Lessons of 30 Years of Total Hip Arthroplasty

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The following are lessons of 30 years of total hip arthroplasty (THA): Prosthetic components should allow for easy preoperative graphic planning with one or two templates only. Polyethylene is the weak link in THA and ought to be replaced by perfectly concentric metallic sockets and femoral heads of casted Cr/Co/Mo alloys. The operating technique should guarantee large exposure, suitable orientation of both components, and adequate fixation. Loosening is correlated with loss of bone stock and changes of the position of the implants. In case of progressive bone loss, one should reoperate already in presence of slight clinical symptoms to prevent more difficult and dangerous revisions. To evaluate objectively the outcome of THA, a combined data and roentgenographic documentation system with standardized terms and scales is necessary.

Harris and the author share the same views on many aspects of total hip arthroplasty (THA). This should be surprising. Differences lie not so much in the analysis as in the choice of what is essential and in what is emphasized.

It has been only recently that surgeons have come to realize that revision surgery for loosening of one or both components is becoming more and more common. This is beautifully documented in the last two books published from Wrightington. Sir John Charnley, the pioneer of total hip surgery, reported in his book "Low Friction Arthroplasty of the Hip" for the years 1966–1977 an incidence of loosening of only 0.4%. His pupil of many years and successor, Michael Wroblewski, published in his book in 1990 strikingly different statistics. In Wrightington in 1986, the number of revision procedures equaled the number of primary replacements.

Revisions are often lengthy and difficult procedures that can be dangerous for the patient and not very satisfying for the surgeon. Therefore, every hip surgeon must do his utmost to ensure the excellence of the primary procedure. This will not only delay loosening and revision surgery, but will go a long way to ensure that the results of revision surgery will approach that of primary procedures. This can only be achieved through a systematic documentation and a regular and meticulous roentgenographic follow-up evaluation of patients. This is the only way to ensure early detection of loosening and early revision before the inevitable destruction of bone stock has occurred.

The lessons of 30 years of THA can be assigned to five, and for the author the most important, aspects of THA: (1) preoperative graphic planning and stem design, (2) material of the prosthetic components, (3) operative technique (exposure, orientation, fixation), (4) loosening and loss of bone stock, and (5) a documentation system of roentgenographs and data. Because of space constraints, only a few pertinent points from these five important aspects of THA can be demonstrated.
PREOPERATIVE GRAPHIC PLANNING AND STEM DESIGN

Each THA must be preceded by a careful analysis of the roentgenographs and a careful drawing of the preoperative plan. In the plan, the surgeon must indicate the implant chosen and the procedure to achieve equalization of leg length. The preoperative drawing, which must correspond to the outline of the postoperative roentgenograph as well as an indication of all the steps of the operative procedure, are immensely advantageous for the surgeon. They force the surgeon to think in three dimensions, greatly improve the precision of surgery, shorten the length of the procedure, and greatly reduce the incidence of complications. The ability to represent graphically the desired result of surgery becomes also unequivocal proof for the surgeon that all the principles on which the procedure is based are understood, and that the procedure will be executed exactly as planned.

Careful preoperative planning is so important that the possibility of simple preoperative planning with one template alone has become one of the three prerequisites for a prosthetic system containing three prosthetic designs, each with six stem sizes. The others are extractibility and the possibility to solve all the problems in a primary THA with one prosthetic system.

In 1975, the author noticed in reviewing the ten- to 15-year results of his straight-stem prosthesis, a direct correlation between the contact of the prosthetic stem with bone and the result. The closer the contact between the stem and the bone, the better were the results. This observation was incorporated in the design of his straight-stem prosthesis released in 1977. The author designed three models (lateralized, standard, CDH), each with six stem sizes. This enabled the author to select prosthetic components that would fit exactly the particular biomechanical and structural demands of the patient’s hip. One template permitted planning for all 18 prostheses (Fig. 1).

MATERIAL OF THE PROSTHETIC COMPONENTS

The introduction of every new material has brought not only solutions but simultaneously new problems and new questions. The disadvantages of a new material have not always been so readily apparent, and sometimes it has taken a long time before the deleterious effects have become fully appreciated.

The introduction of polyethylene (PE) as a replacement for Teflon (DuPont, Wilmington, Delaware) in 1963 was a major step forwards. It has taken years to realize that the wear particles of PE cause synovitis and hypertrophy of the newly formed capsule as
well as cavitation of the endosteum of the femur and bone resorption of the acetabulum.

Most acetabular component migrations and prosthetic loosenings after ten years are probably the direct result of PE wear particles. The author believes that PE is the weak link in THA and not the cement. The so-called cement disease is usually the result of improper operative technique, but "PE disease" is the result of the material used for the socket. Is there any solution on the horizon for this problem?

The author was able to study three cases of metal-to-metal-bearing components he developed in 1965/66 together with Arnold Huggler and Sulzer Brothers. After more than 15 years of implantation, none of the sockets were loose. The reactions in the capsule were minimal and the articular surfaces showed no evidence of wear. As the result of these findings, the author started once again with metal-to-metal-bearing components and have been implanting these on an experimental basis since 1982. These are casted to within a very high tolerance and a gap not greater than 0.05. Some were coated with titanium nitrite or titanium carbide, which disappeared after five years of use. Some were not coated. The model being used today is a titanium shell with the metallic cup lying within a PE insert. The concentricity of the couple is so perfect that not only is the socket specially machined but so is the 28-mm head (Fig. 2). One cannot compare this metal-on-metal bearing with the McKee-Farrar total hip in which a regular Thompson femoral component was articulated with a Vitallium socket.

**OPERATIVE TECHNIQUE**

**EXPOSURE, ORIENTATION, FIXATION**

Operative technique is of immense importance for the success of the operation!

One of the best approaches that has withstood the test of time is the transtrochanteric approach consisting of a chevron (Swiss chalet roof) type of osteotomy, which the author has used now for more than ten years. No
sideway movements of the trochanter can occur and only a single tension wire is needed to secure the fixation (Fig. 3). This is the approach of choice in 15%–20% of the author's primary THAs, especially after previous operations such as osteotomy or arthrodesis or those patients with a stiff hip and in two thirds of the revisions. For all other cases, the author has adopted the modified lateral transgluteal approach, with the patient lying flat on his or her back.10

Orientation on the pelvic side is easier if the patient is in a supine position. The lateral position facilitates the correct introduction of the stem into the medullary canal, as it provides a good posterior view of the neck as in medullary nailing. It is also an advantage in difficult revision cases with a great amount of scar tissue, in which the sciatic nerve must be identified and protected.

Perfect fixation of the femoral stem is difficult in uncemented as well as in cemented procedures. The two main causes of failures with the use of cement are the incomplete sheet of cement if an intramedullary plug is not used and the disturbance of the cement during polymerization. This is followed by multiple cracks of the cement. In such a case, the patient usually begins to complain of pain shortly after surgery and revision becomes necessary within a few months of the primary procedure.

**LOOSENING AND LOSS OF BONE STOCK**

Loosening is characterized by loss of bone stock.

Migration, cavitation, and progressive changes in the position of the implant components on serial roentgenographs indicate loss of bone stock. Radiolucencies seem to be much less relevant than migration, cavitation, or changes in prosthetic orientation.

Cranial migration of the socket is measured from the tear drop line on a pelvic roentgenograph. Medial migration is measured from a perpendicular line to the tear drop. A change of the angle of the PE socket indicates advanced loosening. The frequent discrepancy between the clinical symptoms and the roentgenographic picture is the reason that patients who have only a vague sense of something wrong wait sometimes years before the next follow-up evaluation. If a progressive cranial migration is not reoperated early, extensive allografting combined with acetabular reinforcement devices (acetabular reinforcement ring or antiprotrusio cage) will become necessary and the revision procedure more and more difficult. To prevent lengthy and difficult revisions in the future, more and more patients should be operated on as soon as progressive bone loss is diagnosed, even if they have only minimal pain.

Subsidence of the stem with or within the cement is measured on comparable roentgenographs from the tips of both trochanters. Subsidence does not automatically lead to the same fate as socket migration. In many cases, the process can stop spontaneously, and restabilization occurs and the pain disappears. There is a much greater correlation between progressive stem loosening and increasing pain in the thigh and in the knee than similar pain and acetabular loosening.

**DOCUMENTATION**

Follow-up evaluation of THA should be performed for the duration of the patient's life. For the past 30 years, the author has carefully performed not only a data documentation but also a roentgenographic documentation in the form of chronologically arranged miniaturized copies of the pertinent roentgenographs taken before, just after, and 12 months after the primary THA and at appropriate time intervals. All of the miniatures are fixed to a special roentgenograph card. In the last five years, a copy of the preoperative graphic plan has also been included (Fig. 4). The miniaturized roentgenographs were created by means of a Scanatron (Elmedag AG, Obfelden, Switzerland) that produces detailed and sharp analogous images. The negatives are used also for slide presentation.
Figs. 3A–3D. Osteotomy of the greater trochanter. (A) A flat osteotomy allows side-to-side movements. (B) In a chevron-type osteotomy, the side-to-side movement is not possible. (C) Insertion of ends of bent 1.2-mm wire through drill hole. (D) The stem is then inserted, the wire ends pierced through abductors from inside out, passed through the small loop, and tightened. After bending the wire ends back, fixation is complete.
They are preserved and filed separately from the roentgenograph cards. The demographic, clinical, and roentgenographic data is obtained from standardized forms: Form A is for primary THA, Form B is for complications, and Form C is for follow-up evaluation. The information from these forms has been read and entered into the data base by means of an optical reader. With the data from these forms, the following information can be produced: (1) full case history of patient's hospitalization and follow-up evaluations, including letter to referring physician; (2) summary of all essential data from Forms A, B, and C; (3) statistical summaries of all data from Forms A, B, and C; and (4) statistical data for specific questions and graphic representation of statistical summaries.

This documentation system was demonstrated at the exhibit of the author's foundation at the SICOT World Congress in Munich (1977). The Executive Committee of SICOT decided to create a Commission for Documentation and Evaluation with the mandate to use the tools of the foundation as the basis for the development of an uniform method of reporting and evaluating results of treatment in orthopedic surgery. The first step of the Commission was to obtain a consensus about definitions of terms and scales from The Hip Society and the AAOS Task Force on Outcome Studies. This standardized system of terminology for reporting results was published in the literature. The next step was the creation of a decentralized documentation system located at each participating clinic and the conversion of the roentgenograph from an analogue into a digitized form.

Once a roentgenograph has been digitized and stored, its image can be retrieved and manipulated in a manner not possible with the
FIG. 5. Slides with standardized text: The essential demographic data (patient number, gender, age, time since last THA) on the roentgenograph. Underneath the roentgenograph, there is the essential clinical data (Op, type of operation; W, walking capacity; P, pain; M, motion) and the evaluation of the roentgenographic findings at the acetabulum and at the femur by the surgeon and of the outcome of surgery by the patient (=Ev).

original analogue image. Data stored from the digitized roentgenographs can be used for comparison. A selected roentgenograph can be brought to full scale, enhanced, overlaid with templates for preoperative planning or for measurement of changes, and printed on paper or slides (Fig. 5). Either may be combined with the summary of the case history that is a printout of a digitized roentgenograph combined with the case summary.

Galante asked for the possibility of analyzing the short- and long-term changes that occur in the femur and the pelvis in relationship to the presence of uncemented prosthetic components. It seems that this problem is being solved (Fig. 6). It is also possible to present the various shades of grey as pseudocolors that bring out in sharp contrast previously missed subtleties of changes in the grey scale.

It is possible that with the new techniques, the author will be able to diagnose the success or failure of osteointegration of an uncemented implant in less than a year. The author was also somewhat perplexed to see the rapid disappearance of the subchondral sclerotic bone and the appearance in important
FIGS. 6A–6D. Digitized roentgenographs showing the changes of the bony architecture in the pelvis in relationship with an uncemented shell. (A) Immediately after surgery. (B) Two years after surgery, the subchondral sclerotic bone has disappeared and has been replaced through remodeling by less-dense trabecular bone. The osteopenia appears very important. (C) Immediately after surgery. (D) One and one-half years after surgery, the autografted joint space is filled with normal bone.
FIG. 7. (A) Diagrammatic representation of the overlapping missions of the three organizations that were involved in the consensus on evaluation of THA. (B) Logogram of the author’s foundation indicating the central role of documentation for evaluation, learning, and teaching.

areas of osteoporotic bone. These important changes that have come about from a different type of functional loading need to be re-evaluated later on.

As Alan Apley stated, evaluation varies with the assessor and the feeling of the patient at the moment of the examination. But how is one to minimize errors? Should the assessor and the patient be eliminated? Migration is the essential sign of loosening; therefore, the slightest change in position of the implants must be registered. The measurements of cranial and medial migration, of the socket angle, stem subsidence, etc., are made infinitely easier with the evaluation template on either an analogue or digitized roentgenograph. These measurements can be made by each trained resident or computer specialist.

The new developments of IDES (International Documentation and Evaluation System) were published and presented at the exhibit of the Commission at the SICOT World Congress at Montreal in 1990. On that occasion, the Commission became a Standing Committee of SICOT. Courses on the documentation system IDES will be organized in 1992.

The IDES Standing Commission within SICOT will provide a continuous forum for international standardization of a nomenclature for all aspects of orthopaedic surgery and traumatology.

The consensus obtained on standardized terminology between IDES, The Hip Society, and AAOS Task Force on Outcome Studies has considerably improved the standardization of the author’s personal documentation system of THA (Fig. 7). All the important lessons of 30 years of THA are connected with the combined documentation system of miniaturized roentgenographs and data collected with standardized forms. Analysis of this data permitted the evaluation of the outcome of THA and was essential for teaching and continuing education efforts. This philosophy of documentation points clearly to the author’s philosophy: “Learning through teaching, learning and teaching through evaluation.”

REFERENCES