Joint replacement surgery

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ABSTRACT

- Joint replacement is the most effective healthcare measure in improving patient quality-of-life outcomes.
- More than 46 000 hip and knee replacements were performed in Australia between July 2000 and July 2001.
- The need for joint replacements will increase as the population ages.
- More than 90% of hip and/or knee replacements survive for 10–15 years.
- Prosthesis selection needs to be tailored to each patient, although rationalisation of types of prosthesis used is required.

MJA 2004; 180: S27–S30

JOINT DISEASE IS THE LEADING CHRONIC CONDITION in the elderly; it affects one in every eight Americans and almost half the population over 65.[1] Although many patients with arthritis can be treated by conservative modalities, such as weight reduction, modification of lifestyle, drug therapy, physiotherapy and occupational therapy, surgery, including joint replacement surgery, is available and often necessary for arthritis and other joint conditions. The main indication is pain that is incompatible with normal daily living and that does not respond to conservative treatment.

Joint replacement was initially introduced to treat hip and knee arthritis, and has been used much more extensively in these joints than in others. Arthroplastic prostheses have been designed for shoulders, elbows, wrists, fingers, ankles and toes and, more recently, intervertebral discs.[2] In general, the results of replacing these joints have been less satisfactory than with hip and knee replacement because of problems with bone stock and fixation. In this article, I discuss joint replacement as it relates to hip and knee arthroplasty.

Joint replacement surgery has become more accessible to a wider range of patients because of advances in associated disciplines. Anaesthesia is now safer because there are more effective drugs, improved techniques and better monitoring and postoperative pain control.

More effective treatment of diabetes and cardiac disease, and early diagnosis, prevention and treatment of deep vein thrombosis and pulmonary emboli,[3] has led to safer and more accessible surgery for patients with severe comorbidities. The use of better blood products, autologous blood,[4] cell savers and retrieval systems have made surgery safer, particularly in major procedures such as revision arthroplasty.

Preoperative and postoperative physiotherapy programs, preadmission clinics, the use of clinical pathways, devices such as continuous passive motion machines[5] and home visits by healthcare professionals as part of "hospital in the home programs" have all played a role in greatly improving outcomes and reducing length of hospital stay.

Before surgery, the patient should be aware of the risks associated with joint replacement surgery. In addition to thrombosis, infection and anaesthetic risks, there is the potential for damage to nerves and blood vessels, and wound healing may be a problem. Joints can dislocate, and can wear and loosen in the long term.

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When low-friction arthroplasty was introduced in the 1950s, the infection rate was greater than 7%. The development of laminar flow operating theatres, prophylactic antibiotics[6] and ventilated suits has lowered the infection rate to less than 1% in specialist centres.

Following surgery a rehabilitation program including physiotherapy and occupational therapy is recommended. Joint replacement recipients should be able to walk, cycle and swim normally, play golf and limited tennis, but should avoid heavy impact loading.

In Australia, 46 409 hip and knee replacements were performed from 1 July 2000 to 13 June 2001. The numbers have been increasing in recent years, as has the ratio of private to public operations.[7] New techniques are constantly being introduced. Joint replacement is the most effective healthcare measure for improving patients' quality-of-life outcomes, having a significant advantage over cardiac bypass surgery and treatment for hypertension.[8]

Winston Churchill said: "It is my earnest hope that pondering upon the past may give guidance in the days to come".[9] This has certainly been the case with joint replacement surgery, where many lessons have been learned over the years.

Hip replacement

The first joint replacement, a total hip arthroplasty, was performed in 1936. This procedure involved the use of stainless steel components with screw fixation; the major problems were loosening due to high friction and poor fixation. In the 1950s, Charnley reduced friction and improved fixation with a small-diameter stainless steel femoral head with a low-friction interface and polymethyl methacrylate cement.[10] He introduced ultra high molecular weight polyethylene (UHMWPE) in 1962, and this has persisted as a bearing surface component ever since. Although the Charnley low-friction arthroplasty with the use of a stainless steel stem and high molecular weight polyethylene cup was very successful in THR revision surgery, it was found that a large number of acetabular cups had become loose as a result of failure at the interface between the cement and the bone. This finding directed attention towards a surface that would allow direct ingrowth of bone into the prosthesis; this was achieved by sintering beads or mesh onto a prosthetic surface.[11]

The advantages of acetabular porous coating were that it eliminated the need for cement, provided better choice of fit or size, catered for varying head sizes, and the polyethylene liner could be exchanged without removing the acetabular shell. Initial implants required screw fixation, and early locking mechanisms were not ideal, causing liner wear. Introduction of smooth inner surfaces, better locking mechanisms and press fitting the shells to avoid screw fixation have led to improved results, so that acetabular shell loosening is now a rare event.[12]

Early femoral stems were made of stainless steel, and a single size was used for all femora. Later, as a result of stem fractures, particularly in larger, active patients, stronger metals and stems of variable sizes were introduced.[10] Cement was still used for femoral fixation, creating a "hybrid hip".[13] Loosening did occur in some cases, and was initially attributed to "cement disease". This led to improved cementing techniques with more thorough bone preparation using pulse lavage. Delivery with a cement gun, combined with distal intramedullary plugs to increase pressure, vacuum mixing to reduce bubbles in the cement and the use of low-viscosity cement, all improved the quality of the cement mantle and decreased loosening rates.[14]

The concept of an uncemented prosthesis was also applied to the femoral stem, and prostheses with porous coating were developed in the late 1970s and early 1980s. Hydroxy apatite coating enhanced ingrowth into these prostheses.[15]

Current femoral components come in a range of sizes with interchangeable heads, varying head sizes, a range of neck lengths and variable offsets. In most prostheses, the porous coating is confined to the proximal part of the stem. Precise distal cortical reaming was considered necessary to produce a good press fit, but the use of tapered stems has become more popular.[15]

Wear occurs at the interface between the femoral head and the acetabular liner. Fine particles are produced at UHMWPE interfaces, which migrate and accumulate to produce an inflammatory action causing osteolysis or bone dissolution and eventual loosening.[16]

Wear can be reduced by the use of low friction interfaces, reducing debris during surgery, correct component placement, patient selection and discouraging patient hyperactivity. Some interfaces, such as titanium/polyethylene, have been shown to be unsatisfactory. A chrome cobalt/polyethylene interface produces 4 mm of wear in 10 years, whereas a ceramic/polyethylene interface produces less. There is even less wear with new interfaces, such as metal to metal, ceramic to ceramic or metal to crosslinked polyethylene.[17] These new interfaces need to be used with caution until properly controlled long-term clinical data are available.

Current practice

Good to excellent results can be achieved with or without the use of cement for the femoral component. The choice depends primarily on the patient's bone quality, age, sex and physical demands. At present, wear is the major factor determining outcome.[18]

A recent survey showed that 57% of Australian surgeons used uncemented components for the femur and acetabulum in total hip arthroplasty and a further 29% inserted "hybrid hips" in which the femur only is cemented.[19] Only 14% of surgeons cemented both components. In younger patients (< 60 years), less than 24% of surgeons used cemented components, indicating an effort to tailor the prosthesis to the patient.

Personal recommendations

In patients aged over 70 years (who often have osteoporosis), a cemented all-polyethylene acetabulum and a cemented stainless steel stem with a metal-to-polyethylene interface is the method of choice and is very cost effective.[20] A triple-taper polished stem is now preferred.[21] In men aged over 60 years and women aged over 55 years, I recommend a modular hybrid arthroplasty, with an uncemented acetabulum, a cemented stem, a modular head and a metal/crosslinked polyethylene interface.

In younger patients (men under 60 years and women under 55 years), I recommend cementless components — a porous coated acetabulum, a porous coated stem, a modular neck and a low-wear interface.

In young patients other alternatives should always be considered, such as osteotomy and arthrodesis. Recently, there has been a renewed interest in resurfacing procedures.[22] The results of these procedures were poor when used in the 1980s, but the new prostheses have a metal-to-metal interface. The jury is out on this procedure.

Figures for 1985 to 1994 from the Swedish National Arthroplasty Register showed a 4.3% revision rate for aseptic loosening and 0.4% for infection for primary total hip replacement.[23]

Revision surgery is feasible, but demanding, and inadequate bone stock and higher infection rates are major

1: Results based on objective and functional assessments for 173 patients before and after knee replacement

	Knee score		
	Maximum possible	Before knee replacement	At 2 years
Function	100	46.6	74.6
Pain	50	12.7	42.7
Overall*	100	47.3	83.0

* Calculated by combining pain and objective data.

2: A zirconium oxide femoral component (metallic alloy with a ceramic surface)

problems. Revisions can be made simpler by careful follow-up of patients and anticipating problems earlier.

Knee replacement

The earliest designs for knee-joint prostheses were constrained hinges, which often loosened rapidly. Infection was a major problem because of the large bulk of the prosthesis beneath inadequate soft tissue cover. The introduction of total condylar prostheses in the 1980s was a major advance because the design simulated the normal knee. Modular components of different sizes provided better bone coverage and, with better instrumentation, led to more accurate placement,[24] providing increased movement and more accurate alignment.[25] However, with some designs there was a high failure rate of metal-backed patellae because of polyethylene wear, and excessive wear occurred with titanium-bearing surfaces. Most surgeons now use all-polyethylene patellar prostheses, titanium tibial trays, cobalt chrome femoral components and high molecular weight polyethylene tibial inserts. In revisions, modular component and stems can compensate for bone defects. These developments in prosthetic design have been accompanied by more sophisticated instrumentation. Computer-aided navigation systems are the latest innovation in attempts to position prostheses in optimal orientation.[26]

The outcome of total-knee arthroplasty has been improved by preoperative planning, better instrumentation, accurate bone cuts and more adequate soft tissue balancing. Rehabilitation using continuous passive motion has produced better results in some cases. In our service, as part of an international study group using a scoring system combining objective and functional assessments, marked improvements in pain and functional scores were achieved at 2 years (Box 1). Total knee arthroplasty systems have a 95% survival rate of 10–15 years[25] and, even in young patients, a survival rate of greater than 90%.[27]

There have been a number of innovations in recent years which are still being evaluated in terms of efficacy. Mobile-bearing knees, where the tibial insert is not fixed to the tibial base plate, are used in unicompartmental[28] and total arthroplasty[29] systems. At present, no distinct advantage is seen with these prostheses compared with fixed-bearing, total-condylar prostheses to justify their increased cost. The use of a zirconium oxide femoral component (Box 2) has been shown to reduce wear *in vitro*,[30] and early in-vivo studies have shown an improved range of motion with this surface.

Minimally invasive procedures have become popular and were applied initially to the knee for unicompartmental prostheses,[31,32] and more recently to total hip arthroplasty.[33] Biological resurfacing by autologous chondrocyte implantation[34] and other techniques provides an alternative to arthroplasty, if the patient can be treated at an early stage.

All new developments require monitoring, and the Australian Orthopaedic Association National Joint Replacement Registry — a joint venture between the Australian Orthopaedic Association and the Commonwealth Government — has been introduced to monitor hip and knee joint replacements.[7] This has been a highly successful venture, and there has been 100% compliance by orthopaedic surgeons and their professional associates in supplying data. The registry figures for hip and knee joint replacements between 1998 and 2001 are presented in Box 3. The Australian Joint Replacement Registry is an important innovation developed during the Bone and Joint Decade, but it will require ongoing funding.

It is essential that outcome studies, coordinated by a national prosthetic joint registry, are performed to ensure that the choice of prosthesis for each patient, among the many available, is rational and proven by a history of successful use. Too many different designs of prostheses are being used at present.[19]

3: Number of hip and knee replacements in Australia from 1 July 1998 to 30 June 2001

Joint	1/07/98 to 30/06/99	1/07/99 to 30/06/00	1/07/00 to 30/06/01	Change from 1998 to 2001
Hip	21 697	22 717	24 237	3.1%
Knee	18 819	19 852	22 172	11.7%
Total	40 516	42 569	46 409	9.0%

Table from the Australian Orthopaedic Association National Joint Replacement Registry 2002 annual report,[7] and includes Government joint replacement data from before the establishment of the Registry.

Competing interests

None identified.

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