# Surgery and joint replacement for joint disease

David MURRAY

Nuffield Orthopaedic Centre, Oxford, England

## Background—where do we stand today?

Joint replacements, particularly total hip replacement (THR) and total knee replacement (TKR), are extremely effective treatments for severe joint disease. Patients with severe pain, which may keep them awake and restrict their activity, are rendered virtually pain free by joint replacement. For the vast majority of patients this relief of symptoms lasts until they die, with no further interventions being necessary. The incidence of THR varies between countries and within countries. Within developed countries it is generally between 0.5 and 1.5 THR per thousand patients per year (Malchau et al. 1993). About one million THRs are implanted each year world-wide and the number of the TKR is rapidly catching up. In the United Kingdom about 50,000 THR are implanted annually and approximately 2% of people over the age of 60 have a THR.

Joint replacement is one of the most cost effective procedures in the whole of medicine and surgery. When comparisons are made on the basis of the cost of quality adjusted life years, THR has a similar cost effectiveness to coronary artery bypass surgery (Laupacis et al. 1994). It is substantially more cost effective than the treatment of moderate hypertension and an order of magnitude more cost effective than haemodialysis. These comparisons were based on a three year study of hip replacements. As THR usually last much longer than 3 years the cost effectiveness is substantially better than these comparisons would suggest. For patients with inflammatory arthritis, the cost of the procedure is recovered within two years because of the savings of other medical and social expenses. (Jonsson and Larsson 1991).

In the 1960s Sir John Charnley introduced the use of bone cement to fix implants, a standardized surgical technique, and, after initial failure with Teflon, polyethylene for the bearing surface. As a result of these innovations THR was transformed into a highly successful procedure. The best reported series suggest that about 90% of hip replacements are still working after 20 years in those patients who survive that long (Neumann et al. 1994). However, in other published series, and presumably in many series that have not been published, the results have not been so good because of higher revision rates. Furthermore, virtually all implants have been serially modified so that it is now impossible to obtain the original implants. We therefore do not know the long-term results of the implants in current use. As the number of primary THR implanted is so enormous the number of revisions is also large. The situation with TKR is similar to THR. There were major advances in TKR during the 1970s. As a result of these advances success rates in excess of 90% have been achieved at 20 years. Shoulder replacements are also very effective and are being used increasingly. Ankle, elbow and other small joint replacements are improving.

### *Morbidity and mortality*

The majority of joint replacements failures are a result of wear or failure of fixation. In an attempt to solve these problems there have been many developments within both hip and knee replacement. This has resulted in a rapidly increasing number of different designs joint replacement available. In the UK there are currently over 60 different designs of THR and over 30 different designs of TKR on the market (Murray et al. 1995, Liow 1997). The number available world wide is substantially larger. Unfortunately many of these new or modified joint replacements have ended in disaster (Huiskes 1993). At best they have only resulted in small improvements. Although we like to believe that this disasters are things of the past this is not the case as was recently demonstrated by the 3M Capital hip. Failed innovations have occurred in virtually all aspects of joint replacement, including implant shapes, materials, surface finishes, coatings, polyethylene, bone cement, and surgical techniques. At the time of introduction all these innovations seemed logical, it is only in retrospect that we have learnt why they have been inappropriate.

The long term success of a joint replacement is usually quantified by survival analysis in which revision is the end point (Murray et al. 1993). However many joint replacements that are unsatisfactory have not been revised. This may be because the patient is not fit, the operation is too difficult or the resources are not available. Furthermore some patients have some residual symptoms which are not severe enough to justify revision. For example about 20% of patients report moderate or mild pain (Britton et al. 1997). In addition in the early post-operative period about 20% of patients have complications. These complications may relate to the implant, with dislocation rates of a few per cent and deep infection rates of about 0.5%. The more common complications are medical. The morbidity associated with joint replacement is greater than is generally perceived. There is therefore a need to improve all aspects of joint replacement so as to minimize this.

It is difficult to accurately quantify the mortality associated with joint replacement. Patients who have THR tend to have a lower death rate than aged matched controls. This is presumably because they are in general fitter. Most studies would suggest that the death rate following THR is a few patients per thousand (Murray et al. 1996). However in these studies it is difficult to determine if these deaths were a consequence of the THR or would have occurred anyway. For three months after THR there is an increase in mortality amounting to about 2.5 times the background level (Seagroatt et al. 1991). There is some evidence to suggest that for the following nine months the death rate drops below the background level so that when the whole first post operative year is considered there is no increase in death rate (Dunsmuir 1996).

*Alternative surgical procedures*

Younger and more active patients have worse results from joint replacement than the older patients. In particular, they have a higher incidence of revision and multiple re-revision. Re-revisions are usually associated with substantial bone loss, which causes problems with reconstruction and subsequent high failure rates. Because of this, in young people, attempts are made to preserve the joint and thus delay the need for joint replacement. A joint usually becomes arthritic in a young patient because it is subject to an inflammatory process or has a mechanical abnormality. Surgical techniques, such as synovectomy, can occasionally be used with benefit in inflammatory arthritis. Mechanical abnormalities that predispose to arthritis are those that result in high contact stresses. Joint preserving procedures aim to improve the mechanics of the joint and reduce the contact stresses on the damaged cartilage. For example with unicompartmental knee arthritis, osteotomies are undertaken to transfer the load from the damaged to the normal compartment. Similarly with dysplastic hips, acetabular and femoral osteotomies or shelf acetabuloplasties are undertaken to increase the load bearing area of the joint. These joint preserving procedures are major undertakings with serious complications, which are often undertaken in patients with relatively mild symptoms. To define the role of these procedures there is a need for long term outcome studies to compare them with no intervention until joint replacement is necessary.

## Future perspectives

*Epidemiology*

Over the last two decades, the number of joint replacements implanted has been steadily increasing (Malchau et al. 1993). It is likely that this increase will continue for a number of reasons: As the population ages there will be more people in the appropriate age group. There are currently a large number of people who have symptoms severe enough to warrant joint replacement but have not had one (Edwards et al. 1994). In the future more of these patients will probably have joint replacements. As joint replacement improves, the indications for joint replacement are likely to widen which will, in turn, increase the number of joint replacements. Associated with the increasing number of primary joint replacements it is likely that the number and the complexity of revisions will increase. These revisions are potentially avoidable and are associated with considerable expense and patient suffering. Therefore a conserted effort should be directed at trying to improve the results of primary joint replacements.

*Developments*

The two major problems of joint replacement are loosening and wear. These should be addressed by coordinated clinical, biomechanical and biological research. There are now many bearing couples available, including metal on polyethylene, ceramic on polyethylene, metal on metal and ceramic on ceramic. It is likely there will be further advances in materials and surfaces. However it is essential that clinical trials are undertaken to determine which of the many combinations will work best in the long term. There are many methods of implant fixation, although these are basically either cemented or cementless. With cemented devices it is not clear if the implant should bond to the cement or not. It may be that equally suc-

cessful results can be achieved with both approaches but that different designs and surface finishes are appropriate for the different approaches. Many surfaces and surface coatings, such as Hydroxy-appatite, are available for cementless fixation. Clinical trials are necessary to determine which of these are the most effective at enhancing implant survival, and thus decreasing the need for revision.

Implants usually fail because the bone supporting them is resorbed. There is now some evidence to suggest that drugs such as bisphosphonates can delay or prevented this bone resorption, and thus prevent the implant from failing. When an implant does fail there is often substantial bone loss, which can cause major problems at revision and thereafter. The bone loss is usually addressed with cement, bone graft or massive implants. Improved methods for encouraging bone healing, possibly involving new materials, growth factors or transplanting techniques, need to be introduced. It is however essential that these techniques are studied with well controlled trials before they are used to any great extent.

Another important area in which advances will occur relate to the morbidity associated with joint replacement. Minimal invasive surgery for unicompartmental knee replacement is already being undertaken. This procedure can be done as a day case and the complications are minimized. Similarly, less destructive approaches may be introduced for total knee and hip replacement. Image guided surgery is being introduced for both hip and knee replacement and its wider use may result in improved accuracy of insertion, and thus enhanced reliability and implant survival.

A considerable research effort is being directed towards the development of techniques for repairing cartilage defects. Particularly promising approaches include the use of chondrocyte transplantation, growth factors and implantable resorbable matrixes. Although these techniques may be of use for localized areas of cartilage loss, it is unlikely that they will be successful for the extensive areas of loss that occur in arthritis. This is because the harsh mechanical environment associated with the arthritis will prevent the cartilage from healing. For biological techniques to work with large areas of cartilage loss they will probably have to be combined with mechanical approaches, such as osteotomy, so that the mechanical environment can be improved to allow the cartilage to heal. Even if satisfactory methods of obtaining cartilage healing are achieved they will not necessarily supersede joint replacement, and if they do this will take many years.

*Assessment*

There have been many developments in joint replacement that have resulted in disaster rather than improved results. In order to prevent further disasters methods of assessment should be improved and should be used more widely. Assessment should be undertaken pre-clinically, early after implantation and in the long term. The most relevant preclinical tests are those that relate to wear testing and the assessment of fixation. Wear testing is improving but as yet does not always predict clinical function. Pre-clinical assessment of fixation involves finite element modeling. However these techniques need substantial improvement before implants which will function badly can be identified.

Currently the best technique for early assessment after implantation is Radiostereogrammeteric analysis (RSA). The early migration of an implant is measured with RSA and is used to predict long term function. RSA measures by which good and poor implants can be classified need to be standardized. Once this has been achieved RSA should be more widely used to screen new and modified implants before they are released onto the market. If this screening was introduced it should prevent large numbers of implants that will subsequently fail from being used. More importantly however it will provide a mechanism by which joint replacement can progressively advance, without the need to wait at least 10 years to assess each development.

Orthopaedic surgeons are frequently scorned for not carrying out randomized controlled trials (RCT) to assess joint replacements. An RCT to demonstrate that THR or TKR is effective is unethical because these replacements are so effective. An RCT to demonstrate that one implant or technique is superior to another is difficult to undertake. Not only is it difficult for a surgeon to be equally good at two techniques and to randomize between them, but also, because joint replacement is so effective, such an RCT needs many thousands of patients followed for ten years. It is therefore not surprising that there have been only a few RCTs of joint replacements and they have usally been underpowered and too short. Long term assessment of large numbers of joint replacements has been achieved in Sweden and other countries with a register (Malchau et al. 1993). These registers have successfully identified implants that are functioning badly. Registers should therefore be used more widely. A register, however, only identifies implants that have been revised, and many implants that have not been revised many not be functioning well. There is therefore a need for implants to be assessed with patient based questionnaires to determine their medium and

long term outcome (Dawson et al. 1996). In addition, using these improved outcome assessments, randomized controlled trials are more practical and therefore should be used to compare implants and techniques.

A greater difference in outcome is seen between surgeons than between different designs of implant. Although it is tempting to blame the Surgeon it is much more likely to be the surgical techniques that are at fault. There is little data available to help surgeons decide which techniques to use. Studies of various techniques to enhance fixation and outcome are needed. For these studies to be practical the main outcome measure should probably be RSA. With RSA useful data can be obtained from a relatively small number of patients with a short follow up.

## Goals for the next decade

- Methods for assessing joint replacements need to be improved and used more widely so as to prevent disasters associated with poor implants. These assessments should be undertaken preclinically, soon after implantation and in the long term.
- Implants with better wear characteristics and improved fixation need to be developed.
- Studies should be undertaken to improve surgical techniques so as to enhance implant survival, improve function and minimize complications.
- Further research is needed to develop methods for preventing bone resorption, for reconstructing bone at revision surgery and for cartilage repair. These new techniques should to be studied with properly controlled clinical trials before they are widely used.

## References

Britton A, Murray DW, Bulstrode C. Pain as an outcome measure after total hip replacement. J Bone Joint Surg [Br] 1997; 79-B: 93-8.

Dawson J, Fitzpatrick R, Carr A, Murray DW. Development and validation of a questionnaire to assess patients' perceptions in relation to total hip replacement. J Bone Joint Surg 1996; 78-B: 185-90.

Dunsmuir R A, Allen D B, Davidson L A G. Early post-operative mortality following primary total hip replacement. J R Coll Surg Edinb 1996; 41: 185-91.

Edwards MS, Murray DW, Bulstrode CJ. The need in the community for total Hip and Knee replacement. J Bone Joint Surg [Br] 1994; 76-B S2: 90.

Huiskes R. Failed innovation in total hip replacement. Diagnosis and proposals for a cure. Acta Orthop Scand 1993; 64: 699-716.

Jonsson B, Larsson S. Functional improvement and costs of hip and knee arthroplasty in destructive rheumatoid arthritis. Scand J Rhem 1991; 20: 351-7.

Laupacis A, Bourne R, Rorabeck C, Feeny D, Wong C, Tugwell P, Leslie K, Bullas R. Costs of elective total hip arthroplasty during the first year. Cemented versus noncemented. J Arthroplasty 1994; 9: 481-7.

Liow R, Murray D. Which primary knee replacement. Ann Royal Coll Surg Eng 1997; 5: 335-40.

Malchau H, Herberts P, Ahnfelt L. Prognosis of total hip replacement in Sweden. Follow up of 92,675 operations performed 1978-1990. Acta Orthop Scand 1993; 64: 497-506.

Murray DW, Bulstrode CJK, Carr A. Survival Analysis of Joint Replacements. J Bone Joint Surg [Br] 1993; 75-B: 697-705.

Murray DW, Bulstrode CJK, Carr A. Which primary total hip replacement? J Bone Joint Surg [Br] 1995; 77-B: 520-7.

Murray DW, Britton A, Bulstrode CJK. Thromboprophylaxis and death after total hip replacement. J Bone Joint Surg [Br] 1996; 78-B: 863-70.

Neumann L, Freund KG, Sorensen KH. Long term results of charnley total hip replacement. Review of 92 patients at 15 to 20 years. J Bone Joint Surg 1994; 76-B: 245-51.

Seagroatt V, Tan HS, Goldacre M, Bulstrode C, Nugent I, Gill L. Elective total hip replacement: incidence, emergency readmission rate, and postoperative mortality. BMJ 1991; 303: 1431-5.