

Early Results of Total Hip Joint Replacement

CHARNLEY LOW-FRICTION ARTHROPLASTY

D. DALL

SUMMARY

A prospective analysis of 100 Charnley total hip joint replacements performed between January 1970 and August 1972 is presented. A total success rate of 95% was obtained. Failures were due to 3 deaths and 2 cases of minor sepsis. No case of frank sepsis requiring removal of the prosthesis was encountered.

Pain was completely relieved in 80% or was minimal in 20% of patients. No patient had pain of any significance postoperatively. The total range of movement achieved was 160° or more in 96% of patients. No hip lost movement after surgery. Walking function was improved to normal, or near normal, in 100% of unilateral cases, or in bilateral cases that had bilateral replacements.

Charnley total hip replacement is indicated in all cases with significant disability due to degenerative hip pathology, or when previous surgery has failed.

S. Afr. Med. J., 48, 1979 (1974).

Total hip joint replacement is rapidly becoming the treatment of choice in osteo-arthritis and rheumatoid arthritis of the hip joint in cases with significant disability. This paper reports the results of total hip replacement by the low-friction Charnley technique in the first 100 consecutive hips operated on between January 1970 and August 1972. The majority (87 cases) were done at the Princess Alice Ortho-

Department of Orthopaedic Surgery, University of Cape Town and Princess Alice Orthopaedic Hospital, Cape Town
D. DALL, M.CH. (ORTH.), F.R.C.S., Part-time Consultant Orthopaedic Surgeon

Paper presented at the South African Orthopaedic Congress held in Pretoria on 27 August 1974.

paedic Hospital) and the remainder at a private nursing home. The shortest period of follow-up was 6 months, the longest 4 years. The majority (61%) of operations were done by the author, the remainder being done by colleagues using identical technique, pre-operative preparation, and postoperative management.

Primary osteo-arthritis was the diagnosis in 80% of the series and rheumatoid arthritis in 11%. The residue of 9% comprised conditions such as complications of fractured neck of femur, avascular necrosis of the femoral head and protrusio acetabulae.

Primary surgery was performed on 80 hips. Operations for failure of previous procedures (osteotomy, femoral head replacement or cup arthroplasty) numbered 20. The results of these conversion operations are considered separately.

The statistics in this review relate to hips rather than to patients in order to simplify the recording of bilateral operations.

METHOD OF STUDY

This study was entirely prospective. Special documentation was used. The clinical history and physical examination details were recorded on special cards pre- and post-operatively to simplify the grading of disability.

Grading of Results

A numerical classification was used to grade disability. The method used was strictly in accordance with Charnley's adaptation of the method of Merle D'Aubigné and Postel.² Three parameters were studied, viz. pain, move-

TABLE I. NUMERICAL CLASSIFICATION OF DISABILITY CAUSED BY THE AFFECTED HIP JOINTS

Pain	Walking function	Movement
1. Severe and spontaneous.	1. Few metres or bed-ridden. Two sticks or crutches.	1. 0-30°
2. Severe on attempting to walk. Prevents all activity.	2. Time and distance very limited with or without sticks.	2. 60°
3. Tolerable, permitting limited activity.	3. Limited with one stick (less than 1 hour). Difficult without a stick. Able to stand long periods.	3. 100°
4. Only after some activity. Disappears quickly with rest.	4. Long distances with one stick. Limited without a stick.	4. 160°
5. Slight or intermittent pain on starting to walk but decreasing with normal activity.	5. No stick but a limp.	5. 210°
6. No pain.	6. Normal.	6. 260°

ment and walking ability. In each patient each of these parameters was then assessed and given a numerical value, as shown in Table I.

Pain: The two most common grades of pain which qualify a patient for arthroplasty are grades 2 and 3. In assessing the postoperative results, grade 5 indicates slight intermittent pain and grade 6 that the patient's hip is entirely pain-free.

Movement: This digit indicates the sum of the ranges of movement in the three standard directions. A common pre-operative grade is again grade 3, which corresponds to an arthritic hip which has 90° of flexion but little other movement.

Walking: This digit indicates the function of the hip with regard to the ability to walk. Alphabetical prefixes are added to facilitate assessment of the function of walking (Table II): 'A' — a patient with only one hip involved in whom no other condition interferes with walking; 'B' — a patient with both hips involved, but the rest of the body normal, and therefore not responsible for any defect in walking ability; and 'C' — a patient with some additional factor contributing to failure to achieve normal locomotion, such as the polyarthritis of rheumatoid arthritis, senility, hemiplegia and cardiovascular or respiratory disease.

TABLE II. ALPHABETICAL PREFIXES IN THE ASSESSMENT OF WALKING FUNCTION

- A—unilateral cases without complicating general factors.
- B—bilateral cases without complicating general factors.
- C—uni- or bilateral cases with complicating general factors.

Using these alphabetical prefixes to assess the quality of walking after an arthroplasty, we restricted our study to patients in the A category and those in the B category who had had bilateral replacement arthroplasties. The remainder, for example the B category without the second hip operated on and the C category, can be used for the study of pain and movement before and after operation, but are quite unsuitable for studying the contribution of the arthroplasty to the quality of walking.

An extension of the three-digit system makes it possible to compare the average qualities of different series of cases by expressing the quality as a whole number plus a decimal fraction, e.g. if the average for pain in a series was 5,1, this series would clearly not be as good as one with an average of 5,9. If a series comprises only 2 grades, the figure after the decimal point indicates the percentage in the higher group, e.g. with a series containing only 4s and 5s, an average of 4,7 indicates that 70% of cases are in grade 5. The greatest value of decimal fractions is with regard to the total range of movement.

Pre-operative Clinical Details

Age and sex distributions are indicated in Table III. It will be noted that the majority of cases fell into the 7th and 8th decades with an average age of 65,8 years. The proportion of A, B, and C cases in the primary and conversion

operations is indicated in Table IV. Of the cases with bilateral hip pathology (B category) 7 had both hips done. Only 2 of these were performed at one session.

Average numerical grading in this series pre-operatively is indicated in Table V.

TABLE III. AGE IN DECADES

	No.
1st decade	0
2nd "	0
3rd "	0
4th "	3
5th "	5
6th "	12
7th "	38
8th "	25
9th "	5
10th "	0
Average age: 65,8 years	
Males: 30 years	
Females: 58 years	

TABLE IV. NUMBER OF HIPs

Primary	A	25	} 80
	B	34	
	C	21	
Conversion	A	9	} 20
	B	3	
	C	8	
Total		100	

TABLE V. AVERAGE NUMERICAL GRADING PRE-OPERATIVELY

Pain	2,8
Walking	2,6
Movement	2,8

Surgical and Postoperative Management

Pre-operatively proformas indicating the degree of disability were completed in all cases. A physician always checked the patient's general condition with regard to anaesthetic risk. Prophylactic antibiotics were used as a routine, commencing 24 hours pre-operatively and continuing for 5 days after surgery.

The surgical technique employed was the standard routine as taught by Charnley, using the same exposure by elevating the greater trochanter. The acetabular component of the prosthesis is made of high-density polyethylene, mated with a stainless steel femoral head 22 mm in diameter (Fig. 1). Both components are fixed in their bony beds with self-curing acrylic cement (methyl methacrylate). The socket is orientated with the axis inclined at 45°. Neutral anteversion was used, with a maximum of 5° of anteversion permitted in order to avoid any retroversion.

The axis of the femoral prosthesis was neutral. The bony acetabulum was deepened until no more than 2-3 mm of bone was left in the floor, so that the centre of rotation of the prosthesis could be well medialised and provide better mechanical advantage.

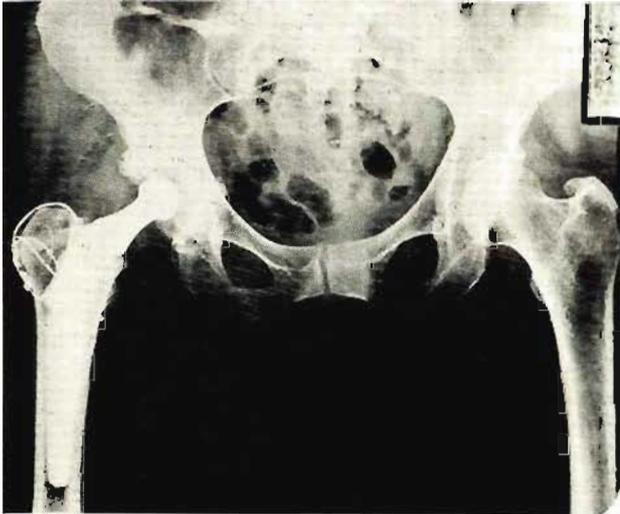


Fig. 1. Postoperative radiograph showing the prosthesis *in situ*. A stainless steel wire marker indicates the thickness of the high-density polyethylene acetabular component which is radiolucent. Barium is mixed with the acrylic cement to make it slightly radio-opaque so that the bone-cement interface can be defined. The trochanteric osteotomy is fixed with stainless steel cross wires.

Postoperatively, patients were lightly immobilised with a triangular pillow placed between the legs, holding the hips in moderate abduction. On postoperative day 5 standing was commenced and on postoperative day 7 walking, allowing full weight-bearing, was commenced. The patients left hospital 3-4 weeks postoperatively, using one or two sticks, depending on their rehabilitation and prowess. Carefully controlled physiotherapy was an important part of the postoperative rehabilitation programme.

COMPLICATIONS

General

Thrombo-embolism: In this series there were 8 cases with clinically detectable deep vein thrombosis. More sophisticated methods are necessary to establish the true incidence of this complication, which is recognised to be high after this type of surgery.

There were 4 cases of pulmonary embolism, fatal in 1 woman. She was, in fact, the only patient who was on prophylactic low-dosage subcutaneous heparin. However, she was a known high-risk patient aged 76 years, with polycythaemia and an initial haemoglobin value of 23 g/100 ml, which was reduced to 12 g/100 ml pre-operatively by venous section.

Postoperative deaths: There were 3 postoperative deaths — all category C, high-risk cases. The first, due to pulmonary embolism, has been mentioned. The second, a man of 68 years, had had previous laparotomies for intestinal obstruction. In the postoperative period he had a recurrent attack of intestinal obstruction which, in spite of two successive laparotomies, eventually caused his death from endotoxic shock 6 weeks postoperatively. At post-mortem the right iliac vein was found to be thrombosed and he had a small pulmonary embolus as well. No infection was present in the prosthetic hip. The third patient, a man of 73 years, had an asymptomatic gallstone at the time of surgery. He underwent bilateral total hip replacements, performed at the same session. Postoperatively he developed empyema of the gall bladder and acute gastrointestinal haemorrhage. In spite of emergency surgery he died 4 weeks after the operation. Postmortem examination was not performed.

Local

Sepsis: As has been mentioned, routine prophylactic antibiotics were used in all cases. In addition, wounds were irrigated during surgery with a 10% Polybactin solution in a litre of normal saline. Portovac drainage was used in all cases.

There were 2 cases with mild sepsis in this series. Both of them presented some months after discharge from hospital. The first presented with a cellulitis surrounding the scar and superficial soft tissues. It is interesting to record that on the third postoperative day she had had an attack of acute cholecystitis, which was treated conservatively. The cellulitis cleared up completely on antibiotic therapy and after 3 years she has no further problems.

The second patient presented with a small sinus 2 months postoperatively, which settled rapidly after an infected suture was removed. He has remained well to date (30 months postoperative).

There were no cases of frank sepsis which required removal of the prosthesis.

This incidence of 2% of cases with mild postoperative infection which settled on antibiotic therapy compares favourably with Charnley's incidence of 1.6%. It should be noted that the follow-up in this series is too short to draw firm conclusions about late sepsis. Although it is now a well-established fact that some patients present with late sepsis up to 4 years after surgery, our results to date are very encouraging.

All the hips operated on at Princess Alice Orthopaedic Hospital (87) were done in a conventional theatre. However, this theatre is rather special in that it is reserved for cold, clean, elective orthopaedic procedures only. The 13 cases done at the private nursing home were done in a specially adapted theatre. This was a modification of the CSIR theatre designed for the Hendrik Verwoerd Hospital in Pretoria, which in turn was a development of the Charnley enclosure used at Wrightington.

Charnley's statistics for sepsis, showing a marked decline from 9% to 2% through the use of an enclosure, are very convincing and I am very much in favour of an enclosure being used for this type of surgery, especially if the opera-

tions are being done in a general theatre. It would be interesting to know what the incidence of postoperative sepsis is for this type of surgery in a general theatre.

The treatment of infection depends on its severity. Our 2 cases have been well controlled with antibiotics, but obviously, if frank sepsis develops, the prosthesis has to be removed and a pseudo-arthrosis created. It should always be remembered that statistics cannot be applied to an individual. Should sepsis intervene, it is important that the patient be left no worse off with his pseudo-arthrosis than he was prior to surgery. Hence the need for selecting cases with significant disability in this type of surgery.

Non-union of the greater trochanter: The incidence of 12 cases with broken wires, but with firm bony union of the trochanter, is really of radiological interest only. Wire breakage occurs some weeks or even months after surgery, by which time the cut bony surfaces are already firm enough, so that bony union can progress. This obviously has no effect on the functional result.

The incidence of 3% in this series (4.2% in Charnley's series) of fibrous union of the trochanter, even with gross separation, does not correlate with any gross defect in the quality of the clinical result. This is underlined by the fact that non-union of the trochanter is not a source of mechanical failure, even in instances where complete separation of the fragments occurs.

Dislocation: There were 3 hips that dislocated post-operatively (Charnley's incidence 1.5%).

With the Charnley technique of exposure by removing the trochanter, there are very few technical iatrogenic causes of dislocation, provided one pays attention to detail. It is essential that a firm strap of superior capsule and the gluteal muscles are left attached to the trochanter to provide stability after rewiring. Furthermore, the two components of the prosthesis should be correctly positioned, and particularly, retroversion of the acetabular component avoided. The limb should be correctly positioned at the time of trochanteric reattachment, and in the postoperative period extreme flexion and adduction should be avoided.

Despite the small diameter of the femoral head, this arthroplasty is not more prone to postoperative dislocation than other types of replacement, provided that the correct technique of insertion is employed.

It is my opinion that the most potent cause of post-operative dislocation after Charnley total replacement is the use of the wrong surgical approach. To quote Charnley: '... with my own type of total prosthesis, with its smaller diameter femoral head, there is a special source of mechanical failure by dislocation if the surgeon thinks he can do the operation without transplanting the great trochanter'. Unlike other types of total prostheses, various neck lengths are not available in the Charnley prosthesis, so that stability has to be provided by transposing the greater trochanter and taking up the gluteal slack.

Dislocations are easily reduced by manipulation under general anaesthesia and are maintained by skeletal traction for a period of 2-3 weeks.

Fracture: Usually one case in a thousand will fracture at the time of surgery, and one has to accept this technical

hazard. This usually occurs in the presence of osteoporosis or other pathology. In this series, 1 femur was fractured during removal of a pin and plate which had been inserted many years prior to surgery. It is interesting that another patient fell some 9 months after surgery and sustained a fracture of the pelvis, leaving the Charnley prosthesis intact.

Lateral popliteal nerve palsy: There were 2 cases—one recovered rapidly and the other made an almost complete recovery after one year. It is possible that positioning on the table may cause direct pressure on the lateral popliteal nerve, but I think in most cases the cause is at the site of operation. Excess acetabular cement coming to lie directly on the nerve may cause damage through the heat of polymerisation. Alternatively, direct damage from retraction or exposure may occur.

Abnormal radiological changes: Some of the radiological changes described by Charnley¹ have been encountered in this series. A fine radiolucent line is commonly seen at the cement-bone interface. This cement-bone line demarcation and trabecular condensation appear to be entirely benign, and of no clinical significance. Periostitis, which in this series occurred in the patient who presented with a superficial cellulitis after discharge from hospital, may indicate low-grade infection. Bone atrophy was not encountered in the series.

Resorption of the femoral neck by about 3 mm without any sinking of the femoral prosthesis is fairly common and merely confirms the fact that the use of cement in the femoral shaft distributes the weight-bearing load throughout the proximal shaft of the femur, and avoids the high stress spot at the cut edge of the calcar encountered in uncemented prosthetic femoral head replacements. In some cases there appeared to be a change in the texture of the bone in the early postoperative period, but this improved as weight-bearing progressed.

Ectopic ossification: There were 6 cases in this series with ectopic ossification in the soft tissues (Charnley's incidence 5%). Although this was associated with a general trend towards less mobility, the over-all result from a functional point of view remained entirely satisfactory in all these cases. This change occurred most commonly in males.

Late mechanical failure: In this series none developed loose components, recurrent dislocation, or subluxation. Charnley's incidence of 1% of loosening of cemented acetabular components is indeed remarkable, especially in comparison with other total hip joint replacements.

Wear of the plastic socket: Although measurements have not been made in this series, no abnormal wear has been encountered in the short period of follow-up. Charnley's average of 0.13 mm per year in the 7 postmortem cases he studied is very encouraging.

Unexplained pain: In this series there was 1 patient with temporary unexplained pain after one year, but which settled completely 18 months after operation. There was no radiological or clinical evidence of any infection or loosening of components.

QUALITY OF RESULTS

Follow-up assessment and examination were made in 86% of the series of 100 hips. Early or late unrelated deaths

prevented follow-up in 6 hips and the remaining 8 hips could not be followed up because of distances involved, although all correspondents indicated that they were well and pain-free. The follow-up period ranged from 6 months to 3 years. The average pre-operative and postoperative grading of results is indicated in Table VI. There was no significant difference in the results of conversion procedures when compared with the results of primary procedures.

TABLE VI. AVERAGE RESULTS

	Pre-op.	Postop.
Pain	2,8	5,8
Walking function	2,5	5,4
Movement	2,8	5,2

Pain Relief

One of the outstanding features of this operation is the complete relief of pain in the vast majority of patients. The change in the average pre-operative grading of 2,8 to the average postoperative grading of 5,8 is highly gratifying (Fig. 2). The grading indicates that the assessment of pain relief resolves itself into an incidence of excellent and good results (80% grade 6 and 20% grade 5).

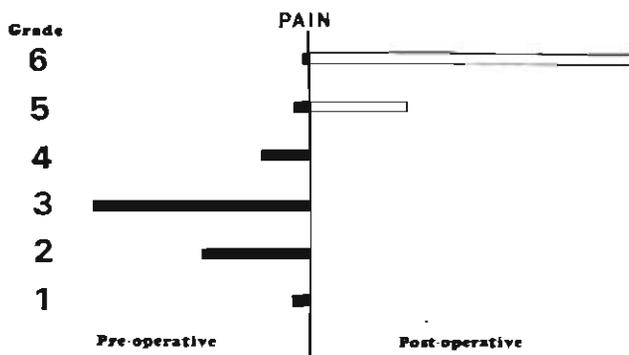


Fig. 2. Relief of pain.

Improvement of Walking Function

The true assessment of improvement of walking function can only be made in unilateral cases (category A) or in bilateral cases (category B) where a total replacement has been performed on both hips. In this series there were 41 hips in which a true assessment could be made (Fig. 3). The absence of a limp after this type of total hip replacement has been one of the most impressive features of the results. The improvement of the average pre-operative grading from 2,5 to the average postoperative grading of 5,4 is again extremely gratifying. This indicates postoperative results are 50% excellent (grade 6) and 50% good (grade 5).

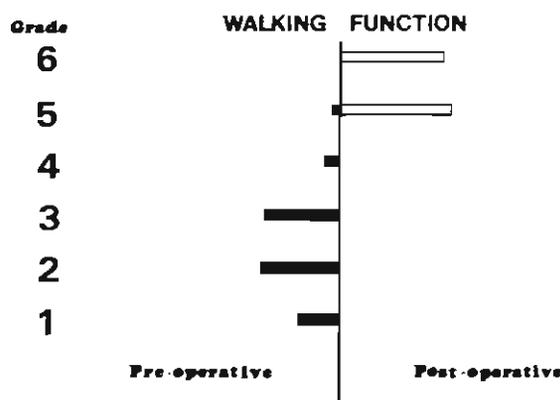


Fig. 3. Improvement in walking function.

Improvement of Range of Movement

In general it can be stated that the more mobile the hip before operation the greater will be the postoperative final range. On the other hand, there were many instances of stiff hips achieving a full range of movement after operation. The average pre-operative grading of 2,8 with a postoperative improvement to 5,2 is gratifying, although only 3 hips achieved grade 3 range of motion and 11 hips achieved grade 4 (Fig. 4). This occurred particularly in men and was sometimes associated with ectopic ossification in the extracapsular soft tissue. A remarkable feature of this surgery, however, is that not a single hip had less movement after operation than before.

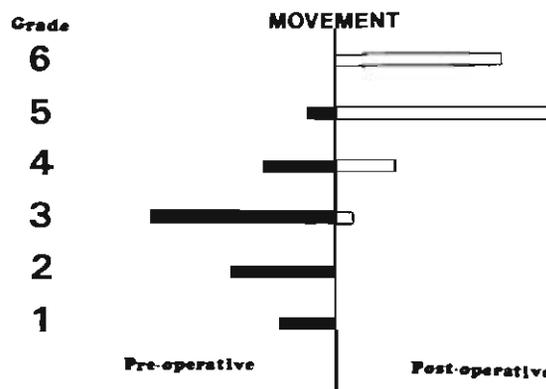


Fig. 4. Improvement in range of movement.

OVER-ALL ASSESSMENT OF FAILURE AND SUCCESS RATES

Table VII indicates a success rate of 95%. In this age group, with this type of major reconstructive surgery, this level of success is highly satisfactory. Although 3 hips dislocated postoperatively, these were easily reduced and there has been no further recurrence of the dislocations. They have therefore not been included in Table VII as

mechanical failures, because dislocation was purely temporary. There were no cases of mechanical failure due to loosening of the components. A sepsis rate of 2% is shown, although in both these hips the sepsis settled down and the prosthesis was not removed, so that at the time of writing, the over-all success rate is, in fact, 97%.

TABLE VII FAILURE AND SUCCESS RATES

Death—Pulmonary embolism	1,0%	}	3,0%
Other causes	2,0%		
Superficial sepsis (settled on antibiotics)	2,0%		2,0%
Frank sepsis (requiring removal of prosthesis)	0%		
Mechanical failure	0%		
Total			5,0%
Success rate			95 %

CONCLUSIONS

Charnley total hip joint replacement is an excellent primary procedure in patients suffering from degenerative osteoarthritis, rheumatoid arthritis and other degenerative pathology, such as avascular necrosis of the femoral head, with significant disability. It is also particularly indicated as a salvage procedure for failed previous surgery, especially cup arthroplasty, femoral osteotomy, or failed internal fixation for fractures of the femoral neck. It can also be successfully applied in difficult reconstructive situations such as congenital dislocation of the hip with secondary arthritis, previous fracture dislocations, bony ankylosis and failed femoral head replacement prostheses.

Reasons for the Success of the Operation

The approach used provides immediate stability after surgery. Furthermore, it is completely versatile and enables one to tackle any reconstruction, no matter how difficult.

The use of cold-setting acrylic cement provides an even distribution of the body load over a large area of bone. An accurate cast of the interior of the bone is formed, so that load is transmitted evenly over all parts of the interface between cement and cancellous bone. As a result there is much less tendency for the prosthesis to loosen. There is, therefore (a) total absence of pain; (b)

remarkable freedom of movement; (c) retention of mobility without loss from ectopic bone formation; (d) excellence of gait; and (e) ability to start weight-bearing within one week of operation.

The design of the prosthetic implant and the materials used are proving entirely satisfactory. Charnley³ now has results of over 12 years' follow-up and wear properties are very encouraging.

Reconstruction following the Charnley technique is aimed at improving the lever systems around the low-friction arthroplasty. This is achieved by moving the centre of rotation of the hip joint medially and the insertion of the abductor mechanism laterally.

Finally, the enormous clinical backing and objective reviews of results at the Wrightington Centre for Hip Surgery are undoubted factors in the success of this operation. Charnley has been meticulous in reviewing his results and making the necessary changes in prosthetic design and surgical reconstruction. It seems foolish not to take advantage of this vast clinical experience.

Indications

At the present stage of experience with this surgery the main indication for total hip replacement is significant disability. Initially this operation was only done in older age groups. With the experience gained and the successes achieved it is now applicable in any age group, provided that disability is significant. For example, one would not contemplate this operation in a 45-year-old woman with moderate hip pain and the ability to walk without any aid. On the other hand, a 30-year-old bed-ridden rheumatoid arthritic with multiple joint involvement and a built-in limitation of activity, would be a suitable candidate. Patients with moderate disability should not have this type of surgery before the age of 60 years, or until such time as a 20-year follow-up is available.

Total hip joint replacement remains an excellent salvage procedure for failed previous surgery in any age group with significant disability.

I should like to thank Dr G. Dall and my colleagues at Princess Alice Orthopaedic Hospital for allowing me to review their cases.

REFERENCES

1. Charnley, J. (1972): *J. Bone Jt Surg.*, **54B**, 61.
2. Merle D'Aubigné, R. and Postel, M. (1954): *Ibid.*, **36A**, 451.
3. Charnley, J. (1974): Personal communication.