tion have been discussed in the accompanying paper,⁷ in which there were 5.3% of deep infections in 352 operations for osteoarthritis of the hip. Arden *et al.*,⁹ using the McKee-Farrar prosthesis, also found an increased incidence of deep infection in rheumatoid arthritis (7.1%) compared with 2.2% in osteoarthritis. In Welch and Charnley's⁵ series the incidence of deep infection was appreciably lower, being 0.7% in 307 operations for rheumatoid arthritis and ankylosing spondylitis. The orthopaedic operating theatre at this hospital is being equipped with sterile laminar airflow, and it is hoped that this will reduce the number of infections.

We are indebted to Sir Henry Osmond-Clarke, Mr. O. J. Vaughan-Jackson, Mr. W. A. Law, and Mr. M. A. R. Freeman for allowing us to review patients under their care. We should like to thank Mr. M. A. R. Freeman and Dr. Michael Mason for their help in preparing this paper, and Miss J. M. Piercy, Miss D.

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Total Hip Replacement in Osteoarthritis using the Charnley Prosthesis

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Summary

Charnley low-friction arthroplasty was performed on 352 osteoarthritic hips, usually because of severe pain. Three hundred and twenty hips were reviewed at a special follow-up clinic or by postal questionnaire. After operation 89% of hips were pain-free or caused only occasional discomfort, and in 76% there was an increased range of movement. Of those patients actually seen for review 79% were judged to have a good or excellent result. The most frequent single complication was deep infection, which occurred in 5.3% of hips.

Introduction

Osteoarthritis of the hip is an important cause of pain and disability, and its treatment forms a large proportion of the work in any general orthopaedic unit. With an increasingly elderly population this problem is likely to become even more important.¹ Undoubtedly total hip replacement can produce extremely good results, especially when performed in a special centre. This review reports the results of one type of total hip replacement—Charnley low-friction arthroplasty—performed over a period of four and a half years in a busy general orthopaedic unit.

Material and Methods

Between August 1966 and December 1970 352 Charnley low-friction arthroplasties were performed at the London Hospital for osteoarthritis. During that time this was, with only one or two exceptions, the only form of total hip replacement used in the unit.

The indications for operation were severe pain disturbing sleep or preventing normal activities or, less commonly, stiffness of the hip with, in each case, radiological changes of advanced osteoarthritis. Initially the operation was performed only on patients over 65 years of age or on younger patients with "built-in brakes," but later this age limit was somewhat relaxed. The operations were performed by surgeons of varying degrees of experience (four consultants and 10 of their senior registrars or registrars). They were carried out on routine operating lists with none of the extra precautions against infection found at the Centre for Hip Surgery, Wrightington.

Eight hips were approached through an anterior Smith-Peterson incision, but in the remainder (344) the standard Charnley technique² was used—that is, a lateral approach and detachment of the trochanter. Postoperatively the patients were kept in bed with the legs abducted for seven days and were then mobilized with walking aids which were discarded when confidence and walking ability allowed. One consultant preferred patients under his care to use elbow crutches for six weeks to reduce the strain on the greater trochanter while it was uniting. There was no regular policy regarding the use of antibiotics, either systemic or local. A large proportion of patients received a course of ampicillin and cloxacillin, starting with the pre-medication and continuing for several days. Others received antibiotics in the postoperative period for chest or urinary infections. A few patients included in this review took oxy-tetracycline for 3-14 days preoperatively when a pathological study was being made of the osteoarthritic femoral head.

Of the 308 patients treated (90 men, 218 women) 44 had bilateral operations. The ages of the patients at operation are shown in Table I. Previous operations had been performed on 111 hips, as shown in Table II.

TABLE I—Age at Operation

Age in years	20-29	30-39	40-49	50-59	60-69	70-79	≥80
No. of patients	1	3	8	70	140	74	12

TABLE II—Previous Operations on 111 Hips

Cup arthroplasty	42	Psoas and/or adductor tenotomy	4
Osteotomy	36	McKee-Farrar arthroplasty	3
Thompson or Moore arthroplasty	11	Arthrodesis	1
Internal fixation for fracture	7	Judet arthroplasty	1
Girdlestone arthroplasty	6		

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Results

A total of 248 patients were reviewed at a special follow-up clinic, of whom 39 had had bilateral operations (287 hips). A further 31 (33 hips) replied to a questionnaire. Eight patients were known to be dead, leaving 22 (24 hips) lost to follow-up. Thus 320 operations (91%) were reviewed. The duration of follow-up is shown in Table III.

TABLE III—Duration of Follow-up of 320 Hips

Time in years	..	<1	1-2	-3	-4	-5
No. of hips	..	105	82	67	51	15

Pain Relief.—Ninety-seven per cent. of the hips were severely painful before operation, while postoperatively 89% were pain-free or gave only occasional discomfort (Table IV). The 34 patients with severe pain after operation are discussed in more detail below.

TABLE IV—Severity of Pain in 320 Hips

	Before Operation	After Operation
None	2	199
Occasional discomfort	8	87
Regularly on walking	51	16
Regularly at rest	259	18

Passive Range of Movement.—The preoperative range of movement was taken from the hospital notes. The postoperative range was assessed only in those patients who attended for follow-up—that is, in 287 hips. The range of movement was graded by the method of d'Aubigne and Postel³ and is shown in Table V. The total range of flexion, abduction, adduction,

TABLE V—Passive Range of Movement in 287 Hips

Grade	Before Operation	After Operation	Postoperative Flexion	
			Degree	No. of Hips
6	4	42	≥90	93
5	21	99	60-90	151
4	80	124	30-60	35
3	97	14	<30	1
2	53	1		
1	32	0		

The prosthesis was removed in seven cases

external rotation, and internal rotation is graded as follows: 1, less than 30° of total movement; 2, 30-59°; 3, 60-99°; 4, 100-159°; 5, 160-209°; and 6, 210-260°. The postoperative range of flexion is also shown in Table V. Movement was increased in 221 hips, in 55% of these by more than two grades. In the patients who replied to the questionnaire movement had increased in 22 hips. Thus 76% of operations resulted in increased movement.

Overall Assessment.—Patients were asked to grade the result of operation as excellent, good, fair, or poor. The main criterion for their assessment seemed to be pain relief. Altogether 281 hips (88%) were rated as excellent or good. A doctor's assessment was based on pain relief and postoperative movement according to a method similar to that of Arden, Taylor, and Ansell,⁴ and was therefore made only on those patients who attended for follow-up examination. Excellent was considered as at least 90° of flexion with no pain, good as 60-89° with no pain or more than 60° with occasional discomfort, fair as 30-60° with no pain or occasional discomfort, and poor as less than 30° of flexion or any patient with regular pain; 230 operations (79%) were rated as excellent or good. The results of the two assessments are shown in Table VI. An attempt was made to

TABLE VI—Overall Assessments

	Patient's Assessment (320 Hips)	Doctor's Assessment (287 Hips*)
Excellent	236	71
Good	45	157
Fair	17	17
Poor	22	35

*The prosthesis was removed in seven of these cases.

relate the quality of the result to the experience of the surgeon and to the time since operation. The ratio of good to bad results was the same for both consultants and other surgeons and was similar for each year.

GENERAL COMPLICATIONS

Four patients (1%) died before leaving hospital. The causes of death were pulmonary embolism, bronchopneumonia, bronchopneumonia associated with carcinoma of the prostate, and cerebrovascular accident. There were no deaths during operation. No patient was suspected of having fat embolism. Ninety-eight patients suffered one or more general complications while still in hospital (Table VII).

TABLE VII—General Complications in 98 Operations

Postoperative death	4	Myocardial ischaemia	2
Chest infection	36	Myocardial infarction	1
Urinary infection	20	Gastrointestinal bleeding	1
Pulmonary embolism	17	(Partial gastrectomy)	
Deep vein thrombosis	15	Jaundice	1
Bedsore	6	Superficial vein thrombosis	1
Cerebrovascular accident	5		

SUPERFICIAL INFECTION

Of the 352 hips 45 (13%) developed either wound haematoma or superficial infection or both. It was often difficult to distinguish the two. Two patients required surgical treatment for such infection; in both cases the wound was drained and irrigated. Both patients remained symptom-free and the wounds were well healed and uninflamed 9 and 17 months postoperatively.

DEEP INFECTION

Seventeen patients (5.3% of those followed up) were known to have or to have had deep infection. There were no cases of bilateral infection in the same patient.

Predisposing Conditions.—Two of these patients were diabetic and another had pancytopenia for which she was receiving steroids. She was nursed in isolation before and after operation but was not given antibiotics until she developed a chest infection postoperatively. One patient had previously had a cup arthroplasty which had become infected; the cup had subsequently been removed and the infection had resolved clinically. The incidence of previous surgery in the infected group was 37.5% compared with 31.8% in the rest.

The time of appearance of the initial symptoms of infection is shown in Table VIII. In three cases the onset of symptoms was associated with some definite episode, either trauma to the hip or infection elsewhere. In nine cases occurring more than six weeks postoperatively pain often preceded inflammation and discharge by several weeks or months. Three of these patients with "late" infections had received antibiotics at the time of the original operation—one prophylactically, one for a urinary infection, and one for a chest infection.

TABLE VIII—Time of Appearance of Initial Symptoms of Deep Infection

Time After Operation	No. of Hips	Remarks
Immediately	6	
6 Weeks	2	One followed reduction of dislocation which resulted from a fall
8 Months	2	
12 Months	2	
18 Months	2	
23 Months	1	Pus found at exploration of a loose acetabulum after a fall
27 Months	2	In one the onset of symptoms was associated with an episode of pyelitis. The pyelitis responded to treatment but the hip symptom persisted. Discharge appeared nine months later

The incidence of deep infection was correlated with the administration of systemic antibiotics at the time of arthroplasty. There was a higher incidence in those who did not receive antibiotics (7 out of 107; 6.5%) than in those who did (10 out of 213; 4.6%).

The initial organism is shown in Table IX. In some cases more than one organism was grown. In five cases intestinal organisms were cultured.

TABLE IX—Initial Organism in Deep Infection

	No of Cases	Remarks
Not known	4	In one discharge had not appeared
No growth	4	Three had received antibiotics before swab was taken
<i>Staphylococcus pyogenes</i>	7	
<i>Staphylococcus epidermis</i>	2	One was on steroids for pancytopenia and antibiotics for chest infection
<i>Escherichia coli</i>	3	
<i>Pseudomonas</i>	1	
<i>Coliform bacteria</i>	1	

Treatment.—(1) Antibiotics. All these patients received systemic antibiotics, often in large quantities and great variety over long periods without the infection being overcome, although in two hips the infection subsided for 10 and 18 months before reappearing. (2) Local irrigation. A variety of methods and irrigating fluids were used in five patients, including noxythiolin (Noxyflex), eusol, neomycin, and cloxacillin, and the irrigation was maintained for periods ranging from a few days to three weeks. It was combined with systemic antibiotics and usually removal of the trochanteric wires. In none of these patients did irrigation succeed in controlling the infection for more than a few weeks. (3) Removal of prosthesis. At the time of writing 10 prostheses had been removed. Seven of these wounds were dry and the three that were still discharging had been removed only a short time previously. Apart from these three and the one other patient who could not be contacted one patient had no pain and five had pain regularly on walking or at rest. Three had more movement than before the arthroplasty, two had the same movement, and one had much less.

LOOSENESS OF PROSTHESIS

In five cases (1.5%) one or other component of the prosthesis had come loose, in four cases the acetabulum and in one the femoral component.

Acetabular Looseness.—One of these patients is mentioned in the infection group (see Table VIII). Two others were found at follow-up complaining of pain; x-ray examination showed that in one the acetabulum was falling through into the pelvis, while in the other it was inadequately covered by bone. The fourth patient had been readmitted two months after operation with disruption of the trochanter and looseness of the acetabulum. This was refixed and at follow-up she complained of occasional discomfort only and rated the operation as excellent.

Femoral Looseness.—This patient had been reoperated on elsewhere. The initial postoperative x-ray film showed very little cement around the femoral prosthesis.

DISLOCATION

In seven patients (2.2%) the prosthesis had dislocated. One is mentioned in the infection group. Another could not be reduced at the original operation (an attempt to convert a long-standing Girdlestone arthroplasty) and remained dislocated. The others occurred at three weeks, five weeks, six weeks, five months, and eight months. One patient suffered two dislocations and another said that his hip dislocates and reduces spontaneously and frequently but painlessly.

One dislocation resulted from a fall, and another was due to the patient being nursed on the side opposite the operated hip when she was seriously ill without the leg being properly supported. A further case can be attributed to the acetabulum being placed too vertically, and another to complete detachment of the trochanter. The one that occurred five months postoperatively did so while the patient was lying in bed with the legs abducted after having the opposite hip replaced. This dislocation required open reduction. The remainder were treated by closed manipulation followed by three weeks of bed rest with the legs abducted.

SCIATIC NERVE DAMAGE

Thirteen patients (4%) had some evidence of sciatic nerve damage postoperatively. In 10 this involved only sensory disturbance, and most of these recovered rapidly and completely. Two of these patients complained at follow-up of minor sensory loss on the dorsum of the foot and shin. Three patients had foot-drop. Two recovered rapidly but the other had not improved nine months after operation.

TROCHANTER PROBLEMS

Seventy-two patients (20%) complained at follow-up of pain and tenderness over the greater trochanter. Most of these complaints were minor and in only two cases were they enough to affect the overall assessment of the operation. In three the symptoms had been sufficient to warrant removal of the wires, with complete relief of symptoms in all three. In at least 22 patients the trochanteric wires had broken, usually without appreciable displacement of the trochanter. At follow-up only eight of these patients complained of discomfort and then only slight. In two patients the broken wires were associated with complete disruption of the trochanter; one of these suffered two dislocations and the other was the patient in whom the disruption was associated with looseness of the acetabulum.

TECHNICAL PROBLEMS

Four of the loose prostheses could be attributed to technical problems—the acetabulum reamed too deeply or not deeply enough, or one or other component not adequately cemented. Similarly two of the dislocations were due to technical failure—the one that was never properly reduced and the one in which the acetabulum was placed too vertically. Another reason for two bad results was fracture of the femur occurring at the time of operation. Incorrect reaming of the femur, causing the stem of the prosthesis to be left protruding from the femoral shaft, produced a bad result in two patients.

Discomfort and swelling of the knee on the operated side was a frequent complaint in the postoperative period. It was persistent in four patients.

PERSISTENT PAIN AFTER OPERATION

Thirty-four patients had a significant amount of pain after operation. The probable causes of the pain are detailed in Table X. The 12 patients with deep infection, the three technical

TABLE X—Causes of Pain persisting after Operation in 34 Hips

Infection	12	Trochanter	2
Possible infection	1	Recent and repeated surgery ..	1
Technical problems	3	Pain arising from other sites ..	8
Possible looseness	2	No cause found	5

problems, and the two painful trochanters are mentioned above. One hip was possibly infected and in two others the prosthesis may have been loose, though no definite proof was obtained. In one patient continuous discomfort seemed to be due to relatively recent surgery after much previous surgery on the same hip.

Eight patients complained of pain which they felt detracted from the quality of the result but which seemed on careful inquiry and examination to be arising elsewhere; in the lumbar spine, for example. Five patients had pain which seemed to be arising from the hip but which could not be explained even after thorough investigation, including in one case reoperation.

OVERALL SERIOUS LOCAL COMPLICATIONS

The total serious local complications are listed in Table XI. The sciatic nerve troubles that cleared, the more minor trochanter problems and those that were relieved by removal of the

TABLE XI—Total Serious Local Complications in 320 Hips

	No. of Hips	%	Remarks
Deep infection	17	5.3	
Possible infection	1	0.3	
Loose prosthesis	5	1.5	One also infected
Possible looseness	2	0.6	
Dislocation	7	2.2	One also infected
Sciatic nerve damage permanent	1	0.3	
Serious trochanter problems ..	4	1.25	One associated with looseness, one associated with dislocation
Technical problems not included above	4	1.25	
Persistent hip pain ? cause ..	5	1.5	
Total	42	13.1	

wires, and the swollen knees are excluded. Those patients in whom persistent pain could reasonably be attributed to a cause unrelated to the hip have also been omitted.

Discussion

It is well recognized that the Charnley arthroplasty can produce very good results and, moreover, in a very short time, so involving the patient in a relatively short stay in hospital and a short period of simple rehabilitation (with all the financial implications for the patient and the National Health Service). On the evidence of this series such good results can be expected in about 85% of operations when they are performed in a general orthopaedic unit by a variety of surgeons. Postoperative mortality is low. An important number of patients will, however, develop serious complications, the most common of which is infection. This and other complications, such as looseness of the prosthesis and dislocation, are to some extent inherent risks of total hip replacement. Problems involving the trochanter are confined to the operation as performed by the orthodox Charnley technique.

In our series these complications were not related to the experience of the surgeon.

In this, as in other series, a remarkable proportion of deep infections became apparent only after a long delay (as great as two years), and in only a third of such late infections at the most could this delay be attributed to the administration of antibiotics at the time of operation which might have masked the infection in the early postoperative period. It has been argued that such late infection is a reaction to acrylic cement, which may or may not become secondarily infected; however, the one patient in this series who had undergone bilateral arthroplasty and had developed infection on one side showed no evidence of infection on the other side. Furthermore, the incidence of such infection can apparently be reduced by the administration of antibiotics at the time of operation.

Antibiotics, however, can be only a partial solution to the problem of infection and the real answer must lie in avoiding contamination at the time of operation, presumably by means similar to those employed at the Centre for Hip Surgery, Wrightington. Probably the high incidence of infection in this series was related to the conditions under which the operations were performed.

During the period covered by this review the operating theatre used for orthopaedic work was one of a suite of eight old theatres situated along a common corridor. It had remained substantially unchanged since it was built over 50 years previously. Ventilation was by means of a positive-pressure supply at floor level. Scrubbing up and some sterilization, by boiling, were performed in the theatre itself. The walls had originally been tiled, but in several places tiles had fallen or been removed and the defects had been covered by plaster which had been left bare. The theatre was also used by a general surgeon and a plastic surgeon. The whole theatre suite was under reconstruction but it was impossible to close more than one theatre at a time because of the pressure of work. The alternatives available were either to continue operating in the theatre as it stood or not to perform this type of surgery. The fact that intestinal organisms were cultured from five infected hips may be related to the fact that the theatre was also used for general surgery. At present the theatre is being rebuilt and is being equipped with a sterile laminar flow air supply and separate autoclaving facilities.

Complications related to the removal of the trochanter can be avoided by using a different surgical approach, but repositioning of the abductor insertion is an important feature of this operation. As Charnley points out, it is a hip reconstruction rather than a replacement. In addition removal of the trochanter gives an extremely good exposure and is undoubtedly of great help in the more difficult cases. It has to be proved that the overall results and complication rate can be improved by any other technique.

We would like to thank the consultant surgeons of the London Hospital (Sir Henry Osmond-Clarke, Mr. O. J. Vaughan-Jackson, Mr. W. A. Law, and Mr. M. A. R. Freeman) for allowing us to review patients under their care, and Mr. M. A. R. Freeman and Dr. Michael Mason for their help in preparing this paper. We are very grateful to Miss J. M. Piercy, Miss D. Hayes, Mrs. P. Young, and Mrs. A. S. McKee, of the Department of Physiotherapy, for their help in assessing the patients.

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