Traumatic Arthritis of the Hip after Dislocation and Acetabular Fractures: Treatment by Mold Arthroplasty

An End-Result Study Using a New Method of Result Evaluation*

BY WILLIAM H. HARRIS, M.D.†, BOSTON, MASSACHUSETTS

From the Department of Orthopaedic Surgery, Massachusetts General Hospital, Boston

Arthritis of the hip secondary to trauma severe enough to produce dislocation of the hip or fracture of the acetabulum presents a problem in treatment which may be compounded by avascular necrosis of the femoral head, sciatic-nerve involvement, severe disruption of the acetabulum, and serious musculoskeletal injuries in other parts of the body. These adverse features are frequently offset, in part, by the absence of systemic disease, the relative youth of the patients who usually have this condition, and the fact that, as a rule, only one hip is involved.

The usual operative treatment is either hip fusion or arthroplasty. In order to judge the efficacy of these two therapeutic measures, long-term end-result studies in large series are necessary, but no such studies have been reported. Waring and Anderson found the best results after Crawford Adams cup arthroplasties in twelve patients, but the traumatic arthritis and avascular necrosis in some of their patients followed femoral-neck fractures. Stewart and Milford, in their series of fracture-dislocations, had nine cup arthroplasties and eleven fusions. Of the other recorded cases of traumatic arthritis treated by mold arthroplasty, Stinchfield and Carroll had two, Law ten, and Aufranc and Sweet nine. (These nine cases are included in the current report.)

In Westerborn's paper on the use of mold arthroplasty in six cases of central dislocation, the longest follow-up was three years. Kelly and Lipscomb in a study of eight cases of posterior dislocation of the hip with associated fracture of the femoral head, found that primary mold arthroplasty yielded satisfactory results in seven.

Rowe and Lowell in their study of fracture of the acetabulum at the Massachusetts General Hospital found twelve patients with traumatic arthritis. Of these twelve, eight were treated by cup arthroplasty, two had spontaneous fusions, and two had surgical fusion. Three of the eight treated by cup arthroplasty were ward patients and were not included in this report; the other five were included.

Lipscomb and McCaslin reported eighty-four fusions for traumatic conditions of the hip but they included patients with slipped epiphysis, avascular necrosis, ununited fractures of the hip, and failure of arthroplasty. Stinchfield and Cavallaro did not include any cases of traumatic arthritis in their series of fusions and Watson-Jones and Robinson did not identify the cases of traumatic arthritis in their report. Stone and Mortens and Jensen included only one case of traumatic arthritis each in their series.

This study reports the follow-up results of thirty-nine mold arthroplasties in a consecutive series of thirty-eight private patients with traumatic arthritis of the hip treated at the Massachusetts General Hospital between 1945 and 1965. Only private

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 29, 1967.

† 266 Beacon Street, Boston, Massachusetts 02116.

patients were included in order to reduce the variables attributed to the individual surgeons. Only three surgeons were involved in these thirty-eight cases (M. N. Smith-Petersen, Otto E. Aufranc, and Morton Smith-Petersen).

Methods and Materials

In this series, only patients with fractures of the acetabulum, dislocations of the hip, or both were included. Patients with femoral-neck fractures and their sequelae were excluded since, for a variety of reasons, including age of the patient, other skeletal diseases, and associated debilitating diseases, these patients present a different problem. Patients who had pre-existing disease or hip symptoms were also excluded, as were patients who had had other forms of hip reconstruction prior to their mold arthroplasty or who had a mold arthroplasty done elsewhere.

A recent follow-up examination was made of thirty of the thirty-eight patients. Five of the current examinations were performed by other orthopaedic surgeons because the patients lived at a great distance. Of the eight patients who were not seen recently, three had died and five were lost to follow-up. The last recorded data on these patients obtained, respectively, at one, one and one-half (three patients), two, two and one-half, four and one-half, and five years after operation were used in this analysis.

Preoperative and postoperative data for all patients were analyzed by the methods of Shepherd [15,16] and Larson and also by a new method for the assessment of the results of hip surgery.

Method of Result Evaluation

The new system was formulated in an effort to encompass all the important variables into a single reliable figure which is both reproducible and reasonably objective. The system was also designed to be equally applicable to different hip problems and different methods of treatment.

The Shepherd system [15] is difficult to use because it does not integrate function with motion and because it does not assign a single over-all value for the rating. Comparison of the status of different patients or of the status of the same patient at different times is complex. Recognition of the inability to resolve the data into one rating is implicit in having two separate rating categories, namely, rating *as a hip* and *as an arthroplasty.*

The Larson system [10], although it does give a single over-all rating figure, appears to favor arthroplasty over other procedures and to lack sensitivity. For example, it is possible for a patient to obtain ninety-eight of one hundred possible points and yet require the use of a cane full time. Only six points are deducted for the use of two crutches full time.

Rationale of New Method of Evaluation

Pain and functional capacity are the two basic considerations. They constitute the indications for surgery in the vast majority of patients with hip problems, and hence receive the heaviest weighting. In specific cases, correction of deformity or restoration of motion may be of prime importance but such cases are uncommon.

Based on this reasoning a point scale with a maximum of 100 points is used with the following maximum possible scores:

Pain	44
Function	47
Range of Motion	5
Absence of deformity	4
Total	100

The gradations of pain, because of its subjective nature, are inevitably imperfect but the following gradations have proved workable and satisfactory:

Amount of Pain	Description	Points Allotted
None		44
Slight	Occasional ache or awareness of pain of low grade, no compromise of activities	40
Mild	No effect on average activities, rarely may have moderate pain following unusual activities, may take aspirin	30
Moderate	Pain tolerable but patient makes concessions to his pain, some limitation of ordinary activities but able to work regularly, may require pain medicine stronger than aspirin occasionally	20
Marked	Severe pain at times, but ambulatory; serious limitation of activities; takes pain medicine stronger than aspirin usually or frequently	10
Disabled	Severe pain even in bed; pain forces patient to bed; crippled by pain; bedridden	0

Although patients do not describe their pain exactly in these terms, reasonable assessment of the level of pain can be made with these guidelines.

Function is broken down into daily activities (fourteen points) and gait (thirty-three points). Although many functional activities could be graded, the following selected tasks give a very satisfactory profile.

	Daily Activity	Points Allotted
Stairs	Foot over foot without use of banister	4
	Foot over foot using banister	2
	Stairs in any manner	1
	Unable to do stairs	0
Transportation	Able to enter public transportation	1
Sitting	Comfortable in any chair for one hour	5
	Comfortable in a high chair for one-half hour	3
	Unable to sit comfortably in any chair	0
Shoes and socks	Puts on socks and ties shoe with ease	4
	Puts on socks and ties shoe with difficulty	2
	Unable to put on socks or tie shoe	0

Gait presents a problem in assessment. Excluding pain, which is considered separately, gait can be characterized in terms of support, limp, and distance that can be walked. Because the support needed and the amount of limp depend on the distance walked in certain cases, gait assessment is based on the support necessary to walk six to nine blocks (about one mile) and the appearance of the gait after walking this distance. Eleven points are assigned each to limp, support and distance walked.

Gait

Description	Points Allotted
Limp is rated as follows:	
None	11
Slight	8
Moderate	5
Severe	0
The support required to walk comfortably and smoothly is rated as follows:	
None	11

Single cane for long walks	7
Single cane most of the time	5
One crutch	3
Two canes	2
Two crutches	0
Not able to walk at all	0 (must specify reason)

Distance walked is rated as follows:

Unlimited	11
Six blocks	8
Two or three blocks	5
Indoors only	2
Bed and chair	0

The Trendelenburg test is obviously an important way to assess one aspect of hip function. It is recorded but not rated in this system, because, in a sense, it is a static rather than a dynamic test. It is possible for many patients to demonstrate a single negative test and yet be unable to walk without a Trendelenburg gait after the first few steps. What the patient can do functionally, as recorded in the rating of gait, is more important than the test itself.

Motion is important only as it affects function. Therefore, in this analysis motion in itself is given minor emphasis, with a maximum possible score of only five points out of the one hundred. Gade maintained that only active motion is significant but one has only to observe a paraplegic standing and then sitting down, to realize the importance of passive motion under certain circumstances.

All types of motion are not of the same utility. Ferguson and Howorth introduced the idea of rating certain motions preferentially, using an index factor and Gade pointed out that the first 45 degrees of flexion is of decidedly more value than the arc from 90 to 130 degrees. However, in Gade's system a patient could have flexion from 0 to 90 degrees, abduction to 15 degrees, internal rotation to neutral from 15 degrees of external rotation, and adduction to 10 degrees—an extremely useful range of motion—and still receive only sixty out of the possible one hundred points which he allots for motion. For this reason a more specific rating of the range of motion is used here with more emphasis on the functionally important aspects of motion.

	Arc of Motion		Index	Maximum Possible Value
Flexion	0–45°	(45°)	1.0	45
	45–90°	(45°)	0.6	27
	90–110°	(20°)	0.3	6
	110–130°	(20°)	0.0	0
Abduction	0–15°	(15°)	0.8	12
	15–20°	(5°)	0.3	1.5
	20–45°	(25°)	0.0	0
External rotation in extension	0–15°		0.4	6
	Over 15°		0.0	0
Internal rotation in extension	Any		0.0	0
Adduction	0–15°		0.2	3
	Over 15°		0	0
Extension	Any		0	0
			Total Motion Point Value =	100.5

To determine the rating for motion the number of degrees of motion in each designated arc is multiplied by the corresponding index factor. For example, a patient with a 30-degree flexion contracture who has further flexion to 100 degrees

but lacks rotation and has no motion in the abduction-adduction range would be rated for motion as follows:

15 degrees in the 0 to 45-degree range of flexion (that is, from the 30-degree flexion contracture further to 45 degrees of flexion), or 15 × 1.0 (index value) = 15 points;

45-degrees in the flexion arc from 45 to 90 degrees, or 45 degrees × 0.6 (index value) = 27 points;

10 degrees in the flexion arc from 90 to 110 degrees, or 10 × 0.3 (index value) = 3 points;

No points for rotation or abduction-adduction;

Total point score is forty-five.

The sum of the point scores for the individual arcs is then multiplied by 0.05 to obtain the number of points for the over-all evaluation of the range of motion. This patient would receive 0.05 × 45 or 2.3 points for motion. All of these calculations can be performed automatically during data processing so that the surgeon need only record the range of motion in the usual way.

The final four points of the over-all total of one hundred are given for the absence of deformity. Any of the following constitutes a significant deformity and eliminates these four points: A permanent flexion contracture greater than 30 degrees, fixed adduction of more than 10 degrees, fixed internal rotation of more than 10 degrees or a limb-length discrepancy of more than 3.2 centimeters.

Synopsis of The Evaluation System

I. Pain (44 possible)

- A. None or ignores it 44
- B. Slight, occasional, no compromise in activities 40
- C. Mild pain, no effect on average activities, rarely moderate pain with unusual activity, may take aspirin 30
- D. Moderate pain, tolerable but makes concessions to pain. Some limitation of ordinary activity or work. May require occasional pain medicine stronger than aspirin 20
- E. Marked pain, serious limitation of activities 10
- F. Totally disabled, crippled, pain in bed, bedridden 0

II. Function (47 possible)

A. Gait (33 possible)

1. Limp

- a. None 11
- b. Slight 8
- c. Moderate 5
- d. Severe 0

2. Support

- a. None 11
- b. Cane for long walks 7
- c. Cane most of the time 5
- d. One crutch 3
- e. Two canes 2
- f. Two crutches 0
- g. Not able to walk (specify reason) 0

B. Activities (14 possible)

1. Stairs
   a. Normally without using a railing 4
   b. Normally using a railing 2
   c. In any manner 1
   d. Unable to do stairs 0

2. Shoes and Socks
   a. With ease 4
   b. With difficulty 2
   c. Unable 0

3. Sitting
   a. Comfortably in ordinary chair one hour 5
   b. On a high chair for one-half hour 3
   c. Unable to sit comfortably in any chair 0

4. Enter public transportation 1

III. Absence of deformity points (4) are given if the patient demonstrates:
   A. Less than 30° fixed flexion contracture
   B. Less than 10° fixed adduction
   C. Less than 10° fixed internal rotation in extension
   D. Limb-length discrepancy less than 3.2 centimeters

IV. Range of motion (index values are determined by multiplying the degrees of motion possible in each arc by the appropriate index)
   A. Flexion 0–45 degrees × 1.0
      45–90° × 0.6
      90–110° × 0.3
   B. Abduction 0–15° × 0.8
      15–20° × 0.3
      over 20° × 0
   C. External rotation in ext. 0–15 × 0.4
      over 15° × 0
   D. Internal rotation in extension any × 0
   E. Adduction 0–15° × 0.2

To determine the over-all rating for range of motion, multiply the sum of the index values × 0.05. Record Trendelenburg test as positive, level, or neutral.

Material

Thirty-one of the thirty-eight patients were male. The left hip was involved in eighteen; the right, in twenty-one. One patient required bilateral arthroplasty for bilateral traumatic arthritis.

Automobile accidents accounted for thirty-two of the thirty-nine injuries. Train accidents caused three, falls two, and skiing one. In one no information was available.

The types of injury to the hip were: posterior fracture-dislocation in eighteen (three with fracture of the femoral head), posterior dislocation in eight (one with fracture of the femoral head), central dislocation in six, bursting fracture in five (one with femoral-head fracture), and posterior fracture without dislocation in two.

The initial treatment consisted in closed reduction in twenty-two cases, open reduction in five, open reduction and internal fixation in four, closed reduction followed by open reduction in one, and traction in the remainder. In four of the ten hips treated by open reduction, postoperative intra-articular infections developed. The organism in three was *Staphylococcus aureus* and in one instance, streptococcus. The sciatic nerve had been injured in four patients, resulting in marked permanent

FIG. 1-A

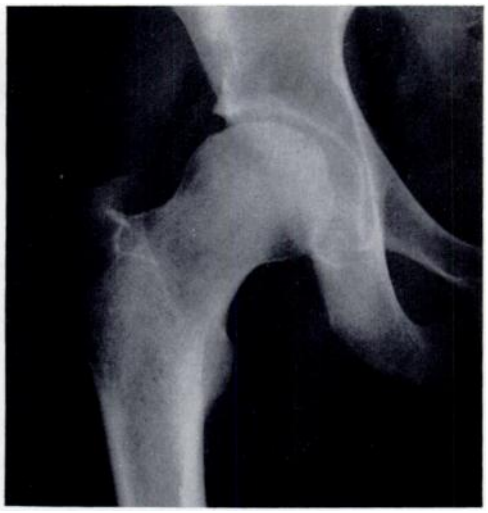

FIG. 1-B

Figs. 1-A through 1-D: P. M., a man, twenty-five years old, dislocated his right hip in a skiing accident. Nine years after the injury he had severe avascular necrosis of the femoral head. Mold arthroplasty was performed and eight years later, he had no pain and was able to ski, play tennis, and run six miles.

Fig. 1-A: Right hip two years after dislocation. The femoral head appears to show increased density.

Fig. 1-B: The right hip, five years later, shows slight loss of sphericity and increased density of the femoral head.

FIG. 1-C

FIG. 1-D

Fig. 1-C: Nine years after dislocation, the femoral head shows segmental collapse and cyst formation secondary to avascular necrosis.

Fig. 1-D: Six years after mold arthroplasty.

loss of sciatic function in three and partial peroneal palsy in the other.

Twenty-one of the patients had no other significant musculoskeletal injury and seventeen had the following concommitant traumatic lesions: fracture of the ipsilateral femur in three, fracture of the ipsilateral patella in four (one requiring patellectomy), fracture of the ipsilateral tibia in three, fracture of the ipsilateral foot or ankle in one, fracture of the contralateral femur in two, fracture of the contralateral patella in one, fracture of the contralateral knee in one, fracture of the contralateral

FIG. 2-A

FIG. 2-B

Figs. 2-A and 2-B: R. B., a man, sixty-two years old at the time of injury, sustained a central dislocation of his hip. Increasing pain and loss of motion led to arthroplasty two years later.

Fig. 2-A: Anteroposterior roentgenogram of the hips and pelvis shows severe disruption of the right acetabulum with central dislocation of the femoral head.

Fig. 2-B: Anteroposterior roentgenogram of the right hip four and one-half years after arthroplasty. The mold was placed against the periphery of the acetabular rim, rather than seating it deeply to the full depth of the acetabulum. He had no pain, an excellent gait, 130 degrees of flexion, and walked two miles without support.

tibia requiring fusion of the knee and ankle in one, fracture of the contralateral ankle in one, contralateral above-the-knee amputation in one, fracture of the forearm in four, crushed chest in one, sciatic-nerve injury in four, and fracture-dislocation of the other hip in two.

The average time between injury and reconstruction was 7.7 years with a range of from two months to thirty years. The mean age of the patients when the hip was reconstructed was forty-seven years with a range of from twenty-two to seventy-one. Thirteen of the thirty-eight patients were over fifty-five; nine, under forty; and seven, over sixty.

The arthroplasty was performed in thirty-four of the patients because of complaints of pain, in two because of pain and limited motion, in one patient because of stiffness, and in two because of persistent dislocation of the hip. One of the persistently dislocated hips had avascular necrosis of the femoral head. Altogether

twelve hips showed roentgenographic evidence of avascular necrosis (Figs. 1-A through 1-D). The acetabulum showed severe changes in thirty-seven. Prior to surgery the Trendelenburg test was positive in thirty-four of the hips and negative in four. The result was not recorded in one instance.

The operative procedure, carried out through an anterior incision in thirty-seven cases and through a Kocher incision twice, took an average of 3.4 hours with a range from two to 5.5. All of the procedures were standard arthroplasties with decortication and reaming of both the head and acetabulum except for two in which the cup was placed on the mid-portion of the femoral head and two in which the cup was seated against the periphery of the acetabulum in preference to inserting it more deeply into an exploded socket (Figs. 2-A and 2-B). Of these latter two, one was rated excellent and one good at the follow-up examination. An average of 3.7 units of blood (range one to eight units) was used for each operation.

The duration of patients' stay in the hospital ranged from one month to 3.5 months with a mean of 1.7 months. One patient discarded his crutches two months after operation while another remained on crutches for forty-eight months until her death from metastatic carcinoma of the lung. On the average, two crutches were used postoperatively for 9.8 months (the mode and the median). All of the six patients who used crutches for over one year had some additional problem such as a contralateral above-the-knee amputation, metastatic malignant tumor, nonunion of a fracture of the distal portion of the femoral shaft, additional trauma to the hip, and the like. The average duration of follow-up was 5.8 years with a range from one to fifteen years.

Results

All thirty-nine hips were evaluated by all three systems. In assessing pain the proposed new system and the Shepherd system are similar but the Larson system is quite different:

Pain Categories and Valuation in Three Systems

Larson		Shepherd	Proposed	
None	35	None	None	44
Pain only with fatigue	30	Ignores	Ignores	40
Pain only with weight-bearing	20	Makes concession	Mild	30
Pain at rest but not with weight-bearing	15	Disabling	Moderate	20
Pain sitting or in bed	10		Marked	10
Continuous pain	0	Crippling	Disabled	0

The categories, identified as *none*, *ignores*, and *totally disabled . . . bedridden* in the proposed evaluation system, are usually easy to define. Because patients in the intermediate groups are more difficult to categorize, this part of the pain classification has been expanded from two categories (*concession* and *disabling*) in the Shepherd system to three (*mild*, *moderate*, and *marked*) in the new scheme. This change makes classification of individual patients easier in the proposed system than in the Shepherd method. While the Larson system has six categories, the definition of the categories and the allotment of points are not consistent with my experience in interviewing patients. For example, it is very rare to find a patient who has pain at rest but not on weight-bearing. Also it is often hard to distinguish between a patient who has pain at rest (fifteen points) and one who has pain sitting or in bed (ten points) or has continuous pain (0 points).

Because the Shepherd system does not use a single over-all rating value, comparison of this method with the other two was difficult. In addition, the Shepherd system rates the result *as a hip* as distinct from the rating *as an arthroplasty*. The

complex functional assessment is done by ascribing a series of *black marks* for functional limitation, improvement being recognized by a decrease in the number of black marks. For example, if the number of black marks is five or less before operation and decreases by three or more after operation or if the number is between six and ten before operation and decreases by five or more after operation, the functional result is deemed excellent. If, however, the number of black marks is four or more before operation and decreases by two or one or not at all after operation or increases by one, the functional result is fair. A *good* rating in the functional category is given if there are three black marks or less and the number decreases after operation or if there are four to thirteen black marks and a decrease of three marks or more occurs after operation.

Weighted equally with this functional assessment are (1) active motion using the Gade system, (2) the patients assessment, and (3) the rating of pain. Objections to the Gade assessment of motion and to the use of only active motion have been discussed previously. The weighting of the subjective response of the patient's own assessment so heavily and the weighting of motion in itself so heavily are questionable. For all these reasons the Shepherd system did not seem to be useful in this study.

The end-result ratings of the thirty-nine hips, evaluated by Larson and the new method were as follows:

Total Points	Larson Rating		New Rating	
	Preoperative	Postoperative	Preoperative	Postoperative
90–100		16		18
80–89	1	17		7
70–79	10	3	3	9
60–69	17	3	7	2
50–59	8		9	2
40–49	2		14	1
30–39	1		3	
20–29			3	
10–19				
0–9				

Comparison of the two rating schemes shows that hips rated by the Larson system tend to fall into a more narrow range. Postoperatively only six of the thirty-nine hips were rated below eighty points. The wider spread of rating in the new system made the recognition of differences between hips easier and appeared to be a more accurate representation of each patient's functional state.

The difference between the two numerical rating systems are shown clearly by reviewing the results in individual patients:

Consider C. S., a fifty-one-year-old salesman, who sustained a fracture-dislocation of the left hip. Following an open reduction and screw fixation of the acetabular fragment, the wound became infected with *Staphylococcus aureus* and drained for six months. Two years after injury, when he was admitted for arthroplasty, his preoperative status was as follows: He had only mild pain in the hip, but marked instability and considerable grating. The Trendelenburg test was positive, active abduction against gravity was impossible, and two crutches were required full time. He was fully active in his business using crutches and could walk unlimited distances. He could tie his shoe and put on his sock, climb stairs using crutches, sit comfortably in any chair, and manage his own car or public transportation. His range of motion was: fixed flexion contracture of 10 degrees, further flexion to 115 degrees, abduction to 50 degrees, internal rotation in extension to 20 degrees, external rotation in extension to 35 degrees, and adduction to 20 degrees (Figs. 3-A and 3-B).

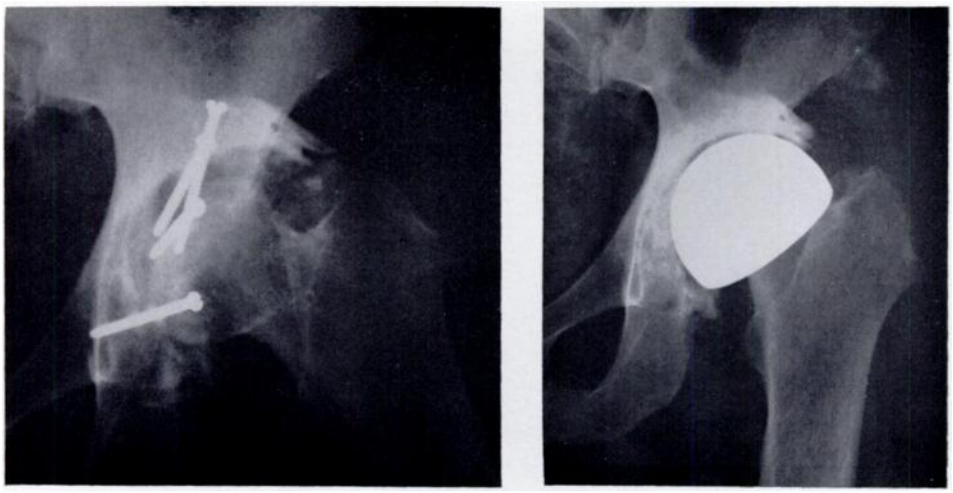

FIG. 3-A FIG. 3-B

Figs. 3-A and 3-B: C. S., a man, was fifty-one years old when he sustained a posterior fracture-dislocation of the left hip in an automobile accident. Postoperative sepsis developed after open reduction and internal fixation of the acetabular fracture at another hospital. A mold arthroplasty was performed two years later after the wound had been healed for eighteen months. Four years after arthroplasty he had an excellent result despite weighing 220 pounds. There had been no signs of sepsis since the arthroplasty.

Fig. 3-A: Anteroposterior roentgenogram of the left hip one year following dislocation.

Fig. 3-B: Anteroposterior roentgenogram of the left hip four years after mold arthroplasty.

In the Larson rating he would receive thirty of thirty-five points for function, losing only "negotiates stairs foot over foot" and "carries objects comparable to a suitcase." He would receive thirty of thirty-five points for freedom from pain, lose six of ten points for gait because he used two crutches, and earn ten of ten points for absence of deformity and eight of ten points for motion, or a total of eighty-two points. In short he would lose only five function points, five pain points, and only six gait points despite using two crutches full time. At the same time he would receive ten points for the absence of deformity and eight points for motion.

In the proposed system he would receive only thirty of forty-four points for pain, lose six of eleven points because of the moderate limp present due to the unstable hip even when using crutches, and lose eleven of eleven support points because of the requirement for two crutches constantly, but he would be granted eleven of eleven distance points on the basis that he could travel unlimited distances on the crutches. He would lose further points because of difficulty with stairs but receive only four points for absence of deformity and five for the free range of motion, making a total of sixty-six. The value of sixty-six, rather than eighty-two, would seem to portray more accurately the over-all status of a man with an unstable septic hip who required two crutches full time.

F.G., an eighteen-year-old boy, sustained a posterior fracture dislocation of the right hip with sciatic-nerve injury in an automobile accident. The severe injury to his left leg required a mid-thigh amputation. His right hip was reduced by closed manipulation but traumatic arthritis subsequently developed. One year later, despite acute pain in the right hip, he had flexion from a 10-degree fixed flexion contracture to 120 degrees, abduction to 5 degrees, adduction to 10 degrees, internal rotation in extension to 30 degrees, and external rotation to −5 degrees. He could tie his shoe and put on his sock but required two crutches because of hip pain and could walk only two blocks. He took Darvon for his pain, had pain at rest, and was unable to sit comfortably on a low chair or toilet. He was able to attend college, getting about by driving in a car.

In the Larson rating he received twenty-three points for function, ten for pain, four for gait, ten for absence of deformity and five for motion, or a total of fifty-four points. In the new system he received ten for pain, five for limp, five for distance walked, none for support, one for being able to climb stairs by any method, one for being able to enter public transportation, none for sitting, four for putting on shoes and socks, four for the absence of deformity and seven for motion, or a total of thirty-seven points. Again the new rating appeared to give a more accurate assessment of this patient who had marked pain and pain at rest, and who required two crutches full time.

A score of ninety to one hundred was considered an excellent result. Eighty to ninety was called good, seventy to eighty fair, and below seventy poor. In the new system the over-all results were eighteen excellent, seven good, nine fair, and five poor. Using the Larson system thirty-three were good or excellent, three were fair, and three were poor.

Of special interest was the comparison of the results of unilateral arthroplasty in the first eighteen patients in the series (done between 1945 and 1957) with those in the second nineteen patients (done between 1958 and 1966). In the first group, three required revision and a fourth had postoperative sepsis. Seven results were excellent, one was good, five were fair, and five were poor. In the second group ten patients received an excellent end-result rating, six a good, and two a fair rating. The remaining patient had a poor result. No revisions were required. The difference between eight good or excellent results in the first eighteen and sixteen good or excellent results in the next nineteen is statistically significant ($p < 0.05$).

The discrepancies between these figures and the over-all figures given previously are due to the inclusion in the over-all figures of both hips of the patient who had bilateral arthroplasty and the two ratings for the patient who changed from the poor category to the excellent category following a revision.

Although the patients under the age of forty had slightly better results than the rest, this difference was not statistically significant.

Special attention was given to any changes in hip function with time after arthroplasty. For the thirty-four hips followed for over two years, the function as determined from data recorded at one year after arthroplasty was compared with the function determined from the latest follow-up information two to fifteen years after arthroplasty. No result deteriorated from a good or excellent rating to a fair or poor category. Three patients with fair results were later rated at the poor level, while one fair result improved to excellent. All three of the patients whose rating deteriorated from fair to poor were never free from pain or able to walk without a cane postoperatively. The rating of all three declined because of increasing pain. Two patients who were rated as excellent at one year dropped to a good rating, the change being associated with a cerebral vascular accident in one and with the onset of Hodgkin's disease in the other. There was thus no significant deterioration of the good or excellent functional results of arthroplasty with time.

Of special interest were the four patients who had intra-articular sepsis of the hip following their initial open reductions. All four hips had been free of drainage for one, two, four, and seven years, respectively, prior to the insertion of the mold. None drained following the arthroplasty during follow-up periods of four, five, thirteen, and fifteen years. One patient whose result was rated good, had a pain-free hip, excellent gait, and full motion but required a cane for long walks. Two patients had excellent results (Figs. 3-A and 3-B). The fourth patient had a fair result because he had mild pain and required a cane.

Complications in this series were few. With the exception of one patient operated on in 1947, no postoperative sepsis occurred. None of the hips dislocated

postoperatively. Two pulmonary emboli were recognized, but accurate data concerning the incidence of thrombophlebitis were not available. There were no deaths.

The preoperative and postoperative pain rating of the patients in this series according to the three systems are shown in Table I.

Postoperatively three patients required pain medication stronger than aspirin. One did so because of pain thought to be related to traumatic disruption of the sacro-iliac joint, one because of knee pain related to a damaged patella, and one because of hip pain.

At the follow-up examination twenty-one patients were able to elevate the opposite side of the pelvis when standing on the reconstructed hip and performing the Trendelenburg test. Of the sixteen with positive Trendelenburg tests, six were able to prevent a fall of the opposite side of the pelvis below the horizontal position but were unable to elevate it. Data were not available for two hips. The development of a negative Trendelenburg test after operation did not show a strong inverse correlation with the patients' age.

TABLE I

COMPARISON OF PREOPERATIVE AND POSTOPERATIVE PAIN LEVELS

	New System						
	None	Slight	Mild	Moderate	Marked	Bedridden	Total
Preoperatively	0	0	5	26	7	1	39
Postoperatively	12	15	8	3	1	none	39

	Larson System						
	None	Only with Fatigue	Only with Wt. Bearing	At Rest but not with Wt. Bearing	Sitting or in Bed	Continuous	Total
Preoperatively	0	3	29	3	3	1	39
Postoperatively	12	18	5	4	0	0	39

	Shepherd System					
	None	Ignores	Concessions	Disabling	Crippling	Total
Preoperatively	0	3	28	7	1	39
Postoperatively	12	19	7	1	0	39

Analysis of the postoperative range of motion in the sagittal plane showed that there was no permanent flexion contracture in twenty-five hips and that in the other fourteen the maximum was 20 degrees (two hips) with an average of 5 degrees. The amount of further flexion ranged from 65 to 130 degrees, the average flexion being 105 degrees. The poorest range of motion in this plane was from 20 degrees of fixed flexion to 85 degrees of flexion.

Preoperatively twelve patients required crutches and three used two canes. At the time of follow-up examination one required two canes (the patient with bilateral hip reconstruction) and three used crutches because of the following special circumstances: One had metastatic carcinoma of the lung, was a chronic alcoholic, and spent much of her time in a mental institution. The second had received additional trauma to the reconstructed hip in a subsequent automobile accident. The third, a patient whose contralateral knee and ankle were fused, had her hip reconstructed in 1953 after it had been dislocated for ten years. The greater trochanter was transplanted distally and wired to the femur but was so osteoporotic that it fractured along the single wire suture and did not unite to the femoral shaft. This patient subsequently did not regain sufficient abductor power to walk well without crutches.

Of the nineteen patients with unilateral operations done since 1958, one used crutches (the one with metastatic carcinoma) and two used a cane full time, one because of a contralateral above-the-knee amputation, the other because of persistent hip pain. Of the remaining sixteen, ten used no support and six used a cane only for long walks.

Penetration of the cup into the acetabulum and resorption of the femoral head underneath the cup were investigated. Small degrees of penetration or resorption were difficult to assess on clinical roentgenograms but a difference in the depth of the acetabulum or relation of the cup to the femur of 6.4 millimeters or more as determined by measurements between landmarks identifiable on roentgenograms which were comparable with respect to projection as well as to rotation and position of the hip was arbitrarily established as evidence of penetration or resorption.

Comparable roentgenograms were available for thirty-five hips. Avascular necrosis of the femoral head had been diagnosed prior to arthroplasty in twelve patients on the basis of roentgenographic appearance and gross and microscopic findings. Of these twelve patients nine showed no evidence of penetration or resorption at one, one, one and one-half, two, three, four, four, eight, and fifteen years, respectively, after arthroplasty and three showed resorption of the femoral head amounting, respectively, to 6.4 millimeters at seven years, 9.6 millimeters at four years, and 1.9 centimeters at thirteen years. Two of the twenty-three patients without evidence of avascular necrosis showed shortening amounting to 1.6 centimeters at two years in one, and 1.9 centimeters at seven years in the other. In the first patient the 1.6 centimeter loss was due to resorption of the femoral head; in the

FIG. 4-A

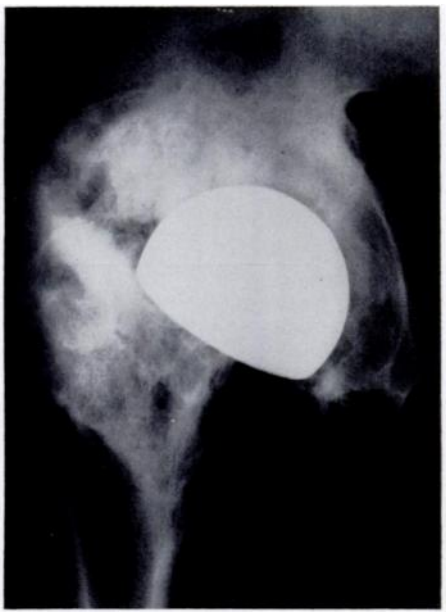

FIG. 4-B

Figs. 4-A through 4-C: B.F., a man, forty-nine years old when he was treated for traumatic arthritis of the right hip four years after an intrapelvic dislocation of the hip caused when he was crushed between two box cars. Preoperative roentgenograms showed osteophytes but no ectopic bone. Arthroplasty was performed and six months later there was severe myositis ossificans, a flexion contracture of 35 degrees and further flexion only to 55 degrees.

Revision was performed one year after the first arthroplasty. Six years later only a slight amount of ectopic bone had reformed and the hip was rated excellent. Hip motions were as follows: permanent flexion contracture of 15 degrees, further flexion to 95 degrees, abduction of 25 degrees, external rotation in extension 25 degrees, and internal rotation in extension 10 degrees.

Fig. 4-A: Frog-leg lateral roentgenogram of right hip before arthroplasty showing traumatic arthritis, osteophyte formation and no ectopic bone.

Fig. 4-B: Six months after the first arthroplasty there was severe myositis ossificans.

FIG. 4-C

FIG. 5

Fig. 4-C: Six years after revision of the arthroplasty there was only a slight amount of ectopic new bone.

Fig. 5: J. M., a man, thirty-three years old, had a central fracture-dislocation caused by a truck accident. An arthroplasty was performed nine years after the injury and six years later there was extensive ectopic bone formation. However, the result was excellent and motions of the hip were as follows: a fixed flexion contracture of 10 degrees, free flexion to 100 degrees, adduction to 35 degrees, abduction to 10 degrees, internal rotation to neutral, and external rotation to 35 degrees.

second, the 1.9-centimeter loss was the result of a loss of 1.3 centimeters of the femoral-head height and 0.6 centimeter of penetration of the cup into the acetabulum. Of these five patients, three had excellent results, one had a fair result, and one had a poor result. The poor rating was given because of hip pain and the need for a cane full time. One patient who lost 1.9 centimeters of length was fully active as a farmer, walked long distances on his farm, and went deer hunting each year without pain or support, thirteen years after his arthroplasty.

Ectopic ossification about the hip following the trauma or subsequent mold arthroplasty can compromise the end result. Myositis ossificans was present prior to mold arthroplasty in fourteen hips. In ten of these, the ectopic ossification developed after closed reduction and was small in amount as a rule. In the other four hips the myositis ossificans followed open reduction and was very extensive in two of them. After arthroplasty myositis ossificans did not reform in two hips, was less than before the operation in one, and was slightly more than existed preoperatively in one. In none of these fourteen patients was motion significantly restricted by the heterotopic bone.

Nine of the twenty-five hips which were free of myositis ossificans prior to arthroplasty had some ectopic bone following reconstruction. In seven the amount was minimum and did not restrict motion. In one instance the amount was great and restricted hip motion markedly (Figs. 4-A, 4-B, and 4-C). Following revision eighteen months later, only a small amount of ectopic bone reformed. The patient had an excellent range of motion, and the result was rated excellent in the end-result study five years later. In one other patient a large volume of new bone developed after his arthroplasty but at follow-up six years after arthroplasty he had a good range of motion and was free of pain (Fig. 5).

Considering the thirty-nine results of the initial arthroplasty only, fifteen hips were rated less than good or excellent: eight fair and seven poor. Analysis of the seven poor hips revealed that extensive ectopic bone formation caused one poor result as already noted and postoperative sepsis another. In the remaining five cases, the patients had pain in the hip on weight-bearing and in each instance the pain had been present since the patient began to walk after the operation. The femoral head of one of these five was shown at subsequent surgery to have areas of bone which were not covered by fibrocartilage. Resorption of the femoral head under the cup occurred in another, as noted previously. The cause for pain in the other three remained undetermined.

Four of the seven patients with poor results were reoperated on. One, as previously noted, had a revision for removal of ectopic bone and was rated excellent five years later (Figs. 4-A, 4-B, and 4-C). Two others had revisions. The one who had areas of the femoral head which were not covered by fibrocartilage improved

FIG. 6-A

Figs. 6-A through 6-C: Construction of the acetabulum in mold arthroplasty.

Fig. 6-A: A poor acetabulum. Note that the lateral lip is higher than the apex of the dome. This arthroplasty was done in 1948 and the patient had a fair result.

Figs. 6-B and 6-C: A good acetabulum.

Fig. 6-B: Preoperative roentgenogram shows distortion of the femoral head and acetabulum after a fracture dislocation of the hip.

Fig. 6-C: One year after arthroplasty done in 1962. Note that the lateral lip of the acetabulum is appreciably lower than the apex of the dome. The cup fits the contour of the acetabulum accurately. This patient had an excellent rating.

FIG. 6-B

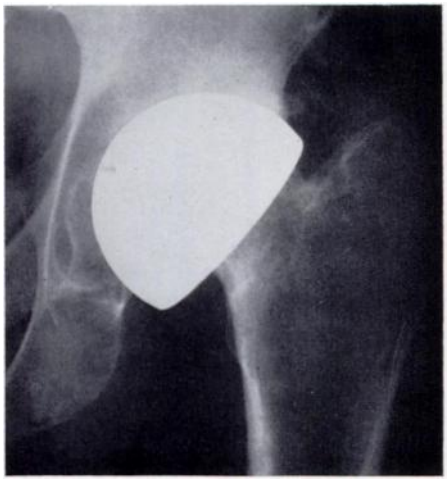

FIG. 6-C

from poor to fair and the one who had satisfactory fibrocartilage on both the socket and the femoral head did not change. The fourth patient had the cup replaced by a prosthesis at another hospital, without improvement.

The group of eight hips rated fair included the following: the patient with bilateral reconstruction for traumatic arthritis who required two canes and had mild pain in each hip, but was very active and considerably improved; the twenty-two-year-old man with the contralateral above-the-knee amputation who required pain medicine because of pain in his ipsilateral knee and used a cane; the patient whose greater trochanter did not unite to the femoral shaft, the patient who had metastatic carcinoma of the lung and the three patients who because of hip pain on weight-bearing required the use of a cane full time. One of these three was a seventy-nine-year-old woman who had had avascular necrosis of the femoral head following a bursting fracture and posterior dislocation. Her abductor power was weak, probably due to failure to transplant the greater trochanter after resecting the avascular portion of the femoral head. Full explanation of the hip pain is not available for these three patients since the hips were not re-explored. All but three of the fifteen hips with less than a good result were operated on during the first half of the series.

Discussion

In evaluating the results in this series the strict criteria used in defining the diagnosis of traumatic arthritis must be emphasized. Only fractures of the acetabulum, dislocations of the hip or both were included. (In five patients, there was a fracture of the femoral head in addition.) In order to be comparable, any series of traumatic arthritis treated by another method must be similarly defined.

The large number of automobile accidents among the causes of injury and the preponderance of men over women in this series are characteristic of trauma in contemporary society. This finding is in keeping with the reports of Brav and of Steward and Milford. The average time of seven years between trauma and arthroplasty reflects the therapeutic principle in this series of delaying reconstructive surgery until pain, limited functional capacity, or both made treatment mandatory. Only one patient in this group had arthroplasty carried out less than six months after trauma. This was done at two months because of a grossly unstable hip joint with a fracture of the femoral head and recurrent dislocation, similar to the unstable hips reported by Kelly and Lipscomb.

The statistically significant improvement in the frequency of good and excellent results in the latter half of the series is important. Four factors appear to have contributed to this improvement:

1. Use of the Aufranc concentric cup[1];
2. Improvement in surgical technique, especially in construction of the acetabulum (Figs. 6-A, 6-B, and 6-C)[7];
3. Better instruments with which to do the procedure[1];
4. Improved postoperative care[1].

Particularly gratifying were the results in the four hips which were septic after open reduction. Carrying out a major hip-joint construction without reactivating the infection is a considerable challenge. None of these patients showed any evidence of sepsis after arthroplasty.

The relief of pain (Table I) and the range of motion obtained were very satisfactory. Preliminary data indicate that the incidence of positive Trendelenburg tests can be reduced by use of the lateral approach with transplantation of the greater trochanter and the attached abductors[7].

The presence of myositis ossificans prior to the arthroplasty was not an important disadvantage and did not appear to increase the liklihood of postoperative ecotopic bone formation.

When considering the choice between arthroplasty and fusion for traumatic arthritis, a number of factors must be weighed. These include the presence of avascular necrosis of the femoral head, persistent dislocation, and disruption of the acetabulum, as well as the condition of the ipsilateral knee, contralateral hip, contralateral knee and lumbar spine, and the height of the patient [4]. Also to be considered are the prolonged immobilization in plaster and the high incidence of non-union after attempted fusion ranging from 20 per cent reported by Lipscomb and McCasling to 6 per cent as reported by Watson-Jones and Robinson in osteo-arthritis. The incidence of non-union after attempted arthrodesis for traumatic arthritis as the term is used in this study, has not been reported in any large series.

Watson-Jones stated "If the joint is destroyed by degenerative arthritis, whether it is a simple traumatic arthritis or an arthritis arising from avascular necrosis, the alternatives are to arthrodese the joint or to perform an arthroplasty. Arthrodesis is difficult, because the dead and avascular femoral head does not contribute readily to sound fusion so that fibrous rather than bony ankylosis often occurs. It is probably better in most of these cases to perform an arthroplasty." He also remarked that his results after attempted arthrodesis in traumatic dislocations which were unreduced after many months "were so bad as to dissuade most surgeons from attempting operative reduction" and fusion.

Among the twenty-five patients under the age of fifty-five in the current group one had a long-standing dislocation, one a fused knee, and another an above-the-knee amputation on the contralateral side. Two had bilateral hip disease and ten had avascular necrosis of the femoral head. In other words, only ten were primarily suitable for fusion. Of these ten, six had excellent results; one a good result, two fair results, and one a poor result. It is, therefore, concluded that mold arthroplasty is the treatment of choice for most patients who require surgery for traumatic arthritis of the hip.

Summary

An end-result analysis is presented of thirty-nine mold arthroplasties performed at the Massachusetts General Hospital between 1945 and 1965 in thirty-eight consecutive private patients for arthritis of the hip following fractures of the acetabulum or dislocations of the hip.

Of the nineteen unilateral cases in the second half of the series, sixteen were rated good or excellent. Results in the second half of the series were significantly better statistically than those in the first half of the series. Possible reasons for this improvement are discussed.

No significant deterioration occurred with the passage of time. Among the thirty-nine hips, three revisions were required. One patient had postoperative sepsis after arthroplasty. Four patients who had had intra-articular sepsis prior to arthroplasty showed no evidence of sepsis postoperatively.

Factors influencing the choice between hip fusion and hip arthroplasty in these cases are presented.

A new system for rating hip function is proposed and is compared with the systems of Larson and Shepherd.

References

1. Aufranc, O. E.: Constructive Surgery of the Hip. St. Louis, C. V. Mosby, 1962.
2. Aufranc, O. E., and Sweet, E. D.: Study of Patients with Hip Arthroplasty at Massachusetts General Hospital. J. Am. Med. Assn., 170: 507–515, 1959.
3. Brav, E. A.: Traumatic Dislocation of the Hip. Army Experience and Results over a Twelve-Year Period. J. Bone and Joint Surg., **44-A**: 1115–1134, Sept. 1962.
4. Charnley, John: Arthrodesis of the Hip in the Treatment of Osteoarthritis, Am. J. Orthop., 169–172, 1960.

5. FERGUSON, A. B., and HOWORTH, M. B.: Slipping of the Upper Femoral Epiphysis. J. Am. Med. Assn., **97**: 1867–1872, 1931.
6. GADE, H. G.: A Contribution to the Surgical Treatment of Osteoarthritis of the Hip Joint. A Clinical Study. Acta Chir. Scandinavica Suppl., **120**: 37–45, 1947.
7. HARRIS, W. H.: A New Lateral Approach to the Hip Joint. J. Bone and Joint Surg., **49-A**: 891–898, July 1967.
8. JACOBSEN, ARNT: Vitallium Mold Arthroplasty for Osteoarthritis of the Hip Joint. A Study of the Ability of the Method to Create a New Joint in an Anatomical-Physiological and in a Clinical Sense, p. 126. Oslo, Oslo University Press, 1957.
9. KELLY, P. J., and LIPSCOMB, P. R.: Primary Vitallium-Mold Arthroplasty for Posterior Dislocation of the Hip with Fracture of the Femoral Head. J. Bone and Joint Surg., **40-A**: 675–680, June 1958.
10. LARSON, C. B.: Rating Scale for Hip Disabilities. Clin. Orthop., **31**: 85–93, 1963.
11. LAW, W. A.: Late Results in Vitallium-Mold Arthroplasty of the Hip. J. Bone and Joint Surg., **44-A**: 1497–1517, Dec. 1962.
12. LIPSCOMB, P. R., and MCCASLIN, F. E., JR.: Arthrodesis of the Hip. Review of 371 Cases. J. Bone and Joint Surg., **43-A**: 923–938, 1961.
13. MORTENS, J., and JENSEN, E.: Charnley Stabilisation of the Hip. J. Bone and Joint Surg., **42-B**: 466–475, Aug. 1960.
14. ROWE, C. R., and LOWELL, J. D.: Prognosis of Fractures of the Acetabulum. J. Bone and Joint Surg., **43-A**: 30–59, Jan. 1961.
15. SHEPHERD, M. M.: Assessment of Function after Arthroplasty of the Hip. J. Bone and Joint Surg., **36-B**: 354–363, Aug. 1954.
16. SHEPHERD, M. M.: A Further Review of the Results of Operations on the Hip Joint, J. Bone and Joint Surg., **42-B**: 177–204, May 1960.
17. STEWART, M. J., and MILFORD, L. W.: Fracture-Dislocation of the Hip. An End-Result Study. J. Bone and Joint Surg., **36-A**: 315–341, Apr. 1954.
18. STINCHFIELD, F. E., and CARROLL, R. E.: Vitallium-Cup Arthroplasty of the Hip Joint. J. Bone and Joint Surg., **31-A**: 628–638, July 1949.
19. STINCHFIELD, F. E., and CAVALLARO, W. U.: Arthrodesis of the Hip Joint. A Follow-Up Study. J. Bone and Joint Surg., **32-A**: 48–58, Jan. 1950.
20. STONE, M. M.: Arthrodesis of the Hip. J. Bone and Joint Surg., **38-A**: 1346–1352, Dec. 1956.
21. WARING, T. L., and ANDERSON, L. D.: Crawford Adams Cup Arthroplasty. A Review of Fifty Cases. J. Bone and Joint Surg., **43-A**: 431–442, April 1961.
22. WATSON-JONES, REGINALD: and ROBINSON, W. C.: Arthrodesis of the Osteoarthritic Hip Joint. J. Bone and Joint Surg., **38-B**: 353–377, Feb. 1956.
23. WATSON-JONES, REGINALD: Fractures and Joint Injuries. Ed. 4, Vol. II, p. 674. Baltimore, The Williams and Wilkins Co., 1956.
24. WESTERBORN, ANDERS: Central Dislocation of the Femoral Head Treated with Mold Arthroplasty. J. Bone and Joint Surg., **36-A**: 307–314, Apr. 1954.