

## Review Article

# Total Hip Replacement: Past, Present and Future

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## INTRODUCTION

Total hip replacement has been one of the most successful operations in orthopedic surgery. By alleviating pain and disability, it has helped patients to return to active life. Several hundreds of thousands hip replacements are conducted every year, worldwide. Hip, the second biggest joint of the human body with its primary role in locomotion, may be exposed to a number of non traumatic and traumatic hazards that may result in the condition known as osteoarthritis. Regardless of the initial pathology, the end result of this process is nearly always the same, characterized by pain, limitation of movements and impaired locomotor function. A number of surgical methods have been designed and developed for this condition in the past including osteotomies, fusions and resections, but they never provided satisfying results for patients and their doctors. Therefore, the idea of prosthetic replacement of the hip has gradually emerged.

This article is a concise review of the development of this concept and treatment modality over the last two centuries. The review also identifies the role of hip replacement today and speculates about its future.

## HISTORICAL ASPECTS

The first attempts to replace the hip joint were made by Gluck from Berlin (Germany) in 1880. The prosthesis was manufactured from ivory. It was obviously not a success. A second attempt, by French surgeon Jules Pean from Paris in 1890 with the prosthesis made from platinum also failed<sup>[1]</sup>. It was not until 1925 that a subsequent trial took place, this time in the USA by Smith-Petersen from Boston<sup>[2]</sup>. The glass and bakelite design that he used could not withstand the mechanical demand and inevitably failed. In 1938, the Judet brothers in Paris invented an acrylic hip prosthesis, but failed again, as it became loose and had to be removed<sup>[3]</sup>. It became obvious that joint replacement could not succeed until appropriate materials were found or manufactured. Milestones on this way have been

the inventions of a chrome-cobalt alloy characterized by high mechanical and surface resistance, high-density polyethylene and bone cement. Initially, only the femoral head was replaced using cementless (Moore) and cemented (Thompson) prosthesis<sup>[4,5]</sup> (Fig. 1). These devices, however, could only be used when the acetabulum was unchanged, limiting the indications to femoral neck fracture. In prostheses that were introduced in the fifties by Mc Kee from Norwich in Britain, and later by Herbert from Aix les Bains in France, first generation metal on metal bearing was used and they were mostly abandoned due to excessive wear and metal particles release causing metallosis<sup>[1,6]</sup>. The first successful series of implantations of the total hip prosthesis (i.e. replacing both hip components) with excellent mid-term results was reported by Sir John Charnley, a renowned British orthopedic surgeon from Wrightington Orthopedic Center, in the sixties of the last century<sup>[7]</sup>. The initial prosthesis consisted of a Teflon acetabular cup and a stainless steel monobloc femoral component. The head diameter used was 22.2 mm consistent with his idea of low friction arthroplasty. The prosthesis was fixed to bone using polymethylmethacrylate, a cold curing polymer that bonds the prosthesis with the bone bed. Teflon proved to be unsuitable as a prosthetic bearing with high wear and tear and was replaced by high-density polyethylene in later designs. The Charnley prosthesis was most successful and long lasting. It became a "gold standard" for hip replacement and is still used in modified versions<sup>[8]</sup>.

## CONTEMPORARY DESIGNS AND TENDENCIES IN HIP REPLACEMENT

Principally, two types of total hip prostheses are in common use. Depending on the type of bonding with the host bone the prosthesis may be either cemented (where bone cement is used to fix the prosthesis to bone) or cementless (where the implant is directly fixed to bone by the principle of press-fit followed by bone reaction known as osteointegration that finally stabilizes the implant)

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Fig. 1: General view of Thompson and Austin Moore prosthesis  
TH: Thompson Prosthesis, AM: Austin Moore Prosthesis



Fig. 2: General view of cemented Exeter Hip Prosthesis and examples of preoperative and postoperative X-rays

A: Neglected fracture of the femoral neck, B: Cemented acetabular cup  
C: Cemented femoral stem

(Fig. 2, Fig. 3). A combination of cemented and cementless elements of the prosthesis is called hybrid hip replacement. More commonly cementless cup and cemented stem are used<sup>[9]</sup> (Fig. 4, Fig. 5). For reasons of versatility, modular designs have emerged. In these designs, prosthesis consists of three or four parts, namely, the acetabular cup, the femoral head and the femoral stem in cemented types and acetabular shell, acetabular insert, femoral head and femoral stem in uncemented



Fig. 3: General view of cementless Zweymueller Hip Prosthesis and examples of preoperative and postoperative X-rays

AI: Acetabular insert, AS: Acetabular shell, Bicon, FS: Femoral stem, SL Plus, FH: Femoral head

A: Avascular necrosis of the femoral head, B: Cementless threaded acetabular cup *in situ*, C: SLFemoral Stem *in situ*

types (Fig. 2, Fig. 3). They come in different sizes that can be assembled according to the need during surgery. In special situations when the anatomy is significantly distorted or if there is significant bone loss or defect, custom made prosthesis is used. It is manufactured according to the particular clinical situation after a detailed three-dimensional study of the hip using CT scan. The diameter of the prosthetic head is related to range of movement, stability and friction coefficient of the prosthetic bearing. Different materials and sizes are in use. In order to unify implants' parameters, generally, a diameter of 28 mm is recommended as it is a good compromise between stability and mobility of the joint and has a relatively low friction coefficient and low particle release incidence. The material used is a chrome-cobalt alloy and alumina or zirconia ceramic<sup>[10]</sup>. The main disadvantage of the cemented prosthesis was loosening of the components. This was partially attributed to the generation of particles by friction between the prosthetic surfaces, surgical technique, physical activity of patients and the ageing of the cement that lost its initial mechanical properties<sup>[11]</sup>.



**Fig. 4:** Hybrid Total Hip Replacement, cementless Bicon cup, cemented long Exeter stem, used for non united fracture of the femoral neck with bone defect in the femoral shaft

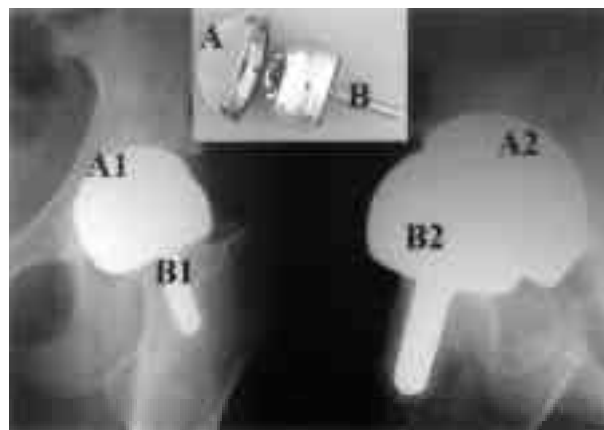
A: Non union of the femoral neck resorption, D1: Proximal femoral bone defect (after removal of metal fixation), D2: Distal femoral bone defect (after removal of metal fixation), BC: Bicon cementless acetabular cup, LES: Long cemented Exeter femoral stem



**Fig. 5:** Hybrid Total Hip Replacement, cementless Bicon cup, cemented standard stem, used for loosening of both components of cemented total hip replacement

A: Loose cemented acetabular component, B: Loose cemented femoral component, BC: Bicon cementless acetabular component, SES: Standard cemented Exeter femoral component

Cementless total hip replacement has been introduced after experimental and clinical studies by Albrektsson from Sweden proved that titanium implants are capable of osteointegrating without cement<sup>[12]</sup>. The porosity of the prosthetic surface, bone friendly properties of implant materials and reduced friction and wear and tear of prosthetic surfaces in contemporary designs (using titanium as a frame of prosthetic components and alumina ceramic as a prosthetic bearing), are decisive factors for firm and long-lasting bonding between the implant and the host bone. Metal-on-metal articulating surface, that was once used and discarded because of wear of metal and adverse tissue reaction, was reintroduced with much success, after surface finishing techniques and selection of appropriate material had dramatically improved. Successful osteointegration of the prosthetic stem and acetabular cup results in



**Fig. 6:** Mc Minn Hip Resurfacing Prosthesis. General view of the implant and X-ray of the implanted prosthesis

A: Cementless acetabular cup, B: Cemented femoral part with short stem, A1: Implanted acetabular cup in AP - view, B1: Implanted femoral part on AP - view, A2: Implanted acetabular cup on lateral view, B2: Implanted femoral cup on lateral view



**Fig. 7:** Most common pathology of secondary osteoarthritis in Kuwait

A: DDH(Developmental Dislocation of the Hip), secondary osteoarthritis, B: Malunited fracture acetabulum, hip ankylosis, C: United fracture of the femoral neck - avascular necrosis of the femoral head, D: Sickle cell anemia - avascular necrosis of the femoral head

permanent fixation of the implant, which becomes physically incorporated in bone. Long term results, however, cannot be predicted with accuracy, as follow up observations are relatively short<sup>[13,14]</sup>. High functional demand and the increasing number of young patients requiring hip surgery stimulated further changes in the design of the hip prosthesis. The resurfacing, that had once been tried and abandoned, has reappeared with technological improvements that assure lasting clinical and radiological results. In this technique, the bone resection is substantially minimized and metal-on-metal surface and high head diameter are used (Fig. 6). The early results of this procedure are excellent<sup>[15]</sup>. The remaining bone stock makes any future revision procedure, if necessary, much easier and with much less surgical impact. The position of the prosthetic components has critical importance for stability. Inaccuracies in the geometrical orientation of the implants may result in its dislocation and ruin the outcome of the operation.

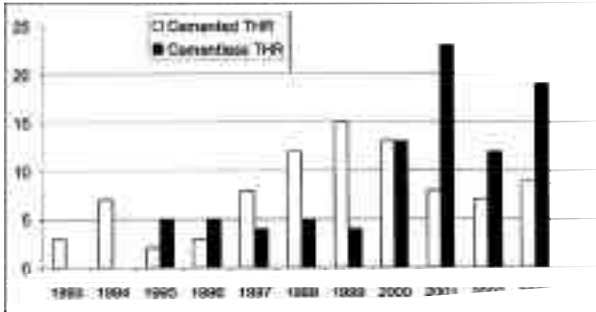


Fig. 8: Graph illustrating frequency of total hip replacement across the last decade at Al Razi Hospital, Kuwait



Fig. 9: Radiological view of EPF press-fit cementless cup implanted without screws and with screws.

- Case 1 A: Avascular necrosis of the femoral head  
 B: EPF Cementless Press- fit cup without screws *in situ*  
 C: SL cementless femoral stem *in situ*
- Case 2 A: Avascular necrosis of the femoral head  
 B: EPF cementless Press- fit cup with screws *in situ*  
 C: SL cementless femoral stem *in situ*

In recent technical developments, a computerized guiding system, "navigation", has been introduced<sup>[16]</sup>. Reference sensors are implanted in the bone during the procedure and the three-dimensional position of the implant and the limb is constantly monitored by the computer interactively, enabling the surgeon to fix the implant within a 2-3 % margin of error from the optimal position, eliminating unexpected X-ray and clinical findings. Bone structure in the vicinity of the implant may depend on many factors and

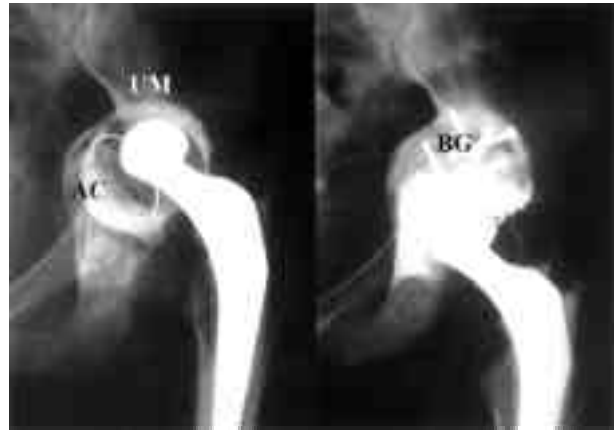


Fig. 10: Loosening of the acetabular component of Exeter prosthesis. (Displacement of the implant and extensive cavitory bone loss. Revision using bone graft and metal mesh. Excellent result at Five years).

AC: Displaced and loose acetabular cup, UM: Upward migration of the femoral head with huge cavitory bone defect, BG: Incorporated bone graft

may have prognostic value on the stability of the bonding<sup>[17]</sup>. A general tendency to minimize surgical trauma, has also been reflected in hip surgery. Minimal approaches to the hip joint have been developed along with special instruments. One incision (posterior) and two incision (anterior and lateral) techniques have been proposed. Encouraging reports<sup>[18,19]</sup>, however, are followed by critical opinions<sup>[20]</sup>. Although still controversial, the so called "day case total hip replacement", found its advocates in the USA. In selected cases, this operation, performed through two small incisions with the help of navigation and image intensifier, allows reduction of the surgical trauma to the extent that patients start mobilization and physiotherapy in a couple of hours after the procedure and is discharged home on the same evening. The costs of treatment are significantly reduced. However, concerns about possible complications hampers the wider application of this method.

## ASSESSMENT OF CLINICAL AND RADIOLOGICAL RESULTS

Clinical and radiological results are rated in hip score systems that permits one to objectively assess and compare the results in the same patient during the time elapsed from the surgery as well as compare it with other patients and other studies. Two scoring systems are in use, namely, the Harris hip score (that is very detailed) and the more concise Merle d'Aubigne-Charnley score<sup>[21]</sup>. More attention is being given to the patient's own satisfaction which may not always coincide with the treating surgeon's assessment. The WOMAC and HOOS system of patient-relevant outcomes of hip replacement<sup>[22]</sup> were incorporated in the clinical assessment and are becoming standard requirement in rating clinical results. However, it is

always important that the patient has realistic expectations from the procedure he or she is to undergo. Radiological results include geometrical position of the implants, possible migration of the components and changes in bone in the vicinity of the implant. Lucencies, radiodense lines, bone atrophy, osteolysis and bone hypertrophy are observed. They indicate bone remodeling as a reaction to the foreign material and modified transmission of loading forces. These radiological changes may or may not coincide with the clinical results<sup>[23-25]</sup>. Complications always cast a shadow on any surgical intervention. Total hip replacement is not an exception in this respect. Complications entail general and local events that jeopardize the clinical and radiological result. Thromboembolic complications may be life threatening and have been successfully reduced or nearly eliminated by the introduction of new generation anticoagulants<sup>[26]</sup>. Infection, a catastrophic complication in any joint replacement has been successfully reduced by technical improvements in the operation theatre, aseptic techniques and implant selection. Still, it cannot be completely eliminated. In best centers its incidence has fallen below 1 %<sup>[27]</sup>. Loosening of the prosthetic component, due to aseptic or infectious causes, remains a major problem in the total hip replacement. Many factors play a role. It may be related to the material used, surgical technique and the patient's tissues reaction to the implant, initial pathology, type of activity and many other factors. In cemented designs, significant improvement of the loosening rate was achieved in the femoral component. A ten-fold reduction in the loosening rate has been observed in the last 15 years<sup>[28]</sup>. On the acetabular side, the success is less visible. Improvements in cementing techniques did not significantly improve the loosening rate. Much hope and expectations are placed in the new prosthetic devices using better materials and cementless bonding. The results, however, still await critical analysis and the test of time.

#### HIP REPLACEMENT IN KUWAIT

In Kuwait, the number of total hip replacements is relatively low. It reflects, contrary to the upper zone of the northern hemisphere, the low incidence of primary osteoarthritis of the hip joint in this geographical area. Most of the cases operated in Kuwait at present include variable secondary pathology like Developmental Dislocation of the Hip (DDH), idiopathic and secondary avascular necrosis and trauma (Fig. 7). The first total hip replacement in Kuwait was performed in 1984 and it was an Exeter cemented design. The number of operated cases since then has gradually increased every year, affirming improved confidence of

Kuwaiti patients in accepting this demanding surgery to be performed locally (Fig. 8). Also the number of expatriates operated for total hip replacement is increasing, thanks to the opportunity of partial or total financing of the cost of implants by the Patient Helping Fund, managed by the Red Crescent Organization. In Al Razi Hospital, two designs of Total Hip Prosthesis are used. Exeter cemented hip prosthesis (Fig. 2) and Zweymueller cementless total hip prosthesis (Fig. 3). Two types of cementless acetabular shells are used: conical threaded Bicon cup ( Fig. 3, Fig. 4, Fig. 5) and press-fit EPF cup (Fig. 9). Indications for use of a particular type of cup depend on the anatomical conditions and the bone quality. On the femoral side, universal SL Plus rectangular tapered femoral stem has been used in all cases. Clinical and radiological outcomes are prospectively monitored and the results are either published or submitted for publication<sup>[29-30]</sup>. The selection of implants is gradually expanding, with the cementless design being used more frequently, in accordance with this trend worldwide. An increasing number of primary cases may be anticipated along with ageing of the population and high demand for functional recovery. We are also aware of the fact that revisions that are unwanted but inevitable, will follow the primary cases after an interval of a decade (Fig. 5, Fig. 10). Building up the experience of the surgical team and use of updated technology are required to meet these demands.

#### FUTURE PERSPECTIVE

The future of total hip replacement should be perceived as a divergent tendency for developed and developing countries. Advances in technology, improved materials and better understanding of natural tissue reactions will certainly result in breakthroughs of implant selection. Whereas, the affluent societies still can afford the rising cost of research and medical expenditure, it is not the case for the majority of inhabitants of the southern hemisphere. In many medico-economical studies, the expected costs of treatment in a decade perspective, amounted to a fraction of what they turned out to be. In other words, these initial anticipations have frequently fallen short of reality. Developing countries cannot afford the expensive failures of implant surgery that we have witnessed in the past. They should develop strategies that will allow them to tackle the problem of increasing demand for medical services in a more simplified and inexpensive way, as they may not even be capable of absorbing the technology in the absence of infrastructure, lack of training and know-how. In these communities, prevention may be even

more important than in the northern hemisphere societies. Reduction of the heart attack rate in the USA and Western Europe, as a result of better understanding of the significance of appropriate dietary and life style modifications may be an example of such attitude. Therefore, we should look forward to the future with wisdom and moderation.

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