Trochanteric rotational osteotomy for osteonecrosis of the femoral head

THE USE OF MRI IN THE SELECTION OF PATIENTS

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The rate of success of transtrochanteric rotational osteotomy for osteonecrosis of the femoral head may be improved if patients are preselected using MRI. We have used three criteria for selection for osteotomy (i) minor collapse of the infarcted area, loss of congruity or the crescent sign, without narrowing of the joint space or acetabular involvement (ii) patients younger than 55 years and with a painful hip (iii) patients with an intact area constituting an arc of more than 120° between the central vertical line of the femoral head and the posterior or anterior margin of the necrotic portion as seen on a midsagittal MRI. Seventeen patients were selected, with a follow-up of more than 42 months. A bone scan four weeks after operation showed adequate perfusion of the proximal segment in all hips. The hip score of Merle d’Aubigné et al improved from 13.5 points before operation to 17.2 points at the latest follow-up. Further collapse of the femoral head did not occur.

The use of MRI instead of plain radiographs for the selection of patients has improved the success rate of transtrochanteric rotational osteotomy.

Received 11 January 2000; Accepted 24 February 2000

Osteonecrosis may lead to progressive collapse of the femoral head followed by degenerative arthritis of the hip.1-4 The condition occurs in young patients, with a mean age of less than 50 years. Replacement arthroplasty in these circumstances is associated with high rates of failure5-8 and there has been a continued search for procedures which preserve the hip.9-16

In transtrochanteric rotational osteotomy the necrotic portion of the femoral head is displaced from the weight-bearing zone and replaced by healthy cartilage and living bone. The osteotomy is indicated when at least one-third of the articular cartilage and underlying bone is intact. Accurate evaluation of the necrotic area is essential before this technically demanding procedure is adopted. Previous studies have used plain radiography to select patients and have reported variable rates of success,9-11,14-16 but this investigation is not sufficiently accurate to define the extent of infarction. Incorrect selection of patients based on radiography and inappropriate operative techniques may give poor results.

MRI can give an accurate determination of the extent of osteonecrosis17-20 and the rate of success may be improved by more precise selection of patients. To date, there has been no study which has demonstrated the change in local anatomy and the extent of necrosis after osteotomy using MRI. We have therefore used MRI to formulate a new set of criteria for selection by which suitable patients for osteotomy may be identified. MR scans have been obtained after three years to evaluate the changes in the necrotic area following osteotomy.

Patients and Methods

Patients who had clinical evidence of osteonecrosis of the femoral head were included in the study and the diagnosis was established by plain radiography and/or MRI.21 The hips were graded according to the system of Ficat and Arlet.22 From this group, patients who met the following criteria were selected for surgery (i) those with minor collapse of the infarcted area with loss of congruity or crescent sign without narrowing of the joint space or acetabular involvement (Ficat and Arlet stage 2B) (ii) those aged younger than 55 years with a painful hip, and (iii) patients with a healthy area subtending an arc of more than 120° between the central vertical line of the femoral head and the posterior or anterior margin of the necrotic portion as seen on the midsagittal MR scan (Fig. 1). The extent of the necrotic area affects the fate of the femoral head. Hips with small areas of necrosis do not collapse even without surgical intervention.1-4,18-20
Our study was not a randomised trial and it lacks a control group. It may be argued that some of the patients have small areas of necrosis which do well without operation. We therefore limited the subjects to those with definite collapse on plain radiographs. We selected patients less than 55 years of age because in young patients total hip arthroplasty is associated with high rates of failure.\(^5\)\(^8\) in older patients the results of the procedure are satisfactory.

Between January 1993 and December 1995, 17 patients met the predefined selection criteria and were treated by transtrochanteric rotational osteotomy. There were 15 men and two women with a mean age 30 years (16 to 48). Associated conditions or factors contributing to osteonecrosis included alcohol abuse in six patients, a history of steroid treatment in one and a traumatic dislocation of the hip in two patients. In the remaining eight, no risk factors were identified.

Transtrochanteric rotational osteotomy is indicated when a segment of the femoral head is viable and intact. This area must be of such a size that, after rotation, the intact portion becomes the weight-bearing surface.\(^9\)\(^11\) Therefore we limited subjects to those with a healthy area subtending an arc greater than 120° (one-third of a circle) on a midsagittal MR scan. Patients who participated in this study gave informed consent and the protocol was approved by an institutional review.

Before surgery, we performed MRI using a 1.5 Tesla superconducting unit (Magnetom; Siemens, Erlangen, Germany). The T1-weighted spin-echo images (echo time (TE), 20 ms; repetition time (TR), 500 ms) were obtained in the coronal and parasagittal planes. The section thickness was 0.4 cm with a gap of 0.1 cm. Images were reconstructed using a matrix of 128/128 or 256/256. The excitation number varied between 1 and 4.

When the infarcted area was located in the anterior hemisphere of the femoral head, the angle of the healthy area was defined as that which subtended the arc between the central vertical line of the femoral head and the posterior margin of the infarct, measured on the midsagittal MRI. When the necrotic area was located in the posterior hemisphere, the angle was defined as that which subtended the arc between the central vertical line of the femoral head and the anterior margin of the infarct (Fig. 1). If this subtended angle of healthy area exceeded 120°, the patient was selected for the osteotomy.

Operative technique. The procedure of transtrochanteric rotational osteotomy was performed by one surgeon (K.-HK) using a technique which has been described by Sugio-\(^9\) and by Sugio-\(^10\)\(^11\) ka.\(^9\)\(^11\) The direction and extent of rotation were determined by the site of the infarct and the rotational angle on the midsagittal MR scans. If the necrosis was located anteriorly, the femoral head was rotated anteriorly. The rotational angle was defined as the angle between the anterior margin of the acetabulum and the posterior margin of the necrotic area in the midsagittal image. If the necrosis lay posteriorly, the femoral head was rotated posteriorly. The rotational angle was then defined as the angle between the posterior margin of the acetabulum and the anterior margin of the infarct (Fig. 3). Theoretically, if the proximal seg-
ment is rotated as much as the angle determined on the midsagittal MR scans, the necrotic portion will move out of the acetabulum when the hip is extended. In addition to rotation, the osteotomy line was inclined at 20° from that perpendicular to the femoral neck in order to place the hips in varus angulation as suggested by Sugioka

9 and Sugioka et al

10,11 (Fig. 4). To avoid excessive stretching and damage to the medial femoral circumflex vessels, the rotation angle was limited to less than 90°.

The osteotomy was stabilised using three or four 6.5 mm cancellous screws. Postoperative care consisted of skin traction for six weeks, and the use of crutches while walking with protected weight-bearing for another six weeks.

In order to detect possible injury to the medial femoral circumflex artery during the operation, we performed scintigraphy at four weeks after the operation and evaluated the blood perfusion of the proximal segment. Patients received an injection of 20mCi of ⁹⁹mTc methylene disphosphonate, and three hours later anterior and posterior radionucleide scans were obtained and the uptake in the proximal segment measured.

Clinical evaluation. Every three months, the patients were assessed clinically using the scoring system of Merle d’Aubigné et al

1 modified by Charnley,

23 by two independent observers who did not participate in this study. Up to six points each were awarded for pain, walking ability, and range of movement. A rating of 17 to 18 was considered excellent, equivalent to a normal hip, 15 to 16 good, 13 to 14 fair and less than 13 poor, or a failure. Standard anteroposterior and frog-leg lateral plain radiographs were also obtained and assessed blindly by two independent observers who did not know the clinical status of the hips. The contour of the femoral head was evaluated using plain radiographs with a template of concentric circles.

24 Radiological failure of the operation was defined as subsidence of the surface measuring 2 mm or more compared with the contour of the immediate postoperative radiograph.

The screws were removed three years after the osteotomy, and follow-up MRI was performed to evaluate the transposed necrotic area and the newly-formed weight-bearing area of the femoral head beneath the dome of the acetabulum. The location of the necrotic area was compared with that demonstrated on the preoperative MR scan. The total volume of the infarct in the follow-up MR scan was determined as described above. In order to determine whether the volume of the necrotic area changed after the osteotomy, the volumes in the preoperative MR scans were compared with those of the follow-up images using the Wilcoxon signed-rank test.

Results

Table I gives the details of the patients. The preoperative mean hip score was 13.5 points (11 to 15). The mean follow-up period was 54 months (42 to 78).

In the 15 hips with an anterior lesion, the proximal segment was rotated anteriorly (Figs 5a to 5i). In the remaining two hips, with a posterior lesion, the proximal segment was rotated posteriorly (Figs 6a to 6k). The mean operating time was 232 minutes (195 to 270), and a mean of 3.2 units of whole blood were transfused.

MRI findings. Before operation, in the 15 hips with a non-traumatic aetiology, the necrotic area was located in the anterior aspect of the femoral head, whereas in the remaining two with traumatic osteonecrosis (cases 3 and 7), it was in the posterior aspect. The mean angle of the intact articular area was 139° (120 to 155). The mean rotational angle determined on the midsagittal MR scan was 82° (65 to 90). The mean volume of the necrotic area was 10.1 cm³ (6.9 to 12.2).

At follow-up after three years, the area of necrosis, as
identified by MRI, had been successfully moved from the weight-bearing region and the volume of the necrotic area in the weight-bearing zone had been significantly reduced. The mean necrotic volume judged by follow-up MRI was $9.9 \text{ cm}^3$ (5.9 to 12.9), which was similar to that measured before operation. There was no statistically significant net change.

Postoperative scintigraphy. This showed adequate perfusion of the proximal segment indicating preservation of the medial femoral circumflex artery. Uptake of radionucleide was increased at the site of the osteotomy (Figs 5f and 6h).

At the most recent clinical follow-up, all patients had either excellent (13 patients) or good results (4 patients). The hip score improved to a mean of 17.2 points (16 to 18). There was no case of clinical failure; 12 patients had no pain, and five had mild pain but without limitation of activity. The mean arc of flexion at the hip was 113.5° (80 to 130). In all patients, the operated limb was shortened by between 1 and 1.5 cm because of intentional varus angulation of the osteotomy. Five patients (cases 2, 4, 5, 9 and 13) had a slight limp but none required the use of a crutch or cane.

Radiological results. Collapse of the femoral head was arrested in all hips and no patient required replacement hip arthroplasty. There was no radiological evidence of failure. A circumferential osteophyte formed around the femoral head in two patients (cases 8 and 15) but the joint space was maintained and both patients retained a satisfactory range of flexion and abduction.

Complications. Delayed union of the osteotomy with excessive varus occurred in one patient (case 10) who was treated with a hip spica cast for six weeks. The clinical and radiological result, however, was successful.

Discussion

Osteonecrosis of the femoral head is a destructive disease that usually leads to secondary arthritis. Most patients are in the third to fifth decade. Although there have been considerable improvements in the materials and techniques used for total hip arthroplasty, a high rate of failure has been reported in young and active patients. It is important therefore to preserve the hip and to obviate or at least delay the need for replacement arthroplasty.

Transtrochanteric rotational osteotomy is one of the surgical procedures used to preserve the hip. For this operation more than one-third of the femoral head should be intact and healthy. MRI is more accurate than radiography in measuring the extent of the infarct. We used MRI instead of radiography for the selection of patients, with excellent results.

Sugioka and Sugioka et al have emphasised two important concepts of the procedure. The first is that it is a vascular procedure and involves a rotational flap of the proximal femur based on a vascular pedicle of the medial femoral circumflex vessels. Osteotomy and rotation will fail if the proximal segment is avascular which is why we recommend that a bone scan be performed after the osteotomy.

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**Table I. Details of the 17 patients with osteonecrosis of the femoral head**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Gender</th>
<th>Hip</th>
<th>Aetiology*</th>
<th>Necrotic volume at initial MRI</th>
<th>Necrotic volume on initial MRI (°)</th>
<th>Necrotic volume on MRI (°)</th>
<th>Degree of rotation</th>
<th>Necrotic volume on follow-up MRI (°)</th>
<th>Duration of follow-up (mth)</th>
<th>Hip score at the latest follow-up</th>
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* Id, idiopathic; Al, alcoholic; Tr, traumatic; St, steroid
† according to the system of Merle D'Aubigné et al as modified by Charnley; pain/walking ability/range of movement (total)
The second concept concerns the line of the osteotomy. In most patients with osteonecrosis, the infarct is extensive and located at the anteromedial aspect of the femoral head. In patients with such a lesion, intentional varus positioning should be considered in addition to adequate rotation in order to remove the necrotic portion from the weight-bearing area and to achieve a greater area of healthy bone in the weight-bearing zone.

Dean and Cabanela reported unsatisfactory results after osteotomy in 21 hips. They showed that the neck-shaft angle had increased in 18 hips. The high rate of failure may have been caused by valgus rather than varus positioning.

In our study, MRI was used to demonstrate changes in the location and the volume of necrosis after osteotomy. The volume of the infarct did not change and the newly formed weight-bearing area has remained viable. This observation justifies the procedure.

The staging system of Ficat and Arlet, which is often used to decide treatment, is based on the radiological stage and clinical symptoms without reference to the extent of necrosis. A necrotic index was designed by Koo and Kim. Collapse occurred in none of the hips with necrosis of less...
Case 7. A 15-year-old boy who had been injured in a road-traffic accident. Figures 6a to 6d – Radiographs showing a) fracture and dislocation b) after closed reduction had been attempted; the epiphysis was separated, c) open reduction and internal fixation and d) one year later when pain had developed with osteonecrosis and collapse of the femoral head. Figures 6e and 6f – Midcoronal e) and midsagittal f) MR scans showing the necrotic area (arrowheads) located in the superior (e) and anterior (f) areas of the femoral head. The angle of the intact area in the anterior aspect of the femoral head was 130°. Figure 6g – Postoperative radiograph showing that the proximal segment was rotated anteriorly with a rotational angle of 90°. Figure 6h – Postoperative scintigraph showing uptake of radionucleide in the proximal segment. Figures 6i and 6j– The mid-coronal (i) and midsagittal (j) MR scans taken three years after the osteotomy (arrowheads) showing that the necrotic area has moved downwards from the weight-bearing area. Figure 6k – Radiograph taken after 54 months showing no evidence of further collapse.
than 30%, in 50% of those with necrosis of 30% to 40%, and in all with necrosis of more than 40%. In hips with necrosis of less than 30%, surgical intervention is hardly justified. In hips with necrosis of 30% to 40%, periodical observation is necessary. If there is evidence of collapse during follow-up, and the arc of intact articular area is more than 120°, transtrochanteric rotational osteotomy is recommended. In hips with necrosis of more than 40%, we recommend transtrochanteric rotational osteotomy even without evidence of collapse (Ficat and Arlet stage 1 and 2A) if the arc of the intact portion is more than 120° (Table II).

The results of transtrochanteric rotational osteotomy can be improved by criteria based on the use of MRI.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References