THE BATEMAN BIPOLAR FEMORAL HEAD REPLACEMENT

A FLUOROSCOPIC STUDY OF MOVEMENT OVER A FOUR-YEAR PERIOD

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The purpose of this study was to establish if the Bateman prosthesis functions as a bipolar device moving primarily at the inner metal-on-polyethylene bearing as originally proposed, or as a unipolar hemiarthroplasty moving at the outer metal-on-cartilage surface as has recently been suggested. One hundred hips were examined at one year follow-up; 78 were examined again at two to four years. The replacement was performed for arthritis in 76 hips and for femoral neck fracture in 24. Movement was assessed both with and without weight-bearing.

In 80% of the arthritis group the prosthesis functioned as a bipolar hip replacement with movement occurring primarily at the inner metal-on-polyethylene surface. By contrast, in 75% of the fracture group the prosthesis functioned largely as a unipolar device with movement occurring primarily at the outer metal-on-cartilage surface. In all cases examined serially the movement pattern was the same at two to four years as it had been at one year. Clearly, the action of the prosthesis depends on the condition of the acetabular cartilage.

The UPF (Universal Proximal Femur) bipolar femoral head replacement was introduced by Bateman in 1974. The purpose of the device was to reduce the acetabular wear experienced with unipolar prostheses of the Moore and Thompson type.

A multitude of bipolar designs have appeared since then (Devas and Hinves 1983; Giliberty 1983; Verberne 1983; Leyshon and Matthews 1984). Devas and Hinves, using their Hastings hip for 161 femoral neck fractures, had no acetabular erosion over a four-year period. By contrast, Leyshon and Matthews, using the Monk hard top prostheses for 162 femoral neck fractures, had an alarming incidence of acetabular erosion necessitating revision in seven elderly patients by two and a half years. Several other short-term reports in the literature have in general shown little benefit of bipolar over unipolar devices (Drinker and Murray 1979; Langan 1979; Lestrange 1979; Long and Knight 1980; Bhuller 1982).

The key issue in determining the value of bipolar femoral head replacements is whether they function as bipolar or unipolar devices. West was one of the first to describe the use of fluoroscopy to assess patients walking on a treadmill (West and Mann 1979). He found that movement was shared, occurring at both the inner metal-on-polyethylene bearing and the outer metal-on-cartilage surfaces. By contrast, Verberne (1983), describing his 20 patients, concluded that the inner bearing became completely stiff by three months. Both series were composed of similar patients with hip fractures although they used different prostheses. Others have also questioned the occurrence of continued movement at the inner bearing (Drinker and Murray 1979; Leyshon and Matthews 1984). It is thus controversial how bipolar devices move when placed into acetabula with intact cartilage; how they move when placed into arthritic acetabula has not even been addressed.

MATERIALS AND METHODS

The prosthesis. The UPF bipolar femoral head was used in all cases. The stemmed femoral component is made of cobalt–chrome alloy and has a polished 22 mm spherical head. The outer head comes in a selection of 13 sizes, ranging from 41 to 60 mm. The geometry of the device is such as to allow a 50° arc of abduction/adduction and rotation before the outer head impinges on the neck. The inner head is free to move in the polyethylene bearing through any degree of flexion and extension around the central axis of the neck. The limiting factor here is not the implant, but rather the soft tissues about the hip.

The patients. One hundred and seven consecutive hips, all operated on by the author in the period 1981 to 1984, were studied prospectively. Of these, 100 returned for examination including fluoroscopy at one year follow-up. Seventy-eight were examined again at times of up to four years from surgery. The patients were divided into two groups based on the condition of the acetabular cartilage. Group I comprised 24 hips with normal acetabular cartilage where the femoral head was replaced as a primary procedure for displaced femoral neck fracture.
Group II comprised 76 hips with degenerative or absent acetabular cartilage due to osteoarthritis in 58, revision arthroplasty in 15, rheumatoid arthritis in two and dismantling an arthrodesis in one. The periods of follow-up are given in Table I.

Radiological study of movement. At first, patients walking on a treadmill were examined by fluoroscopy. However, the simultaneous sway, rotation and translation movements of the body made isolated analysis of the prosthetic bipolar device difficult. The following testing method was therefore developed.

Non-weight-bearing. The patient was first examined supine on the x-ray table. With the hip in extension, the leg was moved into maximum abduction and adduction. An example of movement occurring at the inner bearing is shown in Figures 1 and 2.

To study rotational movements, the hip was flexed 30° and the leg rotated until the face of the outer metal cup was tangential to the x-ray beam. The leg was then rotated medially and laterally about this mid-position to determine if movement occurred at the inner prosthetic joint or at the outer head on acetabular cartilage, as demonstrated in Figures 3 and 4.

Weight-bearing. In the second part of the study, the x-ray table was tilted to vertical with the patient standing on an attached footplate. The x-ray beam was directed horizontally through the hip. The patient lifted the non-operated leg off the floor, placing all weight on the hip under study. The patient actively leaned over first to maximum abduction and then across to maximum adduction as in Figures 5 and 6.

Next, while standing evenly on both legs, the patient leaned forward flexing the upper body and pelvis at the hips and then extended back up to the erect position. An example of movement occurring at the inner bearing with the outer cup tipping in unison with the pelvis is shown in Figures 7 and 8. By contrast, if movement occurred between the outer femoral head and the pelvis, the complete bipolar femoral head assembly remained stationary as the pelvis flexed forward.

All movements were explained, demonstrated and

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<th>Table I. Summary of groups and fluoroscopy times</th>
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<td>Duration of follow-up</td>
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<td>1 year</td>
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<td>Fresh femoral neck fracture (Group I)</td>
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<tr>
<td>Arthritis and revisions* (Group II)</td>
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<td>Total number of hips</td>
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* Including one dismantling of an arthrodesis

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<th>Table II. Fluoroscopy scoring system</th>
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<td>A All movement at inner metal/polyethylene surface until outer head/neck impingement occurs.</td>
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<tr>
<td>B Movement shared between outer metal/cartilage and inner metal/polyethylene surfaces.</td>
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<td>C All movement at outer metal/cartilage surface.</td>
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assisted by the author. The movement study was done within one minute of fluoroscopy time and was recorded on a Sony three-quarter inch video cassette recording tape. Spot films were taken during fluoroscopy to illustrate the results. A new scoring system was designed for this study, categorising the movement pattern as Type A, B or C (Table II). In cases examined at subsequent yearly intervals new scores were assigned without knowledge of the previous values.

RESULTS

The fluoroscopy scores for both groups at one year are given in Figure 9. Most hips had scores of A or C; movement at each surface tended to be an all-or-none phenomenon, occurring along the path of least resistance. For example, if movement began at the inner bearing, it continued there throughout the 50° arc built into the design of the prosthesis. Beyond this, the neck impinged on the outer head and movement was transferred to the outer metal-on-cartilage surface. In every patient the same pattern occurred weight-bearing as had occurred non-weight-bearing.

The arthritic group was characterised by a Type A and the fracture group by a Type C pattern.

When the hips were re-examined at two to four-year follow-up, the scores remained exactly as they had been at one year.

![Fig. 5](image1.jpg)
![Fig. 7](image2.jpg)
![Fig. 8](image3.jpg)

Fig. 5 and 6 – Weight-bearing radiographs of the same patient as Figures 1 and 2, taken standing with all weight on the prosthetic hip: maximum abduction (Fig. 5) and maximum adduction (Fig. 6). The outer head has remained fixed in the acetabulum and movement is entirely at the inner polyethylene-on-metal joint (Type A pattern).

Figures 7 and 8 – Weight-bearing radiographs of the same patient, taken standing with equal weight on both legs: standing erect with the hip in extension (Fig. 7) and leaning forward with 30° of flexion at the hip (Fig. 8). The leg and femoral stem remain stationary and the pelvis has flexed forward as shown by the change in the obturator foramen. The outer head has flexed forward in unison with the pelvis, as shown by the projection of the lateral face of the cup being perfectly flat in Figure 7, but convex in Figure 8. Movement has thus occurred at the inner prosthetic joint (Type A pattern).

![Fluoroscopy Score](image4.jpg)

Histogram of fluoroscopy scores at one year for all 100 patients. Most arthritis cases (80%) showed inner metal-on-polyethylene movement (Type A) while in most fractures cases (75%), where the acetabular cartilage was normal and slippery, the outer head glided on the cartilage (Type C pattern). In a few (15%) cases in both groups movement was shared at the outer and inner surfaces (Type B pattern).
DISCUSSION

The results show that the behaviour of the bipolar implants depends on the condition of the host acetabular surface. Once movement is initiated at the most slippery surface, it continues there until additional forces such as head/neck impingement or soft-tissue entrapment come into play. In the fracture group, where the acetabular cartilage is normal, the outer head slides easily on the slippery cartilage and the UPF functions as a unipolar endoprosthesis. In the arthritic group, where the acetabular cartilage has been lost, the outer metal-on-bone friction is higher and movement is transferred to the inner metal-on-polyethylene bearing. The results also show that the movement pattern of this bipolar head replacement is independent of weight-bearing load. This allows for a simplification and reduction of radiation exposure in future studies: two single anteroposterior radiographs taken in a conventional manner supine on the x-ray table, one in maximum adduction, the other in maximum abduction, are sufficient. Furthermore, keeping the body and pelvis stationary in this manner allows a much clearer demonstration of movement than previous techniques using a treadmill where many movements of the body and the hip were superimposed.

These results agree with those recently reported by Verberne (1983), that where the acetabular cartilage is normal as in hip fractures the bipolar femoral head replacement behaves in a manner similar to that of a unipolar endoprosthesis. However, this study has shown that his conclusions do not apply to cases where the acetabular cartilage is degenerate or absent.

Some questions continue. When the UPF is used in fresh hip fractures, will outer movement cause acetabular erosion as suggested by Leyslon and Matthews (1984) but denied by Devas and Hinves (1983)? Will erosion of the acetabular cartilage increase friction at the outer surface? Will movement then be transferred to the inner prosthetic joint, thus arresting further acetabular erosion? It is an intriguing possibility that the bipolar femoral head provides this back-up feature. However, this will probably take five years or more to determine, as erosion following unipolar hemiarthroplasty is usually just beginning at three years (D’Arcy and Devas 1976; Phillips 1985). Even in the arthritic group, 4% of cases did exhibit mainly outer head-acetabulum movement. Whether this will lead to late acetabular erosion and/or a transfer from Type C to Type A movement also requires longer follow-up.

Two recent reports have shown that many of the late failures of conventional total hip replacement relate to loosening and erosion of the cemented acetabulum (Stauffer 1982; Sutherland et al. 1982). It is possible that the UPF, which presents a cementless smooth surface to the acetabulum, may decrease these problems. If Verberne’s conclusions had applied to these arthritic cases, the chance of success would be low. However, now that we have shown that the UPF does move primarily at the inner bearing in arthritis, clinical trials of the UPF for arthritis and revision appear justified.

It has been shown that late acetabular loosening is more frequent with 32 mm diameter prosthetic heads (Sutherland et al. 1982; Ritter et al. 1983) than with the low-friction 22 mm heads recommended by Charnley (1970). Small inner heads result in less torsion on the outer socket (Charnley 1970; Ma, Kabo and Amstutz 1983). Therefore the results of this study on the 22 mm UPF design cannot with certainty be applied to other bipolar femoral head designs which use different inner head diameters, head/neck ratios, eccentricities, surface finishes or materials.

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REFERENCES


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