (Smith-Petersen) approach, anterolateral (Watson-Jones) approach, Lateral (Hardinge) approach and several modifications of these; which are mostly used for hemiarthroplasty, following femoral neck fractures in elderly patients. The medial approach is not used for THA, but usually indicated for open reduction of congenital hip dislocations, joint washouts in paediatric arthritis, biopsy and treatment of tumours around the hip joint, psoas release, as well as obturator neurectomy\textsuperscript{36}.

**Types of THA**

**Cemented THAs**

This involves the use of acrylic bone cement or similar substances to fix the femoral and/or acetabular prostheses to the bone. The widely acclaimed success of THAs was initially due to the invention of the cemented low friction Arthroplasty (LFA) with its very good survival rate\textsuperscript{29, 37}. However, the survival rates of many subsequent cemented designs were less satisfactory due to early loosening as a result of poor implant designs and bad cementing techniques. These failures were initially thought to be as a result of the cement itself, and therefore this phenomenon was termed cement disease\textsuperscript{4}. Cement loosening can involve the acetabulum, femur, or both, but early catastrophic failure is more commonly observed in cemented cups (acetabulums) than femurs\textsuperscript{4}.

The technique of cemented THAs has evolved over the years and has progressed from first to third generation of cementing. The type and quality of bone cement has also been modified and improved in the last few years, so as to improve the long term survival of the cemented hips. These third generation techniques currently employed for cementing include porosity reduction by vacuuming; cement pressurisation, pre-coating of stems, rough surface finish and use of cement centralisers in order to prevent voids in the cement mantle during cement implantation. It is also recommended that the cement mantle should
have a minimum of 2mm thickness around the femoral stem, to allow for adequate fixation of the stem to bone\textsuperscript{35}.

\textbf{Un-cemented (Cementless) THAs}

Un-cemented (Cementless) THA involves the use of femoral and acetabular implants which have been circumferentially pre-coated (for example hydroxyapatite coating), in order to provide bone in-growth or on-growth; without the need for bone cement. This can be porous-coated or grit-blasted, which are supposed to provide a strong biological implant fixation that is very rigid and prevents loosening of the prosthesis with time, especially in young active patients. There are different types of implant designs for both acetabulum and femur, and the femoral stem can be collared or collar-less; each providing different types of advantages.

The acetabular cup can be a coated metallic shell with a plastic liner, or ceramic liner. These implants have helped to increase the survival rates of THAs, in spite of the additional cost involved in using them\textsuperscript{38-40}. There was a strong recommendation for the use of porous-coated cementless cups over cemented implants due to the previously reported high rate of loosening in cemented acetabular cups. As a result of this, hybrid THAs (cemented femurs and cementless cups) have recently become more popular.

However, in general un-cemented (cementless) femoral stems are more favoured in fit young patients, due to the previously reported high rate of loosening of cemented stems in this category of patients\textsuperscript{35}. Although there was initial apprehension on the use of cementless prostheses in rheumatoid arthritis patients due to a perceived high rate of mechanical failure in these patients, recent evidence suggests that there was no significant difference in the overall outcomes between cemented and cementless prostheses in rheumatoid patients\textsuperscript{41}. Other workers have also recently shown very good medium term outcomes of cementless THAs in a cohort of patients with Paget’s disease; with 84% of these patients having excellent outcomes after 79.4 months of follow-up\textsuperscript{42}. 


Discussion

Outcomes and Survival measures

Several types of prostheses have been used in different countries all over the world with variable outcomes, but the low friction Arthroplasty (LFA) introduced by Charnley about fifty years ago has been one of the most versatile and successful THAs with very good mid and long term survivals of up to thirty years in many studies. Survival of THAs is usually assessed on the rate of loosening of the prosthetic-cement interface, wear rate of the polyethylene in the acetabular cup, infections, peri-prosthetic fractures, as well as revision rate, among others. A French series from Lyon France published survival series of 85% after 25 years of follow-up in their cohort of patients. Older reported 96% survival rate of the prosthesis after 25 years, while Berry and colleagues reported 86.5%. However, Callaghan and colleagues reported a survival rate of 78% after 35 years, while Wrobleski reported survival rates for Charnley’s THAs after a period of up to 38 years.

In view of this, more time is required to follow-up some of the newer versions of cemented and cementless prosthesis to see whether they will stand the test of time. A recent review of the survival rates of un-cemented acetabular mono-block cups in two hundred and ten arthroplasties in a Swedish registry revealed good medium term survival rates in the two different implants reviewed. However, there was no sufficient data to allow for a conclusion of the long term survivals of such implants and therefore more time was suggested to follow-up these patients.

Although there has been widespread anxiety about the systemic adverse effects of metal-on-metal (M-o-M) hip Arthroplasty, a recent systematic review of some hard-on-hard (H-o-H) implants revealed a 96-100% mean survival rate of metal-on-metal (M-o-M) implants at 38-60 months follow-up, about 94% at 56 months for hip resurfacing implants, and up to 100% survival rate at 51 months for ceramic-on-ceramic (C-o-C) implants. This recent success was attributed to improved prosthetic designs, surgical technique, implant positioning and proper selection as well as preparation of patients for surgery. Another recent review of the pros and cons of C-o-C implants revealed a 68-84% mean survival rate at 20 years follow-up, and a 10 year revision-free interval of 92-99%, which were comparable to the figures for the non C-o-C implants. However, it was observed that C-o-C
implants still had the problems with fracture of the ceramic liners, squeaking, and impingement especially in fit, young, and active patients leading to dislocation\textsuperscript{49}. A recent systematic review of risk factors for revision of primary THAs has identified several factors as being contributory. These include age of the patient, sex of the patient, presence of medical co-morbidities, underlying diagnosis such as rheumatoid arthritis and AVN, as well as surgical and implant-related factors. This article also highlighted the role of health care provider-related factors which may negatively influence the outcome of the THAs and lead to early or late revision\textsuperscript{50}.

**Complications of THA**

**Dislocation** is one of the most common complications of THA. This can be early (peri-operative) or late, and has a number of causes which may be related to the patient, implant or surgical technique. Dislocation can result from component mal-alignment of either the acetabular or femoral prosthesis, which should be addressed in treatment of such cases. It can be treated by closed or open reduction in the acute setting, but recurrent dislocation needs planning to revise the mal-aligned component or consider conversion to hemiarthroplasty (HA) or excision arthroplasty (Girdlestone’s) for very difficult cases\textsuperscript{35}.

**Aseptic acetabular and femoral stem loosening** are the commonest indications for revision surgery in THA. The common reason for revision in cemented arthroplasty is failure of cemented cup, while the most common reason for revision in un-cemented THA is failure of the femoral stem as a result of osteolysis. Acetabular loosening is assessed based on the DeLee and Charnley zones; with the cup considered to be loose in the presence of >2mm radio-lucency in all 3 zones, progressive lucent lines in zones 1&2, or a change in position of the cup\textsuperscript{35}. Femoral loosening is assessed based on involvement of the seven Gruen’s zones, starting from the greater trochanter (GT) going anti-clockwise towards the lesser trochanter (LT) (Miller, 2004)\textsuperscript{34}. The risk of aseptic loosening has been recently linked to bone quality and the severity of defects in the bone\textsuperscript{49,60}.

**Intra-operative fractures** can happen while preparing the acetabulum or femur. Acetabular fractures can happen especially in cases with protrusion acetabuli or inflammatory arthritis, and can be made worse by aggressive reaming on the medial side of the acetabulum. If this
happens, there may be need to use bone graft or augments before implanting the prosthesis. Femoral fractures can occur during reaming or broaching of the canal, especially in osteoporotic bones; or while trying to reduce the replaced femoral head into the acetabular socket. These fractures can occur around the calcar or the GT and can easily propagate down the femoral shaft. In this case, the fracture must be fixed with wires before cementing the femoral prosthesis, in order to avoid propagation. The patient may need protected weight bearing in the immediate post-operative period for a few weeks to allow the fracture to heal before full mobilisation commences (personal experience).

**Peri-prosthetic fractures** are fractures which happen around the femoral stem of a THA or HA. The prevalence of these fractures varies from 0.1-4%, and is thought to be higher following revision THAs. These fractures have various classifications, which include the Vancouver classification. They can occur a long time after the operation and are usually associated with falls or trauma, but may also be caused by loosening around the femoral stem, or stress rises from previous surgery or screw positions. The management depends on whether the femoral stem is loose or well fixed, and is also influenced by the general mobility and health of the patient.

Cementless implants are usually associated with peri-prosthetic fractures within the first 6 months after surgery, while their cemented counterparts have peri-prosthetic fractures late; up to five years following the operation. The treatment of these fractures may be conservative for undisplaced fractures, ORIF with plates and wires in displaced fractures with well fixed stems, or revision to long stems to bypass the fractured site if the stem is loose. The final outcome depends on the fracture union, implant stability, early functional recovery and return to pre-injury independence.

**Heterotopic ossification (HO)** is the formation of ectopic bone in soft tissues usually around the hip following THA. The risk factors include hypertrophic OA, Ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis (DISH), post traumatic OA, previous hip fusion, previous involvement of the contra-lateral hip, direct lateral (Hardinge) approach to the hip and previous HO. It can be prophylactically treated with low dose radiation and NSAIDs.

**Infection** following THA is seen in 1-2% of cases from many studies and between 7-16% of revisions is carried out because of infected hips. This can be acute, sub-acute or chronic,
and has been associated with various risk factors such as prolonged surgery, post-traumatic OA, previous Arthroplasty, dislocation, diabetes mellitus, rheumatoid arthritis, steroid use, alcoholism, smoking, obesity, infections in other sites, chronic liver disease, malignancy, and other causes of Immunosuppression. This causes a lot of morbidity to the patient and may lead to loosening and subsequent failure of the prosthesis. Early infection can be treated with intravenous antibiotics, hip washouts and component retention or change of acetabular cup liner as the case may be, whereas sub-acute or chronic infection may require one or two stage revision of the whole prosthesis in addition to use of antibiotic-impregnated cement spacer and prolonged intravenous antibiotic treatment (up to six weeks). Diagnostic measures to assess and follow-up progress of joint infections include blood parameters such as WCC, ESR and CRP. Other helpful investigations include CT scan, bone scan, and white cell-labelled scan (Leuco-scan). However, clinical judgement is required to confirm the diagnosis or absence of infection, in order to institute the proper treatment.

**Osteolysis or cup wear** is one of the most common and difficult problems in THA. This represents a histiocytic response to wear debris which has several sources such as the polyethylene (PE), metal debris, ceramic debris, polymethyl-methacrylate (PMMA) or bone cement, and hydroxylapatite (HA) particles. Because PE is softer than the other materials, it is considered to be the commonest source of wear debris due to the volume of debris it produces. As a result of particle ingestion by the macrophages, they release osteolytic and pro-inflammatory factors which assist in bone dissolution or lysis around the implants, leading to micro-motion and further generation of wear particles. Subsequently, this leads to more lysis which allows for implant macro-motion, loosening and pain.

**Limb length inequality (LLI)** following THA can be a source of distress and anxiety to the patients, especially if it is more than 2cm. This can result from problems with the femoral neck offset, femoral cut, or defect in femoral prosthetic implantation; and may be exaggerated by pelvic tilt or abnormal posture. Mild LLI may be corrected with shoe raises or wedges, but more significant ones may require revision of the femoral implant to adjust the length.
Systemic metallosis has been described following M-o-M hips especially in hip resurfacing. As a result of the growing use of these metal-bearing surfaces, there has been increasing anxiety on the effects of the metal ions in the local tissues and systematic circulation, and these have been linked to an increased risk of neoplasia in future following the use of metal implants in joint replacements. Adverse local tissue reaction to M-o-M hips has also been described in a series of patients who had large head M-o-M THAs. High concentrations of these metal ions which include cobalt, chromium, nickel, titanium and molybdenum have been recently described in a systematic review of cases. Therefore, in view of the local and perceived systemic effects of these metals, many people are apprehensive and even careful to use these M-o-M implants, and clinicians are therefore advised to weigh the pros and cons and use their clinical judgements to choose the best implants for their patients.

Squeaking is commonly seen in ceramic-on-ceramic (C-o-C) bearing surfaces, which are increasingly used more recently because of their hardness and ability to provide a smooth bearing surface very similar to the native hip joint. Although squeaking is harmless, it may cause some anxiety and distress to patients, which may lead to the need to revise the prosthesis even in the absence of mechanical failure or infection. Squeaking has been described in 6% of a series of patients who had C-o-C implants. This started happening in an average period of about 20 months post-operatively, and was not associated with pain or functional impairment on the patient. It was associated with different types of activities such as walking, bending, climbing stairs, and was constant in 25% of the patients reviewed.

Recent advances in THA

Minimal access or minimally invasive surgery (MIS) for THA is becoming increasingly popular because of its obvious advantages of minimal soft tissue stripping and dissection, quicker recovery following surgery, as well as early discharge and return to normal activities. This has been linked to a better and more controlled physiological response of the body to the surgical trauma, as compared to conventional or open surgeries. As a result of this increasing popularity of MIS THA, short and smaller femoral prostheses are being designed and now frequently used as they allow for easier and smaller surgical approaches, and also
preserve more bone stock than conventional femoral prostheses which are longer and bulkier.55

However, both conventional and short stem femoral prostheses can be used for MIS THA with satisfactory outcomes, therefore; the selection of these prostheses should be based on other factors such as patient’s age, bone quality, type of pathology being treated, and of course the preference of the surgeon who is operating.55 In a recent systematic review regarding the effect of MIS THA on the patients’ outcomes, it was revealed that MIS is safe for hip replacements and does not increase the length of the operation once the learning curve is achieved. Also, it was observed that MIS was not associated with increased blood loss, rate of complications, or rate of component mal-position compared to the conventional open techniques.56 Similar results were also published following minimally invasive direct anterior approach (DAA) combined with navigation, which led to more accurate implantation of the prostheses and also spared the need for extra assistants in the operation therefore, leading to savings in the cost of surgery.57

**Computer-aided (CA) THA** has also being introduced and is currently tried in many centres across the world. This entails the use of computers for templating and navigating the cup and/or stem placement, which requires some training to achieve a sufficient level of skill, and it, is often combined with MIS. In view of this, computer-aided surgery (CAS) for hip replacements is currently having increasing popularity because of its potential to increase the accuracy of implant placement, which can reduce the rate of complications like dislocations and impingement.56 A systematic review on the value of this technique revealed that although CAS increases the operating time, it was still observed to show an average decrease in blood loss during the procedure, in addition to decreased complication rates compared to other conventional forms of surgery.56

Another review of one type of CAS using an active robotic system (ROBODOC) which was used in femoral cavity implant preparation revealed better stem alignment and less variance in LLI, decreased incidence of pulmonary embolism (PE), as well as less stress shielding than the conventional technique on Dual Energy X-ray Absorptiometry (DEXA) scan analysis (Sugano, 2013).58 A meta-analysis of five trials involving four hundred patients revealed that navigated hip implantation for THA helps to optimise acetabular cup placement and reduce
the risk of complications and subsequent failure. However, there is still insufficient evidence regarding the long term outcomes of this technique, as well as the overall cost implications of using navigational tools. Therefore, more research is needed to support these findings (Beckmann et al, 2009)\textsuperscript{59, 60, 61}.

\textbf{Conclusion}

This review article has demonstrated that THA has evolved over the century from a very simple operation for hip osteoarthritis, to the very high-tech minimally invasive computer-aided surgery currently undertaken for a wide range of indications including trauma. It is one of the most common Orthopaedic procedures undertaken throughout the world, and has demonstrated its true versatile nature and excellent outcomes. In addition to that, it is easy to learn, and the patients are often very happy for ‘getting their lives back’. However, like any other surgical procedure; occasionally complications arise, which may end up with disastrous consequences.
References


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