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Effective Health Care

Bulletin on the effectiveness of health service interventions for decision makers

Nuffield Institute for Health, University of Leeds,

NHS Centre for Reviews and Dissemination, University of York

Total hip replacement

- The rate of elective total hip replacement is increasing. Around 40,000 were carried out by the NHS in 1994/95 and a substantial number by the private sector.
- Total hip replacement is a highly cost-effective procedure, however outcomes vary across the country.
- Decision aids to identify patients suitable for referal for total hip replacement have been developed.
- A large number of hip prostheses are used in Britain widely differing in price. Very few of these have had proper long-term evaluation.
- The cheaper, standard cemented, implants such as the 'Charnley' and the 'Stanmore' have been the most thoroughly evaluated and have been shown to have the lowest long-term failure rates over 10–20 years follow-up.
- Purchasers and providers should promote the use of those prostheses which have been shown to perform best in long-term follow-up.
- New prostheses should only be used after they have been thoroughly evaluated or as part of a national coordinated study.
- There is some evidence that patients operated on by trainees and surgeons with low volume of activity have poorer outcomes.
- Purchasing 'lifetime hip care' rather than individual procedures may provide an incentive to promote quality.

A. Background

Elective total hip replacement (THR) surgery is performed primarily to relieve pain, stiffness and deformity caused by disease of the hip joint.

There has been an increase in the overall rate of THRs performed over the last decade (Fig. 1) with over 38,000 elective THRs performed by the NHS in England in 1994/5. Over three-quarters of these were performed as a primary procedure.[1] The demand for primary THR may increase further because disease of the hip is age-related and people are living longer (Table 1).

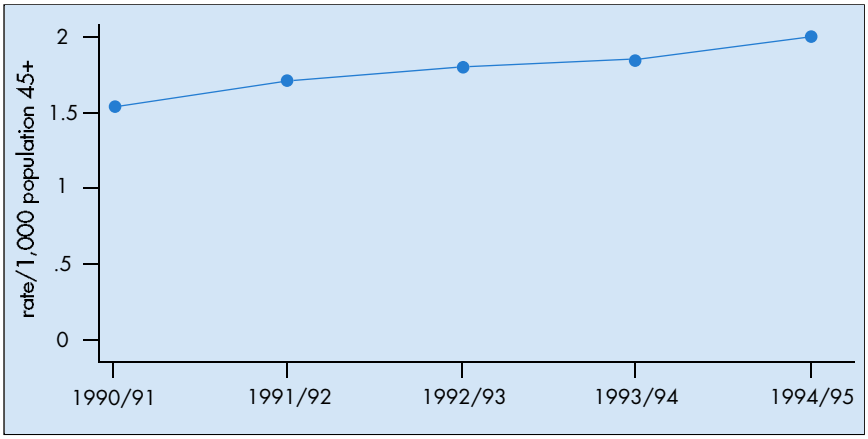

Fig. 1 Rate of Elective Total Hip Replacement in England (Age-sex standardised rate/1,000 population 45+)[1]

Some hip replacements fail after a period of time by breaking, loosening, wearing or becoming infected. Hip replacements to replace a failed one (revision procedure) form about 11% of all elective THRs and are likely to increase as the length of life of those receiving hip replacements increases.

Table 1 Age and sex-specific elective THR rates per thousand population, English NHS hospitals 1994/5[1]

Age	Male	Female
45-54	0.4	0.5
55-64	1.6	1.9
65-74	2.5	3.8
75-84	3.4	4.6
85+	1.7	1.9

In a study of three English health districts in 1991, 20% of THRs had been performed privately.[2] This is confirmed by a recent estimate that around 11,000 operations are undertaken in the private sector each year. (Houghton, personal communication, 1995)

This bulletin considers the research evidence on whether health care needs are being met, the effectiveness and cost-effectiveness of different types of THR surgery and suggests how this evidence can be used by purchasers, providers and policy makers to improve the quality of care. Relevant literature was identified by electronic and manual searches, as detailed in Appendix 2.

There are important aspects of this subject that are not dealt with in this bulletin:

- **Rehabilitation after surgery:** whilst the quality of surgery is important, the degree to which it can improve physical and social functioning may be affected by the programme of post-operative rehabilitation. Research on rehabilitation was not reviewed as part of this bulletin.
- **Antibiotics to prevent infection:** One of the complications following THR is loosening of the prosthesis due to infection which may result in the need for a revision. A systematic review of the research on antibiotic prophylaxis in THR is being conducted by the NHS Centre for Reviews and Dissemination on behalf of the Standing Group on Health Technology and will be available at the end of 1997.
- **Prevention of deep vein thrombosis:** Another complication of major surgery like THR is the development of deep vein thrombosis and, more rarely, pulmonary embolus. There is a widely held view that all patients should be given thromboprophylaxis (such as the low molecular weight heparin or warfarin). There is a concern however, that the incidence of serious complications is now so low, and the costs and risk of using the drugs relative to potential benefits too high to justify routine thromboprophylaxis.

  The whole question is methodologically complex and many of the studies and reviews in this area are of doubtful quality or relevance to contemporary practice. On the basis of existing knowledge we feel that it is not possible to produce valid evidence-based recommendations on this issue as part of this bulletin.

B. Need for surgery

B.1 Who should receive THR surgery?: Although severity of pain and disability are the principal indications for surgery, few studies have examined the appropriate indications for surgery in detail.

According to the US National Institutes for Health Consensus Development Conference Statement,[3] 'Candidates for elective THR should have radiographic evidence of joint damage and moderate to severe

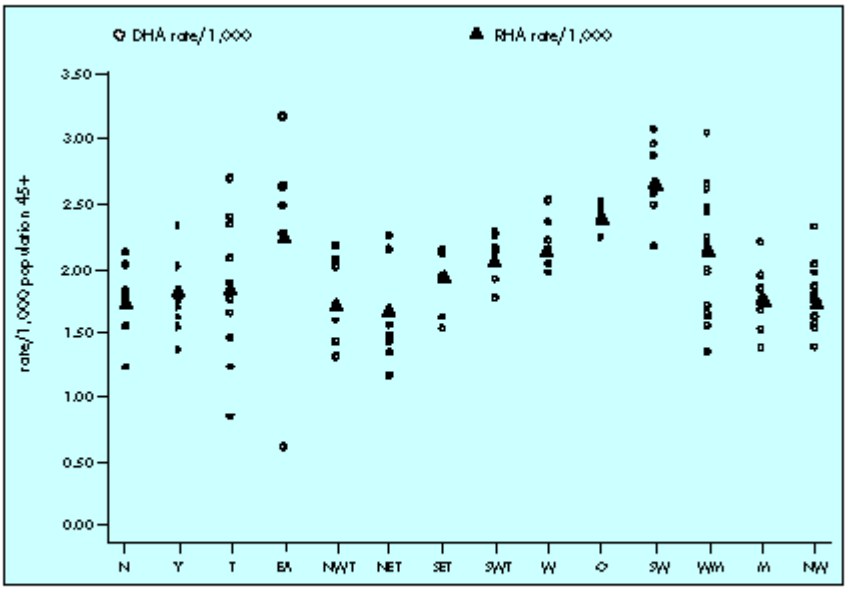

Fig. 2 Rate of elective total hip replacement in England by region and district (Age-sex standardised rate/1,000 population 45+)[1]

pain and/or disability that is not relieved by an extended course of non-surgical management.' However, this does not provide clear indications for referal or treatment. A recent study[4] employed a structured approach to develop consensus indications for the appropriateness of surgery based primarily on the Charnley score of severity.[5]

Particularly helpful, especially for general practitioners and purchasers, is a recent set of patient referal appropriateness ratings and urgency rankings.[6] Structured as a decision tree, it allows GPs to take into account important clinical and social factors which indicate the likely benefit patients will derive from a THR. These include factors such as the patientís age, level of functioning, degree of pain, problems with work or caregiving and the likely survival of the prosthesis based on patient characteristics. This decision aid can be used by practitioners and managers to rapidly assess the need and urgency for referral, and the degree of appropriateness of referral for hip or knee replacement in audit.

B.2 Unmet need for THR: A study of Oxford districts showed that there has been a trend towards greater equity in local NHS THR surgery in the decade from 1976–85.[7] Recent national data however, show that there are still significant variations in district age and sex adjusted rates (Fig. 2 and Appendix 1).

Various community surveys have been carried out to estimate the degree of unmet need for THR in the population. A postal questionnaire and follow-up telephone interview of a general practice population in Oxford in 1993 estimated that 3.3% had hip symptoms which warranted surgery.[8] A large postal questionnaire survey in North Yorkshire has estimated that about 2% of people over 55 may benefit from knee replacement[9] and that over 1% had levels of pain and disability consistent with the need to consider THR.[10]

These studies are limited by their sole reliance on a limited set of symptoms. A population study of 28,000 adults has recently been undertaken in Avon and Somerset, which screened a randomly selected sample of the population. Five per cent reported symptoms of hip disease[11] and these will be followed up with detailed history, clinical and radiological examination with the aim of estimating the population requirements for THR surgery. The full results will be available at the end of 1996 and may give more reliable estimates of levels of unmet need.

It is not clear the extent to which identified unmet need is the result of a backlog created by insufficient surgery in the past or whether current rates of surgery are failing to meet the needs of new or incident cases. Estimates of need are also likely to vary over time as critiera change in reponse to changes such as advances in anaesthetic technique which reduce the risk of surgery for older patients.

C. Effectiveness of THR

There is no doubt that total hip replacement results in a significant and sustained improvement in the quality of life for the majority of patients who have the operation.[12] Because of the dramatic and immediate effects on pain and mobility there is no need for placebo-controlled trials to establish the effectiveness of the procedure.

The outcomes of primary THR surgery however, in terms of technical success, morbidity and patient satisfaction, are highly variable.[13,14] The success of THR depends *inter alia* on the type of prosthesis used, method of fixation (whether cement is used and what type), the surgical technique, and a range of measurable and unmeasurable patient and clinician factors.

C.1 Large number of unevaluated prostheses: It has been estimated that there are around 62 different replacement hip joints available in Britain manufactured by 19 different companies, ranging in cost from £250 to £2000; half of these have been introduced since 1990.[15] Most of these prostheses have not been properly evaluated and so no one knows how long they will last.

There are broadly three classes of hip replacement, defined according to the method by which the prosthesis is fixed (Fig. 3). In cemented THR the prosthesis is fixed by cement at both the acetabulum (hip socket) and femur; for cementless THR, the prosthesis is not fixed by cement at all; for hybrid THR there is a cementless socket with a cemented femoral component.

C.2 Difficulties in evaluating the evidence: There are many problems in trying to assess the relative effectiveness of different types of THR surgery. Firstly, there are few high quality prospective comparative studies. In most of the research there is short follow-up, groups of patients and surgeons are very selective, and patients receiving different types of prosthesis and their surgeons may differ in important ways. Apart from the more sophisticated registers in Sweden[16] and Norway[17] which collect a lot of relevant patient data and use these to adjust for the effects of case-mix, most comparisons are likely to be heavily confounded by differences in patient and practitioner characteristics.[18] This brings into question the validity of the comparisons.

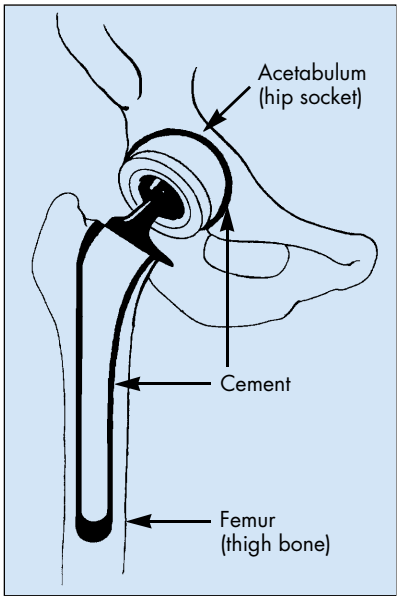

Fig. 3 Total hip replacement using bone cement

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The variability of results has increased the demand for audit data on the THR failure rates in orthopaedic units. There have been recent calls for a national arthroplasty register which will collect comparative data on implants and outcomes.[19] One has been developed in the Trent Region.[20]

Length of follow-up

Many of the complications arising from THR and failure rates are long-term phenomena. Some implants, for example, had promising short term (e.g. five year) results but have been shown subsequently to have high failure rates between 5 and 10 years after surgery.[21] This means that reliable evidence on the clinical effectiveness of a prosthesis can only be obtained by long-term (at least 10 years) follow-up. Therefore, case series reporting the outcomes of different prostheses are only reported in this bulletin when there has been at least 10 years follow-up and where at least 200 patients were included.

Various intermediate or surrogate outcome measures, are being developed in order to try and predict longer-term outcomes. For example, those prostheses which are likely to fail early tend to show a more rapid rate of migration (or sinking into the femur or pelvis) of the prosthetic components, as detected by standard radiographs or more sophisticated spatial imaging techniques such as three-dimensional stereo radiogrammetry (RSA).[22-24] These techniques if properly validated, will allow more rapid evaluation of new prostheses at around 2 years, by predicting the longer-term survival of the implant.

Outcome measures

Lack of standardisation in outcome measurement for THR surgery has made comparisons between published series difficult. For example, some studies use clinical outcomes or revision as a final outcome measure while others use X-ray evidence. Most grading systems for assessing outcome include measures of pain, joint geometry and function. These over-emphasise physician-defined pain relief and measures of technical success rather than more patient-centred outcomes such as quality of life and the extent to which the goals and expectations of the patient are met by surgery.[25]

Use of different endpoints may influence the results.[27] Qualitative research has shown that patients may be disappointed by the outcome if function is not improved, even if substantial pain relief is achieved.[28] However recently some studies have measured health-related quality of life,[29,30] and a feasible validated outcome measure - the Oxford Hip-Score - is now available.[31]

D. Different prostheses and methods of fixation

D.1 Charnley and other cemented prostheses: The most commonly used cemented prosthesis - the Charnley - has been evaluated in several long-term studies. However, as with other prostheses, what is called 'the Charnley' has been modified over time and so studies are not always evaluating identical prostheses. Also the techniques for inserting it and applying the cement have changed over time. In earlier case series for example, procedures were performed using hand-packing cement methods and the prostheses were made with older metallurgic technology. In addition, many of the surgeons performing the operations had little experience with the procedure.

Despite these early shortcomings, at a minimum of 15 years follow-up, 80-90% of surviving patients experienced little or no pain,

though X-ray results, showing changes in the bone, were less encouraging. More experience, new techniques for insertion (including pressurization of cement), improved design and newer metallurgy have led to minimal loosening rates at 5 and 10 year follow-up. Altogether, 20 series meeting our criteria (*C.2*) were found for the Charnley prosthesis (Table 2a).[16,21,26,32-49] A further two series examined outcomes for acetabular components only (Table 2b).[45,50] Most of these studies show that at 10-20 years follow-up, around 90% or more of patients followed have reasonably good clinical outcomes.

Implant survivorship at a level of 90% or better has been found with some alternative cemented implants, notably the Stanmore, and the Lupinus (Table 3).[21,26,51-53] The comparability of the Stanmore and the Charnley was also suggested by a recent randomised controlled trial.[54] In contrast, the 10 year follow-up results of other cemented implants such as the McKee-Farrar, the Exeter matt surface, Muller curved and the Christiansen are not so impressive (Table 3).[21]

D.2 Non-cemented prostheses: Tables 4a and 4b summarize the four series which assessed the outcome of primary surgery with a cementless femoral component or a cementless acetabulum and meet the criteria.[53,55-57] These prostheses are generally poorer than the cemented prostheses. Non-cemented prostheses are not a homogeneous group. The early generation of, mainly, porous implants gave disappointing results. Failure rates were generally higher than for cemented prostheses, partly because they were not fixing well into the bone. Newer ones, which have a hydroxyapatite coating in order to promote bone ingrowth, are producing more encouraging results which remain to be confirmed in trials with longer follow-up.[58]

Cemented and uncemented prostheses have also been compared in randomised controlled trials (Table 5)[12,59-63] Results from the trials are marginally in favour of cemented prostheses, but are inconclusive because of small numbers, inadequate adjustment of risk factors and limited duration of follow-up.

Overall the case series and trials favour the routine use of cemented prostheses, in particular the Charnley and the Stanmore. This is supported by data collected from all 64 Norwegian hospitals performing THR.[64] 24,408 primary THR operations were registered between September 1987 and February 1993. The cumulative failure after 4.5 years was 2.7% for cemented, compared with 6.5% for cementless.

D.3 Revisions: Generally there are much poorer outcomes following revision of THR, than with primary THR, with loosening rates ranging from 20%[65] to 29%[66] and with re-revision rates of 6.7% and 19% respectively. Results of cemented revisions with or without bone grafting appear inadequate in the intermediate (5-10 years) and long run (greater than 10 years). The overall data relevant to cementless revision surgery are short-term, of poor quality and inconclusive.

E. Volume and specialisation

E.1 Skills: Implant design and the method of fixation are not the only aspects of surgery which affect the outcomes of care. It is likely that surgical skill and technique are also important. A randomised controlled trial comparing the Charnley with the Stanmore implant, for example, found that the THRs carried out by trainees in England were over 11 times more likely to need a revision than those carried out by a consultant (P=0.005).[54]

E.2 Volume: Ten studies were identified which have examined the relationship between the short term outcome of patients undergoing hip or knee replacement and hospital or surgeon volume of surgical activity.[16, 67-75] Most were carried out in the USA and were mainly based on retrospective analyses of discharge abstract data. Only 6 of them made any serious attempt to adjust for differences in case mix between high and low volume institutions or clinicians.[16,67,69,70,72,73]

All but two of the better studies[12,69] found that higher hospital volume and/or clinician volume of joint replacement surgery was associated with a lower rate of post operative death, shorter length of stay or post-op complications. However the level at which this occurs appears to be relatively low. Only the study based on a large Swedish Registry, examined any association with medium- or long-term outcomes. It found significant variations in the rate of aseptic loosening between consultants. This could not be explained however, by differences in the volume of activity.[16]

F. Economic aspects

F.1 Cost-effectiveness of THR: THR results in a considerable improvement in quality of life in a high proportion of patients which is sustained for several years.[29,30] THR has also been estimated to be highly cost-effective.

Williams[76] (assuming a failure and revision rate of 2% per year) estimated the cost utility of THR at about £750 per Quality Adjusted Life Year (QALY) gained. This compared favourably with a cost/QALY gained of £14,000 for one year of hospital haemodialysis, and of £5,000 for heart transplantation. Broadly similar conclusions have been reached in other studies.[12,77,78] A recent US cost-effectiveness analysis from a

Table 2a Charnley primary total hip replacement series with at least 200 THRs and 10 years follow-up (with trochanteric osteotomy) using old cementation

Authors/ study design/ age of patients	No. of operations/ % follow-up/ duration of follow-up (yr)	Other risk factors	Status of surgeon/type of hospital	Outcome measures	Results
Britton et al (1996)[26] Descriptive (prospective)	208 94% (amongst alive) 24% died 1-16 yrs	Diagnosis OA, diagnosis RA	Consultant/ District general hospital	Survivorship, pain, observer-defined function, gait, joint geometry	Survivorship at 10yrs 84% (revision); at 10yrs and 14yrs 84% and 79% (revision, moderate or severe pain)
Older (1986)[32] Descriptive (prospective) including pre-op status 42-55 yrs (median=64)	217 70.5% 10-12 yrs	Age at surgery, sex, diagnosis OA, diagnosis RA, surgical approach, patient risks: infection	Consultant/ Specialist centre	Survivorship, pain, observer-defined function, gait, joint geometry, X-ray criteria	88% satisfactory, 6% revision, 92% satisfied
Johnston & Crowninshield (1983) [33] Descriptive (retrospective) Age not stated	326 55.8% 10 yrs	-	-/Teaching hospital	X-ray criteria	9% femoral loosening, 7.9% acetabular loosening
Neumann et al (1994)[34] Descriptive (prospective) including pre-op status 34-79 yrs (median=62)	241 96% survivors (n= 103) 15-20 yrs	Age at surgery, sex, body mass index, diagnosis OA, diagnosis RA, surgical approach, previous surgery, weight	Consultant/Teaching hospital	Survivorship, pain, observer-defined function, joint geometry, X-ray	Probability of revision 10.7% at 20 yrs, 7% <3 for pain movement (Charnley score), 30% loosening
Older & Butorac (1992)[35] 42-85 yrs (mean=68)	388 34% 17-21 yrs	Age, sex, diagnosis OA, diagnosis RA, patient risks: infection	-/District general hospital	Survivorship, X-ray	Revision 6%, loosening 17% cups, survivorship 89% at 20 yrs (cup & stem)
Wroblewski & Siney (1993)[36] Descriptive (prospective) post-op status only 23-68 yrs (mean=47)	1324 - 18-26 yrs (av 10 yrs)	Age at surgery, diagnosis OA, diagnosis RA, surgical approach	-/Specialist centre	Survivorship, pain, observer-defined function, joint geometry, X-ray defined criteria	Dislocation 0.63%, revision 0.11%, infection 0.3-1.5%, pain free 85%; normal function 60%
Dall et al (1993)[37] Descriptive (retrospective) Mean age = 60 yrs	811 66.2% 10-12 yrs	Age at surgery, sex, diagnosis OA, diagnosis RA, bilateral/unilateral	-/Teaching hospital	Survivorship, pain, observer-defined function (d'Aubigne), joint geometry, X-ray defined criteria	Survivorship 87% 10-12 yrs, 8% revised
Schulte et al (1993) [38] Descriptive (prospective) including pre-op status 29-86 yrs (mean=65)	322 98.5% 20+ yrs	Diagnosis OA, diagnosis RA	Consultant/Teaching hospital	Survivorship, pain, observer-defined function, joint geometry, X-ray defined criteria	90% survivorship (retained implant), 85% pain free, 53% no walking aids, 10% revised
Skeie et al (1991)[39] Descriptive (prospective) post-op status only 23-88 yrs (mean=66)	629 89.7% 10-15 yrs	Diagnosis OA, diagnosis RA	-/District general hospital	Survivorship, pain, observer-defined function, joint geometry, X-ray defined criteria	92% survivorship at 13 years; 86% patients good result, 7% revised
Thomas & McMinn (1991)[40] Descriptive (retrospective) Ages not stated	1069 - 10+ yrs	-	-/Specialist centre	Survivorship	92% survivorship at 10 yrs, no improvement following changes of cement techniques
Charnley (1979)[41] Ages not available	302 - 12-15 yrs	-	-	-	>5.8% revisions
Stauffer (1982)[42] Descriptive (retrospective) 39-84 yrs (mean=64)	207 90% 10 yrs	Age, sex, diagnosis OA, diagnosis RA, surgical approach	-/Specialist centre	Survivorship, X-ray	Revisions 10.8%, cup loosening 11.3%, stem loosening 29.9%
Johnsson et al (1988)[43] Descriptive (retrospective) M 36-87 yrs (median=65) F 47-84 yrs (median=67)	204 100% 4-14 yrs	Age, sex, diagnosis OA, surgical approach, other	-/Teaching hospital	Survivorship	Revision 14.7%

Table 2a Continued

Authors/ study design/ age of patients	No. of operations/ % follow-up/ duration of follow-up (yr)	Other risk factors	Status of surgeon/type of hospital	Outcome measures	Results
Malchau et al (1993)[21] (incorporates Ahnfelt et al, 1990 [16]) Descriptive (prespective), Swedish national registry M median = 66 yrs F median = 64 yrs	92,675 100%? 10 yrs	Age, sex, diagnosis OA, diagnosis RA, other	All grades of surgeon/All types of hospital	Survivorship	Revisions around 9%. Similar results for C.A.D. and Lubinus. Worse results for other cemeneted implants: Muller curved, Exeter, Spectron, PCA and the Christiansen.
Carter et al (1991) [44] Descriptive (retrospective) Ages not stated	1616 31% 10-20 yrs	Not stated	-/District general hospital	Survivorship	Survivorship 91% 10 yrs, Survivorship 82% 20 yrs
Garcia-Cimbrelo & Munera (1992)[45] Descriptive (retrospective) 18-79 yrs (mean=56)	680 60% at 10 yrs 18 yrs	Age, sex, diagnosis OA, diagnosis RA, body mass index, surgical approach	Senior surgeons/specia list centre	Survivorship, pain, observer-defined function, gait, joint geometry, X-ray	Survivorship 81% at 18 yrs, survivorship 91.6% at 10 yrs, pain 4.6 at 17 yrs (Aubigne/Postel & Charnley), walking 4.6 at 17 yrs, ROM 4.4 at 17 yrs
Wejkner & Stenport (1988) [46] Descriptive (retrospective) >30 <80 yrs (mean=64)	325 50% 10-14 yrs	Age at surgery, sex, body mass index, diagnosis OA, other diagnoses, previous surgery, surgical approach	-/Teaching hospital, 86% hip surgeons	Pain, observer-defined function, gait, X-ray criteria	56% excellent, 28% good, 8% fair, 8% failure (Charnley scores)
Eftekhar (1987) [47] Descriptive (retropective) Ages not stated	1009 (20% revision/ conversions) 69% 5-15 yrs	Surgical approach	-/Specialist centre, Single surgeon	Survivorship	Mechanical failure and infectious causes
Kavanagh et al (1989) [48] Descriptive (retrospective) M 35-85 yrs (mean=65) F 39-84 yrs (mean=64)	333 49.8% 15 yrs	Age at surgery, sex, body mass index, diagnosis OA, surgical approach, previous surgery	-/Specialist centre	Pain, observer-defined function, gait, X-ray criteria	Probability of failure: 1 yr, 0.9%; 5 yrs, 4.1%; 10 yrs, 8.9%; 15 yrs, 12.7%
Iannoti et al (1986) [49] Descriptive (retrospective) mean=62.2 (SD=10.8)	258 (primary) 100% 3-10 yrs	Age at surgery, sex, body mass index, diagnosis OA, other diagnoses	-/Teaching hospital	Pain, observer-defined function, gait, X-ray criteria	75% satisfactory pain; 95% satisfactory function

Table 2b Primary surgery with a Charnley cemented acetabulum (with at least 200 THRs and 10 years follow-up)

Carlsson et al (1986) [50] Descriptive (retrospective)	207 68.7% (207 OA, 34 RA) 5-12.5 yrs (OA) 3.4-12 yrs (RA)	Age at surgery, sex, diagnosis OA, diagnosis RA, other	-/Teaching hospital	X-ray criteria	OA 26% loosening, RA 34% loosening
Garcia-Cimbrelo & Munera (1992) [45] Descriptive (retrospective)	791 86% 12.8 yrs (mean)	Age at surgery, sex, diagnosis OA, diagnosis RA, other	-/Teaching hospital	Survivorship, X-ray criteria	81% survivorship at 18 yrs

societal perspective, estimated that for most people the procedure was relatively cost-effective.[79] For women under 60 the ratio ranged from $16,000 per QALY gained, (cost saving) to $27,000 per QALY gained in the best and worst case scenarios respectively. Even for men over 84 years the cost effectiveness ranged from $4,600 to $80, 000 per QALY gained. These estimates vary according to a number of factors such as the severity of the pre-operative state, potential for achieving benefit, length of remaining life and co-existing disease.

F.2 Cost containment and promoting quality: In view of the expanding costs of THR, cost containment programmes have been established in some US hospitals. Because the cost of the prosthesis is becoming an increasing proportion of the total hospital THR costs, these programmes have tended to concentrate on keeping down the cost of the prosthesis. A 14% reduction in prosthesis costs was reported in one hospital in the USA by adopting a structured approach to the choice of prosthesis.[80] Standardisation of the hip prosthesis has been estimated to be able save about 25% of the cost of implants in some US hospitals.[81]

Because the Charnley and Stanmore prostheses are both

Table 3 Primary surgery with other cemented prostheses (with at least 200 THRs and 10 years follow-up)*

Authors/ study design	Prosthesis	No. of operations/ % follow-up/ duration of follow up (yr)	Other risk factors	Status of surgeon/type of hospital	Outcome measures	Results
August et al (1986) [51] Descriptive (retrospective)	McKee-Farrar	808 28.4% 13.9 yrs (mean)	Age at surgery, diagnosis OA, diagnosis RA, surgical approach	-/District general hospital, 72% by consultant	Pain, observer-defined function, gait, joint geometry, X-ray criteria	Good/excellent (Harris), 49%; survivorship 91% 10 yrs, 84% 15 yrs, 49% 19 yrs
Jantsch et al (1991)[52] Descriptive (retrospective)	McKee-Farrar	330 56% 14 yrs (mean)	Age at surgery, sex, weight, diagnosis OA, diagnosis RA	-/Specialist centre	Pain, observer-defined function, gait, joint geometry	62% excellent/good (Mayo score); 22% poor. 35% of those followed up revised
Britton et al (1996)[26] Descriptive (prospective) Comparison with Charnley (Table 2a)	Stanmore	982 94% (amongst alive) 24% died 1-16 yrs	Diagnosis OA, diagnosis RA	Consultant/District general hospital	Survivorship, pain, observer-defined function, gait, joint geometry	Survivorship at 10yrs 93% (revision); at 10yrs and 14yrs 88% and 80% (revision, moderate or severe pain)
Bryant et al (1991) [53] Descriptive (prospective)	Ring	253 90.5% 1-21 yrs	Age at surgery, diagnosis OA, diagnosis RA	-/Teaching hospital	Survivorship	70% and 60.4% cumulative survivorship (revision) after 10 yrs and 20 yrs respectively

*Also see Malchau et al 1993[21] Table 2a

Table 4a Primary surgery with cementless femoral prostheses (with at least 200 THRs and 10 years follow-up)

Authors/ Study design	Prosthesis	No. of operations/ % follow-up/ duration of follow up (yr)	Other risk factors	Status of surgeon/type of hospital	Outcome measures	Results
Engh et al (1990)[55] Descriptive (prospective)	AML	1048 (primary) 91.5% 2-11 yrs	Age at surgery, sex, weight, diagnosis OA, diagnosis RA, surgical approach, patient co-morbidity, patient risks: Type femoral stem thromboembolism?	-/Specialist centre	Survivorship, pain, observer-defined function, gait, joint geometry, X-ray criteria (Postel-d'Aubigne)	Survivorship: 96.4% (revision) at 10 yrs; 90.8% (mechanical failure) at 10 yrs 19.5% revision
Bryant et al (1991)[53] Descriptive (retrospective)	Ring Mark 2	253 46.7% 11-21 yrs	Age at surgery, sex, diagnosis OA, diagnosis RA	-/Teaching hospital	Survivorship, pain, observer-defined function, gait, joint geometry	Survivorship 60.4% at 21 yrs; 26.5% revisions; 6.4% excellent, 31.9% good, 40.4% fair, 21.3% poor
Engh et al (1990)[55] Descriptive (retrospective)	PCA	959 91.5% 2-12 yrs	Age at surgery, sex, weight, body mass index, diagnosis OA, diagnosis RA, other	-/Specialist centre	Survivorship, pain, observer-defined function, gait, X-ray criteria	Survivorship at 10 yrs: 96.4% (revision); 90.8% (revision and loosening)

Table 4b Primary surgery with a cementless acetabulum (at least 200 THRs and 10 years follow-up)

Hauser et al (1993)[56] Descriptive (prospective) including pre-op status	Endler Belgrist	715 - 5-10 yrs	-	-/Teaching hospital	X-ray criteria	Probability of survival after 5 yrs: Endler 94% Balgrist 88-91% after 10 yrs: Endler 44%
Scmitt et al (1993)[57] Descriptive (retrospective)	Spiked 134 Screw rings 77	227 - 9.5 yrs (mean)	-	-/Teaching Hospital	Revision, X-ray criteria	Screw: 1/3 migration, 13% revision Spikes: 15% migration, 2% revision

Table 5 Randomised controlled trials comparing prostheses

Authors/ Study design	Prosthesis	No. of operations/ % follow-up/ duration of follow up (yr)	Other risk factors	Status of surgeon/type of hospital	Outcome measures	Results
Godsiff et al (1992)[59] UK	Ring femoral cemented, acetabulum cementless v femoral and acetabulum cementless	Cemented 30. Uncemented 28 4 months (81%), 1 year (100%), 2 years (81%)	Age at surgery, sex	Consultant/ District general hospital	Pain, use of walking aids, activity	Pain-free at 4 months: 58% cemented, 43% uncemented; pain free at 1 yr: 63% cemented, 50% uncemented; pain free at 2 yrs: 65% cemented, 63% uncemented. Walking without support at 2 yrs: 96% cemented, 62% uncemented ($p<0.05$). (Difference not significant at 4 months or at 1 year
Wykman et al (1991)[60] (incorporates 119 patients in Olsson et al, 1985[61]) Sweden	Charnley cemented v Honart Patel-Garches (press fit).	75 v 75 6 months 1 year 5 years Charnley 91% HP Garches 93%	Age at surgery, sex, weight, diagnosis OA, diagnosis RA, surgical approach, infection bilaterial and unilateral disease	Major hospital	Pain, observer-defined function, gait, joint geometry, X-ray criteria. Harris hip score, patient satisfaction, re-operation	At 2 years, excellent or good (Harris Hip Score) 79% Charnley, 70% HP Garches. Revisions for mechanical loosening in 6.7% Charnley and 18.7% HP Garches (11% and 19% overall)
Onsten & Carlsson (1994)[62] Sweden	All polythene cemented Charnley socket vs uncemenete d porous Harris-Galante type 1 socket.	30 Charnley vs 30 H-G 100%1 2 years	Sex, side, age, weight	Specialist unit	Socket migration and rotation by radiostereo metry (RSA). Pain and function by Harris Score)	No revisions after 2 years. Mean Harris Hip score was equal at baseline and after 2 years. No difference in migration or rotation
Rorabeck et al (1996)[63] (4 year follow up of Rorabeck, 1994 [12] and same results as Mulliken, 1996) Canada	Mallory cemented v Mallory uncemented	125 cemented 126 cementless up to 6 (59% followed up for at least 4 years)	Age at surgery, sex, weight, diagnosis OA, diagnosis RA, surgical approach, patient risks: infection/ thromboemboli sm	Consultant/ Teaching hospital	Pain, observer-defined function (Harris hip score, d'Aubigne). Patient defined arthritis score, SIP,TTO	Both showed large and sustained increases in health related quality of life. No difference at 4 years in disease specific and patient-centred measures. Cemented metal-backed acetabular components have high rate of radiographic failure
Marston et al (1996)[54] England	Charnley cemented vs Stanmore cemented	200 vs 213 hips (360 patients) 5-10 years (mean 6.5) 5yrs 80% Ch, 70% Stan 10yrs 8% Ch, 7% Stan	Age at surgery, sex, weight, diagnosis OA, diagnosis RA, surgical approach, seniority of surgeon	Specialist hospital	Clinical and radiological assessment, revision	Mean Harris Score post operatively = 46 91 in both groups. Revision rate the same in both groups. In all but one revisions the operating surgeon was a trainee.($P<0.005$) Slightly higher radiological evidence of subsidence of the Stanmore stem than in the Charnley in the first 6 months ($P=0.003$)

amongst the cheapest and best performing prostheses for most patients, cost minimisation and the promotion of quality can be achieved by standardising on these implants. A survey of 261 NHS hospitals showed that 30 types of cemented and 35 types of cementless hip replacements are currently used in orthopaedic practice.[82] The Charnley low friction implant was only used in about 75% of the hospitals. A survey of Fellows of the British Orthopaedic Association also suggests that only around a quarter of surgeons use 'modern' cementing techniques.[83]

An increasing proportion of the total expenditure on hip replacement surgery is on revisions due to the failure of hip prostheses. One approach put forward for increasing quality of surgery is for purchasers to buy a lifetime care package which includes the present cost of the surgery plus a premium for any future surgery due to failure.[84] The lowest price will be offered by providers who, because they know that their surgery is of high quality, are less likely to have to carry out a revision in the short-term. Thus, rather than the price

of a THR being the determinant of purchaser choices, total future expected expenditure and benefits would be more important. No research evaluating such a scheme has been identified.

The Safety and Efficacy Register of New Interventional Procedures (SERNIP) recently established by the Medical Royal Colleges may play a role in helping to control the diffusion of untested prostheses.[85]

G. Implications for services and research

- A wide variety of untested prostheses are in use in the NHS. Commissioners should be aware of what prostheses are being used by those with whom they contract for THR and should ensure that cheap and thoroughly evaluated standard implants like the Charnley low friction or the Stanmore are routinely used unless there is adequate justification for an exception.
- Commissioners and providers should ensure that new implants and techniques, that have not been demonstrated to be more cost-effective than the standard, ones are not introduced without proper evaluation.
- In order to promote quality, providers and purchasers should require information on and or monitor the outcomes of THR, and require audit of adverse cases and high rates of revision. One aspect of potential importance is the grade of surgeon carrying out the operation and the level of supervision.
- Commissioners might wish to consider contracting for the lifetime hip care of patients including a premium to cover the risk of future costs due to revision of surgery.

Research Areas

- The likely impact of population ageing, changes in thresholds for surgery, and trends in hip disease to assess future need for orthopaedic services.
- The effect of a range of environmental factors influencing outcomes such as skills, training and supervision of junior staff.
- Validation of 'pro-active' methods of predicting the long-term success of hip surgery which can be carried out using feasible measures within a few years of the operation. This will facilitate more rigorous testing of new equipment.
- The use of these early indicators of failure in order to identify patients who would benefit from earlier revision, thus avoiding more complex surgery at a later date and improving long-term outcomes.
- Evaluation of approaches to promoting quality such as purchasing 'lifetime hip care'

Appendix 1: Routine hospital data

Data on the number of procedures came from the Hospital Episode Statistics for the relevant years. Total Hip Replacement procedures and prosthetic replacement of the head of femur (OPCS codes W37, W38, W39, W46, W47, and W48 and all subsidiary codes). Emergency cases and those where the primary diagnosis was fractured neck of femur (ICD codes 820 and 821) were excluded.

Appendix 2: Search strategy

The following databases were searched: Medline (1966-1995); EM-base (1981-1995); Science Citation Index (1975-1995).

A manual search was made of Index Medicus and of references listed in other publications.

For the general search the key words used were: hip replacement, hip arthroplasty, hip prosthesis. The searches were limited to human subjects and English language articles. Foreign articles were reviewed if there was an abstract in English.

Studies using experimental and observational data which followed up patients and measured patient outcomes, including radiographic changes, were identified.

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The Research Team:

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Writing of the bulletin and additional research by the *Effective Health Care* research team:

NHS Centre for Reviews and Dissemination, University of York

- Professor Trevor Sheldon, Joint Manager of *Effective Health Care*
- Alison Eastwood
- Dr Amanda Sowden
- Frances Sharp

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- Dr Peter Bourdillon, Head of Specialist Clinical Services Division, NHS Executive
- Dr Jenny Carpenter, Health Care Directorate Public Health, NHS Executive
- Ian Donnachie, Chief Executive, Bradford Health Authority
- Professor Mike Drummond, Centre for Health Economics, University of York
- Jane Emminson, Chief Executive, Wolverhampton Health Executive
- Mr Philip Hewitson, Leeds FHSA/NHS Executive
- Dr Anthony Hopkins, Director of Research Unit, RCP
- Dr Liz Kernohan, Deputy Director of Public Health, Bradford Health Authority
- Andrew Long, Joint Manager of Effective Health Care, Nuffield Institute for Health, University of Leeds
- Dr Diana McInnes, Principal Medical Officer, DoH
- Dr Tom Mann, Head of Division, Health Care Directorate Public Health, NHS Executive

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