



## Total Hip Replacement Arthroplasty – Past, Present and Future

Marvin E. Steinberg, M.D.

### Abstract

*Since the introduction of total hip replacement arthroplasty in the United States in the early 1970s, this has become one of the most frequently performed and successful procedures available to the orthopaedic surgeon. It has revolutionized the treatment of patients with disorders of the hip. Excellent function can be achieved in over 95% of patients with minimal risk of complications. As a result, between 200,000 and 250,000 total hip replacement arthroplasties are done annually in the United States alone. Despite the current success of total hip replacement, we continue to strive for improvements, particularly in the durability or survivorship of the components, and for a further decrease in complications*



Figure 1- McKee-Ferrar Total Hip-This is one of the earliest devices using metal on metal articulation. Both the femoral and acetabular components were anchored to bone with methyl methacrylate

### THE PAST: DEVELOPMENT OF TOTAL HIP REPLACEMENT ARTHROPLASTY (THR)

A review of the development of total hip replacement is not only of historical interest, but will give us a better understanding of this subject and assist us in making further improvements. The first hip arthroplasty done in the United States was performed at the University of Pennsylvania in 1827 by John Rhea Barton.<sup>1</sup> He performed a proximal femoral osteotomy on an ankylosed hip. By moving the limb daily a pseudarthrosis was formed which allowed both correction of the deformity and motion. Resection arthroplasties of the hip were first reported in Europe in the early 1800s and

became well established by the middle of the nineteenth century. These procedures were initially performed for the treatment of chronic bacterial and tuberculous infections of the hip, but the indications were gradually extended to include various types of non-infectious arthritis. This procedure was popularized between 1921 and 1945 by G. R. Girdlestone at the University of Oxford and soon became known as the Girdlestone pseudoarthrosis.<sup>2</sup> Various types of non-interposition arthroplasties were performed for the treatment of degenerative arthritis and usually involved resection of osteophytes from the femoral head and acetabular margins and reshaping the femoral head into a sphere, when necessary. The results were variable and long term results were generally not encouraging. It was felt by many that the use of some type of foreign material interposed between the joint surfaces would improve the results. Various materials were used. In 1902 Murphy began to use muscle and fascia as interposing materials.<sup>3</sup> In 1918 Baer reported on the use of chromicized pig's bladder as an interposing material. This became known as Baer's membrane.<sup>4</sup> In the 1920s Campbell<sup>5</sup> and MacAusland<sup>6</sup> reported that fascia lata interposition gave reasonably good results, compared to other procedures available at that time.

Non-union, avascular necrosis, and other complications were frequently encountered

#### Address for Correspondence:

Marvin E. Steinberg  
Hospital of the University of Pennsylvania, Department of Orthopaedic Surgery  
3400 Spruce Street, 2 Silverstein Building  
Philadelphia, PA 19104  
Phone: 1-215-662-3340  
Fax: 1-215-349-5890  
Email: marvin.steinberg@uphs.upenn.edu

Marvin Steinberg is a Professor Emeritus of Orthopaedic Surgery, University of Pennsylvania, School of Medicine

after fractures of the hip. Accordingly other procedures were developed to treat these complications. Most of these entailed resection of the femoral head and neck and reshaping of the proximal femur, which was then placed into the acetabulum. One of the most successful of these procedures was reported in 1935 by Paul C. Colonna, Professor of Orthopaedic Surgery at the University of Pennsylvania. This became known as the Colonna trochanteric reconstruction.<sup>7</sup>

Another difficult problem which confronted the orthopaedic surgeon was the treatment of developmental dysplasia of the hip (DDH). Most of these cases were not diagnosed early and thus the time for effective nonoperative management had passed. Considerable hip deformity and disability often required surgical treatment. One of the most successful procedures was again described by Colonna at Penn and referred to as a capsular arthroplasty. After deepening the shallow acetabulum, he inserted into it the femoral head over which he carefully sutured the elongated hip capsule. This would undergo metaplasia to a type of fibrocartilage.<sup>8</sup>

Prior to the development of effective total hip replacement arthroplasty, the cup arthroplasty was often considered the preferred procedure for the treatment of advanced arthritis of the adult hip in the United States. In 1923 Smith-Petersen initially used a cup made of glass as an interpositional arthroplasty between the femoral head and the acetabulum. Unfortunately these glass cups frequently fractured and eventually led to the use of Vitallium. Between 1938 and 1948 Smith-Petersen performed 500 Vitallium cup arthroplasties and reported a high percentage of satisfactory results. However, all patients required prolonged physical therapy after surgery, and surgical revision to improve motion or relieve pain was frequently performed.<sup>9</sup>

During the 1950s various modifications of the cup arthroplasty were developed in the United States and abroad. In the early 1950s Sir John Charnley experimented with the use of a double cup arthroplasty using two cups made of Teflon. In 1953 Haboush reported on two cases of double cup arthroplasty using metallic cups fixed respectively to the femoral head and the acetabulum with acrylic cement.<sup>10</sup> This was perhaps the first use of methylmethacrylate in the performance of hip arthroplasty. Townley performed a hemiarthroplasty using a metal cup mounted on a short, curved, intramedullary stem

and inserted over the reamed femoral head. In 1960 he combined the femoral component with a polyurethane acetabular cup, thus making this a total arthroplasty rather than a hemiarthroplasty. The polyurethane soon deteriorated and was later replaced by polyethylene. The femoral and acetabular components were now attached with cement. This device became known as a total articular replacement arthroplasty or TARA. Although Townley reported excellent results, this device never gained the popularity of other forms of hip replacement.<sup>11</sup>

In the late 1960s and early 1970s numerous surface replacement arthroplasties were developed in the United States and abroad. These included components designed by Wagner in Germany, Freeman in England, and Eicher and Amstutz working in the United States. This latter component known as the THARIES (total hip articular replacement with internal eccentric shells) employed a metallic femoral cup articulated with a thin, high density polyethylene acetabular component, both fixed with cement.<sup>12</sup> Initially the results with these components seemed satisfactory, but within a short period of time an alarming failure rate was noted with virtually all designs. The most common causes of failure were loosening of the acetabular component which resulted from fracture of the cement under the extremely thin acetabular shell, loosening of the femoral component, and fracture through the femoral neck. As a result, double cup or surface replacement arthroplasties were by and large abandoned in the early 1980s.

Various types of femoral endoprostheses were designed over the years. The earliest components employed hardened rubber or ivory as a femoral head replacement. Later Judet employed an acrylic component for the replacement of an ununited or necrotic femoral head. In 1940 Moore and Bohlman designed what was perhaps the first "modern" metallic femoral endoprosthesis, used to replace the upper end of the femur in a patient with a malignant giant cell tumor.<sup>13</sup> Additional metallic femoral endoprostheses were introduced with those designed by Thompsen and Moore among the most popular. Initially they were used for the treatment of proximal femoral fractures, but later they were used in the performance of hip arthroplasties after reaming of the acetabulum. The results in general were only mediocre and inconsistent.<sup>14</sup>

The concept of a bipolar endoprosthesis was introduced in the 50s using Teflon lined metal cups placed over a metallic femoral

endoprosthesis. These components were modified, and in 1973 the Giliberty and Bateman components were introduced.<sup>15</sup> These used metallic cups lined with high density polyethylene that were locked securely onto the head of the metallic femoral component. These were used for the treatment of various arthritic conditions of the hip as well as for femoral neck fractures. Despite the initial enthusiasm that accompanied their use, with time it was found that the bipolar endoprosthesis had few advantages over a simpler unipolar prosthesis and were substantially inferior to total hip replacement in the long term when used as an arthroplasty.<sup>2,14</sup>

In 1890 Gluck in Germany performed a total hip replacement using ivory femoral and acetabular components cemented to bone by a combination of resin and pumice or plaster of paris.<sup>16</sup> In 1938 Wiles in London performed six total hip replacements using femoral and acetabular components of stainless steel, anchored with screws.<sup>17</sup> These components did not function well. As early as 1940, McKee of Norwich, England began designing metal on metal hip replacements. However, it was not until his collaboration with Watson – Farrar and the use of methylmethacrylate that a successful component was developed (Figure 1).<sup>2,18</sup> In 1960 Ring of England introduced an uncemented metal on metal prosthesis which consisted of an acetabular component, anchored into the pelvis with a single central screw, and an uncemented Moore femoral endoprosthesis. The results were variable and many of these devices loosened with time.<sup>2,18</sup>

Although not the first to introduce total hip replacement arthroplasty, Sir John Charnley is appropriately credited as being the father of modern total hip replacement (Figure 2). After his initial experience with double cup arthroplasties, he focused his attention on total hip replacement as we now know it. Between 1958 and 1963 he implanted approximately 300 “low friction arthroplasties” which consisted of a Teflon acetabular component and a stainless steel femoral endoprosthesis, both anchored to bone by methylmethacrylate. Unfortunately, serious problems were encountered within a few years due to excessive wear of the acetabular component with the generation of large amounts of particulate debris. This caused a dramatic inflammatory reaction which led to bone resorption and gross loosening of the components. Charnley also encountered an infection rate approaching 10%. In 1962 he

switched to high density polyethylene for the acetabular component. With this change, the results improved dramatically and the prevalence of osteolysis and bone resorption diminished significantly (Figure 3).



**Figure 2- Sir John Charnley- Charnley was considered to be the “father of modern total joint replacement”.**

The rate of infection was also dramatically reduced by the use of prophylactic antibiotics, clean air rooms, and the use of body exhaust suits.<sup>18,19,20</sup>



**Figure 3 Charnley- Low Friction Arthroplasty Components- A 22 mm. stainless steel femoral head articulated with an all-polyethylene acetabular component**

In the late 1960s, Tronzo, working at the Hospital of the University of Pennsylvania, modified the Ring acetabular component by replacing the central screw with one large and three smaller prongs, which were driven into the acetabulum, thus preventing rotation. This articulated with a modified Weber femoral component which included a high density polyethylene ball that rotated on a trunion. Initially these components were inserted without

the use of cement. In 1969 – 1970 methylmethacrylate was approved by the FDA for use in hip arthroplasties. These components could then be anchored to the acetabulum and the proximal femur with methylmethacrylate. At approximately the same time Tronzo modified these components for fixation by bony ingrowth, thus providing us with what was perhaps the first uncemented biological ingrowth component developed in the United States (Figure 4, Figure 5).<sup>18,20</sup>



**Figure 4 Tronzo Femoral Component- This device was used both with and without cement fixation. Note the large polyethylene ball which rotated on a trunion.**

The era of modern hip arthroplasty in the United States can be dated to 1970 with the introduction of total hip replacement using methylmethacrylate to anchor both the femoral and acetabular components. The Charnley and the Mueller prostheses were among the most popular components used in the United States. They were quite similar in that a metallic femoral endoprosthesis articulated with an all-polyethylene acetabular component, both of which were anchored to bone using methylmethacrylate. The design of the femoral components was somewhat different. The Charnley component had a 22 mm. head and initially came with only one neck length (Figure 3). Charnley mandated that a femoral osteotomy should be performed for the insertion of the femoral component and required individuals to spend time observing him do surgery before allowing them to use his components. The acetabulum was then deepened or “medialized”.<sup>19</sup> The Mueller component had a 32 mm. femoral head, had three neck lengths, and had a curved stem which could be inserted without the need for a trochanteric osteotomy (Figure 6). The early results with these



**Figure 5 Tronzo Acetabular Components-The prosthesis on the right was used both with and without cement fixation. The component on the left was modified to include a rough surface and was designed for bone ingrowth**

components was roughly comparable. However with the passage of time the incidence of loosening with the Mueller component was considerably higher than with the Charnley and the stem was subsequently modified to eliminate the sharp medial border. The early surgical techniques were relatively simple. The acetabulum was reamed until bleeding cancellous bone was encountered. Multiple drill holes were then made. The methylmethacrylate was mixed by hand until it achieved a doughy consistency. It was then pressed into the acetabulum manually. The acetabular component was held in place with a positioner until the methacrylate had set. On the femoral side, the femoral canal was prepared with a rasp and cleaned with lavage and suction. The methacrylate or “bone cement”, was then inserted manually into the proximal femur. The femoral component was inserted into the cement column and held in place until setting occurred.<sup>18</sup>

Generally a large incision was made. In the Charnley approach this was a direct lateral approach to the hip with a trochanteric osteotomy and subsequent reattachment of the greater trochanter. In the Muller approach a posterolateral incision was made usually splitting the fibers of the gluteus maximus, retracting the medius and minimus, dividing the short external rotators, and resecting much of the hip capsule.

Patients were kept at bed rest for at least a few days following surgery and then allowed to ambulate carefully using a walker or two crutches. They progressed slowly but were usually not allowed unprotected weight bearing for at least six weeks following surgery. They remained in the hospital for approximately ten to fourteen days and then were discharged home.

Clean air rooms were used, either with or without body exhaust suits, and prophylactic antibiotics were routinely employed. Heparin, Coumadin, or aspirin were generally used for prophylaxis against thromboembolic disease.

Following discharge, patients were placed on a careful regimen designed to avoid positions of instability to minimize the chance of hip dislocation. Despite this, the incidence of dislocation with the posterolateral approach often approached 4% although it was significantly less with an anterolateral or a transtrochanteric approach. Patients were cautioned to avoid undue stress and strain to the hips on a permanent basis and running, jumping, and impact loading were to be avoided. Surgeons were reluctant to perform the procedure on younger patients, and the age of 65 was generally used as a guideline. It was expected that most hips would function for 10 to 15 years.<sup>18</sup>



**Figure 6- Mueller total hip replacement- This articulated with an all-polyethylene acetabulum, similar to the Charnly.**

## PRESENT APPROACH TO TOTAL HIP ARTHROPLASTY

This review will focus on primary total hip replacement and will not discuss revision surgery. Since the early 1970s, a number of changes have taken place in total hip replacement arthroplasty. Older devices which gave inferior results have been taken off the market, and a large number of new components are now available. The osteolysis and loosening which were seen with the early cemented components was initially felt to be due to a reaction to particles of methylmethacrylate and was often referred to as "cement disease". This served to hasten the transition to noncemented, biological ingrowth components in the United States (Figure 7). However, lysis and loosening was seen even when cement was eliminated, and it was concluded that wear debris from the polyethylene acetabular components rather than from cement was the culprit.<sup>21</sup> Thus steps have been taken to eliminate this source of failure,

although the trend towards the use of non-cemented components in the United States has continued. The hybrid hip has served as a transition between cemented and non-cemented components.(Figure 8) At the present time most acetabular components are uncemented. On the femoral side, cemented components are still being used, especially in older individuals, although proximally coated biological ingrowth components are being used with increasing frequency. Results with fully coated components have been good, but stress shielding of the proximal femur has been a concern. Although some surgeons continue to use these for primary cases, many feel that the basic indication for the fully coated component is in a revision setting.<sup>18</sup>



**Figure 7- A generic proximally coated femoral component- This modular component, designed for bone ingrowth, allows the attachment of a variety of femoral heads.**

Although there has been a steady shift away from cement and towards biological ingrowth components in the United States, in many other countries cemented total hip replacement arthroplasty remains the standard. The Swedish total hip registry indicates that during the past five years 85 to 90% of femoral components were fixed with cement, whereas only 10 to 15% utilized uncemented fixation.<sup>22</sup> Cementing techniques have improved over the years and have resulted in a better survivorship, especially of the femoral component.

The primary cause of component failure remains late loosening secondary to osteolysis caused by reaction to wear debris. Three solutions to this problem are currently being evaluated.<sup>21,23-26</sup> The first is to alter the polyethylene by exposing it to a sequence of radiation in an inert environment coupled with either annealing or melting. This produces what is referred to as "highly cross linked poly" which also has less free radicals present. This treatment has been shown to improve the wear characteristics dramatically and thereby to decrease the generation of particulate debris many fold. By decreasing free radicals, later oxidative degradation should also be diminished.

There remains some concern however about the fact that some of the mechanical properties of the poly have been altered, and its “toughness” has been decreased. Whether this will lead to fracture or other problems in the future has yet to be determined. Many feel that these changes will be extremely beneficial and should diminish the rate of loosening dramatically, so that we can now use these components with little concern even in the young, high demand patient.



**Figure 8- A Hybrid Total Hip Replacement- The Centralign® (Zimmer) femoral component with a ceramic head was designed for implantation with bone cement. The Harris – Galante Porous Coated One acetabular component® (Zimmer) was designed for bone ingrowth.**

A second approach has been to eliminate the use of polyethylene completely by introducing bearing surfaces on both the femoral and acetabular sides made of ceramics (Figure 9). With some of the early ceramics there was a small but definite incidence of fracture. However with improvements in the manufacturing process, the fracture incidence has been dramatically decreased so that the incidence of fracture with modern components is in the order of 1 in 60,000. Ceramics are extremely hard, are smoother than metal, and have other properties which decrease friction considerably. Wear is minimal and the production of wear debris is negligible. Ceramic components are less user friendly to the surgeon and meticulous attention to the detail of insertion is required. In addition, there has been recent concern about changes in the material properties of ceramic with time and a small number of cases of squeaking and stripe wear have been identified. Whether the prevalence of these problems will increase with time has yet to be determined.

A third alternative is to use metal on metal bearing surfaces. These were used over 50 years ago in some of the earliest components and gave mixed results. However, with improvements in metallurgy, design and manufacturing, it is felt by many that these will

function well. However, cobalt chrome components do generate small wear particles and metallic ions which can be deposited into tissues locally and into the circulation, and be trapped by distant organs. This has led to concern about immunologic problems and possible carcinogenesis at some point in the future. This is of particular concern since these bearing surfaces have been advocated for use in younger, high demand patients. There is also concern about the use of these components in patients with present or pending kidney disease. Only the passage of time will tell to what extent these theoretical problems will be encountered.



**Figure 9- A total hip with a ceramic on ceramic articulation- The “Reflection”, Third Generation (R3)™ (Smith and Nephew) hip system is one of the newest designs which incorporates a ceramic on ceramic articulation with bone ingrowth fixation for the femoral and acetabular components.**

A number of changes have taken place in component design and production since 1970. Unfortunately not all of them led to improvement. The change from stainless steel to “super alloys” of cobalt, chromium, and nickel and to titanium alloys for the femoral stem had certain advantages. However, when titanium was also used for the femoral head, a higher prevalence of early failures resulted, as this material functions poorly as a bearing surface.

Initially it was felt advantageous to increase the bond between the femoral stem and the methylmethacrylate when cemented components were used. This was done by roughening the metal surface and in some instances by using a precoating with methylmethacrylate.<sup>29</sup> Unfortunately, this led to an increased prevalence of failure and many now feel that a smooth or even polished surface, which allows a small amount of motion between stem and cement, is best.

In an attempt to enhance the wear characteristics of high density polyethylene, carbon fibers were added, giving a product referred to as “Poly 2”. Another approach

involved the use of heating and pressurization to yield "Hylamer". Both of these modifications resulted in an inferior product and were abandoned.

In the initial shift from cemented to non-cemented components a number of designs were introduced which had an unacceptable failure rate. These were abandoned and eventually both acetabular and femoral components were developed which gave a very high rate of success and excellent survivorship. A hydroxy apatite coating was added to the surface of certain non-cemented components to act as a stimulus to more rapid bone ingrowth. There was initially some enthusiasm for this approach, but subsequent studies showed that it added little if anything to the stability of a well designed component.<sup>30</sup>

Thus we have learned that not all changes will improve total hip components. When changes are made, the results must be evaluated carefully in a clinical setting before they are generally adopted.

There is currently an ongoing controversy regarding the type and size of the surgical incision to be used. Decreasing incision size has been referred to as minimally invasive surgery or MIS.<sup>31-34</sup> Some have advocated two small anterior incisions, whereas others have favored a single small posterolateral approach. The theoretical advantage of a small incision is that it causes less tissue trauma, less blood loss, does not cause instability of the hip, and allows a shorter period of immobilization and recovery. Although some authors have reported that this has occurred, a number of reports have indicated that the tissue damage is actually greater with a minimal incision, the incidence of complications such as femoral fracture, nerve damage, or malposition of components is increased, and that no advantages can be observed after the initial six to twelve weeks.<sup>31,33,34</sup> Even experienced hip surgeons have found that a minimum of 40 to 50 procedures are required for them to be comfortable with this approach. Often intraoperative image intensifiers are needed, and special instrumentation has been designed. At the present time few favor two small anterior incisions, whereas some still feel that a single posterior incision has advantages. Although this may work well in the hands of the experienced hip surgeon who performs a large number of cases annually, it is generally recommended that for most surgeons it is wise to use a standard approach with which they are familiar, although

the general trend is to make the incision somewhat smaller than in the past.

The posterolateral approach has many advantages, however one of its disadvantages is that in the past it has been associated with a relatively high incidence of postoperative dislocation, which some have reported as high as 4 to 5%, compared to 1 or 2% for an anterolateral or transtrochanteric approach. However, with retention of the capsule and short external rotators and careful reattachment, the prevalence of dislocation even with a posterior approach has dropped dramatically and now differs little from the prevalence with other approaches.<sup>32,35,36</sup> Attention to closure has also resulted in more rapid mobilization of patients and less concern with postoperative precautions previously felt to be essential to minimize dislocation.

There is currently increased attention to perioperative details including pain management. The use of preoperative analgesics and anti-inflammatory agents as well as a modified intraoperative and postoperative routine, has resulted in a considerable decrease in discomfort. This has led to more rapid postoperative mobilization, a decrease in the prevalence of complications, and the ability to discharge patients from the hospital sooner.<sup>37</sup>

Early discharge has been a topic of interest. Currently most patients are discharged from acute hospital care on the third or fourth postoperative day, although many of these may go to an extended care facility. Some surgeons, especially those advocating minimal incision surgery, have discharged patients home on the first postoperative day and occasionally even on the day of surgery. This has led to concern since recent articles have documented that a small but definite number of serious postoperative complications may occur as late as the sixth postoperative day.<sup>38</sup> Many of these may go undiagnosed if the patient has already left medical surveillance. This also led to concern regarding postoperative anticoagulation since it frequently does not allow sufficient time for the dose of Warfarin to be stabilized if this agent is chosen. Attempting to do this after discharge is less than ideal. This has given added weight to the arguments of those who favor the use of aspirin or low molecular weight Heparin where careful attention to dosage is not required.

The controversy regarding the best method of prophylaxis against thromboembolic phenomena continues. Warfarin and low molecular weight Heparin are still the most

commonly used following surgery in the United States. However, there is increasing evidence that the use of postoperative aspirin combined with hypotensive anesthesia, careful and rapid surgery, and both intraoperative and postoperative mechanical measures is equally effective in preventing postoperative pulmonary embolism.<sup>39</sup> This has been demonstrated to be associated with a lower incidence of postoperative bleeding complications, which can be serious. Studies are currently in progress to evaluate this issue in what is hoped will be a definitive manner. It should be noted that in Great Britain, for example, many feel that chemical prophylaxis is not required so long as meticulous attention is paid to mechanical measures to decrease postoperative thromboembolism.<sup>39,40</sup>

Issues of costs and reimbursement are currently receiving more attention than they have in the past.<sup>27, 41</sup> Total hip replacement is one of the most expensive procedures in total dollars expended by Medicare and private insurance carriers. This is not only because of the cost of the procedure itself, but also because of the cost of the components and the number of total hip replacements done annually. Accordingly, it is receiving considerable scrutiny from the federal government and insurance carriers. Hospitals and physicians have taken a more active role in negotiating the cost of implants with the suppliers and have been able to reduce costs significantly by this approach. Physician reimbursements have declined dramatically during the past ten years. The pressure on hospitals to discharge patients earlier has increased, thus decreasing their overall costs. Although one must be realistic and be conscious of the cost of total hip replacement as well as any other medical care, it is essential that this focus not drive physicians and hospitals to take potentially harmful shortcuts in the quality or quantity of care delivered or in the decision as to which of the various components should be used.

Despite experience with total hip replacement, optimum positioning of components remains somewhat elusive. We have seen the development of a number of navigation systems designed to insure optimum positioning of both the acetabular and femoral components. Although some of these are relatively simple, most require elaborate and expensive equipment, as well as considerable experience. They may not be practical for use by the individual performing a relatively small number of total hips annually, whereas

individuals performing a large number of total hips may find such devices of less value. Some have favored their use in conjunction with minimally invasive surgery. Their role in the day to day performance of total hip replacement has yet to be determined.<sup>42, 43</sup>

Conventional total hip replacement using stemmed femoral components remains the standard. In the United States however there has been increasing interest in the use of surface replacement or hemi surface replacement arthroplasty in selected cases.<sup>44</sup> Proponents feel that these may be indicated in younger patients with minimal deformity. As advantages they cite the fact that less femoral bone is sacrificed, the medullary canal is not invaded, the dislocation rate is lower, the procedure is more physiologic, and the postoperative function and activities are more normal. Even advocates however admit that these components are not indicated when there is significant deformity or leg length inequality, or when the residual bone in the femoral head is inadequate.

Surface replacements which were popular in the late 70s routinely failed. The present components now use a thin metallic acetabular cup fixed by biological ingrowth, rather than a thin cemented polyethylene acetabular liner. However, the femoral components are similar. Some authors have reported satisfactory early to intermediate results while others have found a higher incidence of failure compared with conventional total hip replacement. Devascularization of the proximal femur with osteonecrosis, and notching of the femoral neck with fracture remain problems to be considered. In addition, there is concern that the use of metal on metal bearing surfaces in young active patients will lead to possible future problems secondary to metallic debris and ion release. Whether this will or will not come to pass will await the passage of time. At present the use of surface replacement arthroplasty as an alternative to conventional total hip replacement requires close scrutiny.<sup>44-47</sup>

Hemi-Surface replacement arthroplasty has been used in a limited number of patients in whom pathology is essentially limited to the femoral head. In this procedure only the femoral component is used and the acetabulum is allowed to remain intact. Unfortunately, pain has been reported in up to 20 % of cases and a relatively high incidence of acetabular failure has been noted. Accordingly, this should be considered primarily a temporizing procedure



with the goal of delaying the need for total hip replacement.

## FUTURE DIRECTIONS

The advent and development of modern total hip replacement arthroplasty has led to dramatic improvements in the care and function of patients with advanced stages of hip pathology. At the present time there are a number of total hip components which have stood the test of time and which provide the majority of patients with complete or nearly complete relief of pain, and with a level of function which may approach that of a normal hip. The average age of patients undergoing THR is 65 and older. These patients usually are relatively low demand. This coupled with their life expectancy means that the vast majority of these patients will have satisfactory function of their THR throughout their lifetime. Our concerns are therefore focused mainly on the younger, more active patient. Because of the success of THR we are now doing these procedures in increasingly younger individuals, many of whom choose to resume a very active lifestyle. Thus the focus must be on extending the durability and survivorship of these components. The mechanical failures of earlier total hip components due to deficiencies in design or manufacturing have by and large been eliminated. The main cause of failure in the young active patient remains component loosening due to osteolysis. As mentioned earlier, this has been addressed by improving the quality of polyethylene, the use of ceramic on ceramic bearing surfaces, and the use of metal femoral and acetabular components.

With further improvements in design and manufacture of prostheses and surgical techniques, we anticipate greater durability and longer survivorship with total hip replacement arthroplasties. This means that younger patients with significant hip disabilities will undergo total hip replacement with less fear about repeated revisions. Thus we will come to a point at which even individuals in their 20s and 30s might anticipate that a single total hip replacement will last a lifetime. Certain procedures which are currently indicated for the treatment of younger patients with hip pathology will become less utilized. For example, there are a variety of procedures advocated to treat the patient with early to intermediate stages of hip dysplasia or osteonecrosis in the hope of forestalling the need for hip replacement. Many of these are

complicated, the chance of success is less than optimum, and even successful cases do not necessarily result in a normal hip. Many of these procedures will be abandoned in favor of total hip replacement arthroplasty which will be offered to younger and younger patients. In addition, those individuals who are interested in returning to an active lifestyle will find that less restrictions are placed upon them.

The heated debates currently going on regarding surgical approaches will be resolved. The marketing appeal of offering a minimally invasive approach will hopefully dissipate and surgeons will use surgical approaches with which they are comfortable, and which will allow them to insert components without excessive soft tissue damage, with minimal complications, and with the ability to achieve satisfactory component position. Incisions will be smaller than we have used in the past, but the use of a minimally invasive incision will be limited. Attention to soft tissue closure has eliminated the major disadvantage of the posterolateral approach, dislocation, and thus this approach will continue its popularity.

Greater attention to preoperative patient preparation and the use of preoperative analgesia, anti-inflammatory agents, and other medication will become more widely used. This will provide the patient with a more comfortable perioperative experience, will decrease the prevalence of complications and allow for earlier discharge and increased functional activity. The current debate regarding thromboembolic prophylaxis will hopefully be resolved once the results of studies now in progress become available.

Increased financial pressures from third party carriers and hospitals, will continue and presumably increase. Hopefully the medical community will have the courage to resist these pressures so that patient care and comfort are not unnecessarily sacrificed. This will require increased patient preparation and education and the availability of adequate intermediate care units following discharge for those patients who cannot be adequately cared for at home. Hospitals will continue a more aggressive bargaining position with the suppliers of medical equipment and devices, so as to get the best possible prices without sacrificing the quality of items supplied. Hopefully insurance coverage will be extended to the 45 million individuals who are presently uncovered. This should enable individuals to receive optimum medical

care which today may not be available for those with inadequate resources or insurance coverage.

The extent to which changes will take place in medical insurance and the delivery of health care cannot be predicted. Will we get to a single payor universal coverage and if so, when? It has been demonstrated that individuals and institutions performing a higher volume of certain surgical procedures in general get better results than those with quite a low volume. Will this at some point mandate that total hip replacement and other procedures will be performed only in special centers and by those with added training and qualifications? This may very well come to pass.

We have been most gratified to see the dramatic benefits afforded to patients with hip pathology with the advent and improvement in total hip replacement. We anticipate that further progress will take place, and that many of the problems for which we currently have no ideal solution will in fact have a satisfactory resolution in years to come.

## References

1. Barton JR. "On the Treatment of Ankylosis of Artificial Joints: A New Operation" No. American Medical Journal. 3: 279-400. 1827
2. Peltier LF. A History of Hip Surgery. In Callaghan JJ, Rosenberg AG, Rubash HE (eds). The Adult Hip. Philadelphia, Lippincott-Raven 3-36, 1998.
3. Murphy JB. Ankylosis: Clinical and Experimental. J Am Med Assoc 44: 1573-1582, 1671-1678, 1749-1756. 1905.
4. Baer WS: Arthroplasty with the aid of Animal Membrane. Am J Orthop Surg 16:1-19, 94-115, 171-199. 1918.
5. Cambell WC: Arthroplasty of the Hip: An Analysis of 48 Cases. Surg Gynecol Obstet 43: 9-17, 1926.
6. MacAusland WR, MacAusland AR: The Mobilization of Ankylosed Joints by Arthroplasty. Philadelphia, Lea & Febiger. 1929.
7. Colonna PC: A New Type of Reconstruction Operation for Old Ununited Fracture of the Femoral Neck. J Bone Joint Surg 17: 110-122, 1935.
8. Colonna PC: An Arthroplastic Procedure for Congenital Dislocation of the Hip: A Two-stage Procedure. Surg Gynecol Obstet 63: 771-781, 1936.
9. Smith-Petersen MN: Evolution of Mould Arthroplasty of the Hip Joint. J Bone Joint Surg 30B: 59-73, 1948.
10. Haboush EJ: A New Operation for Arthroplasty of the Hip Based on Biomechanics, Photoelasticity, Fast Setting Dental Acrylic and Other Considerations. Bull Hosp Joint Dis 13: 242-277, 1953.
11. Townley CO: Hemi and Total Articular Replacement Arthroplasty of the Hip with the Fixed Femoral Cup. Orthop Clin North Am 13: 869-894, 1982.
12. Amstutz HC: The THARIES Hip Resurfacing Technique. Orthop Clin North Am 13: 813-832, 1982.
13. Moore AT, Bohlman HR. Metal Hip Joint, A Case Report. J Bone Joint Surg 25: 688-692. 1943.
14. Murray WR: Endoprosthetic Replacement. In Steinberg ME: (ed). The Hip and Its Disorders. Philadelphia, WB Saunders Company. 823-848, 1991.
15. Bateman JE, Berenji AR, Bayne O, Greyson ND: Long Term Results of Bipolar Arthroplasty in Osteoarthritis of the Hip. Clin Orthop 251: 54-66, 1990.
16. Gluck T: Die Invaginationsmethode der Osteo-und Arthroplastik. Berl Klin Wochenscher 28: 732-736, 752-757, 1890.
17. Wiles P: The Surgery of the Osteoarthritic Hip. Br J Surg 45: 488-497, 1958.
18. Steinberg ME: Reconstructive Surgery of the Adult Hip: An Overview. In Steinberg ME (ed). The Hip and Its Disorders. Philadelphia, WB Saunders Company. 705-725, 1991.
19. Charnley J: Total Hip Replacement by Low Friction Arthroplasty. Clin Orthop 72: 7-21, 1970.
20. Shands AR: Fundamentals in Hip Surgery. In Tronzo RG (ed). Surgery of the Hip. Ed 2. New York, Springer-Verlag. 1-26, 1984.
21. Parvizi J, Purtill JJ: Hip, Pelvic Reconstruction, and Arthroplasty. In: Vaccaro AR (ed). Orthopaedic Knowledge Update-8. AAOS, Rosemont, Illinois. 411-424. 2005.
22. Karrholm J, Garellick G, Lindahl H, Herberts P: Improved Analyses in the Swedish Hip Arthroplasty Register. Scientific Exhibition at the Annual Meeting of the AAOS, San Diego, CA. Feb 14-18, 2007.
23. Campbell P, Shen F-W, McKellop H: Biologic and Tribologic Considerations of Alternative Bearing Surfaces. Clin Orthop 418: 98-111, 2004.
24. Dumbleton JH, D'Antonio JA, Manley MT, Capello WN, Wang A: The Basis for a Second-

- Generation Highly Cross-Linked UHMWPE. *Clin Orthop* 453: 265-271, 2006.
25. Fisher J, Jin Z, Tipper J, Stone M, Ingham E: Tribology of Alternative Bearings. Presidential Guest Lecture. *Clin Orthop* 453: 25-34, 2006.
26. Wright TM: Biomaterials and Bearing Surfaces in Total Joint Arthroplasty. In: Vaccaro, AR (Ed) *Orthopaedic Knowledge Update –8*. Rosemont, Illinois, AAOS. 57-67, 2005.
27. Huo MH, Gilbert NF: What's New in Hip Arthroplasty. *J Bone Joint Surg.* 87-A, 2133-2146. 2005
28. Jewett BA, Collis DK: Radiographic Failure Patterns of Polished Cemented Stems. *Clin Orthop* 453: 132-136, 2006.
29. Ong A, Wong KL, Lai M, Garino JP, Steinberg ME: Early Failure of Precoated Femoral Components in Primary Total Hip Arthroplasty. *J Bone Joint Surg* 84-A, 786-792, 2002.
30. Lombardi AV, Berend KR, Mallory TH: Hydroxyapatite-coated Titanium Porous Plasma Spray Tapered Stem. *Clin Orthop.* 453, 81-85, 2006.
31. Bal BS, Haltom D, Aleto T, Barrett M: Early Complications of Primary Total Hip Replacement Performed with a Two-Incision Minimally Invasive Technique. *J Bone Joint Surg.* 88-A. Supplement, Part 2. 221-233, 2006.
32. Iorio R, Secht LM, Healy WL, Tilzey JF, Presutti AH: The Effect of EPSTR and Minimal Incision Surgery on Dislocation after THA. *Clin Orthop.* 447: 39-42, 2006.
33. Meneghini RM, Pagnano MW, Trousdale RT, Hozack WJ: Muscle Damage During MIS Total Hip Arthroplasty. *Clin Orthop.* 453: 293-298, 2006.
34. Pagnano MW, Trousdale RT, Meneghini RM, Hanssen AD: Patients Preferred a Mini-Posterior THA to a Contralateral Two-incision THA. *Clin Orthop.* 453: 156-159, 2006.
35. Kwon MS, Kuskowski M, Mulhall KJ, Macaulay W, Brown TE, Saleh KJ: Does Surgical Approach Affect Total Hip Arthroplasty Dislocation Rates? *Clin Orthop.* 447: 34-38, 2006.
36. Chivas DJ, Smith K, Tanzer M: Role of Capsular Repair on Dislocation in Revision Total Hip Arthroplasty. *Clin Orthop.* 453: 147-152, 2006.
37. Maheshwari AV, Boutary M, Yun AG, Sirianni LE, Dorr LD: Multimodal Analgesia without Routine Parenteral Narcotics for Total Hip Arthroplasty. *Clin Orthop.* 453: 231-238, 2006.
38. Parvizi J, Mui A, Purtill JJ, Sharkey PF, Hozack WJ, Rothman RH: Total Joint Arthroplasty: When Do Fatal or Near-Fatal Complications Occur? *J Bone Joint Surg.* 89-A, 27-32, 2007.
39. Beksac, B, Gonzalez Della Valle A, Salvati EA: Thromboembolic Disease after Total Hip Arthroplasty. *Clin Orthop.* 453: 211-224, 2006.
40. Lachiewicz PF, Soileau ES: Multimodal Prophylaxis for THA with Mechanical Compression. *Clin Orthop.* 453: 225-230, 2006.
41. Bozic KJ, Saleh KJ, Lavernia CJ, Parvizi J: Economics of Total Hip Arthroplasty. In: Callaghan JJ, Rosenberg AG, Rubash HE (eds): *The Adult Hip, Second Edition Volume II*. 829-835, 2007.
42. Noble PC, Sugano N, Ursey MM, Murphy SS: Surgical Navigation: What's Available? *Proceedings of The Hip Society, Thirty-Fifth Open Meeting of The Hip Society, San Diego, CA: 32: 2/17/2007.*
43. Murphy SB, Ecker TM, Tannast M: THA Performed Using Conventional and Navigated Tissue-Preserving Techniques. *Clin Orthop.* 453: 160-167, 2006.
44. Amstutz HC, Beaulé PE, Dorey FJ, LeDuff MJ, Campbell PA, Gruen TA: Metal-on-Metal Hybrid Surface Arthroplasty. *J Bone Joint Surg.* 88-A. 234-249, 2006.
45. Campbell P, Beaulé PE, Ebrahimzadeh E, LeDuff M, DeSmet K, Lu Z, Amstutz HC: The John Charnley Award. A Study of Implant Failure in Metal-on-Metal Surface Arthroplasties. *Clin Orthop.* 453: 35-46, 2006.
46. Lachiewicz PF: Metal-Metal Hip Resurfacing: A Skeptic's View. *Proceedings of The Hip Society. Thirty-Fifth Open Meeting of The Hip Society. San Diego, CA. 2/17/2007.*
47. Ritter MA, Lutgring JD, Berend ME, Pierson JL: Failure Mechanisms of Total Hip Resurfacing. *Clin Orthop.* 453: 110-114, 2006.