JOINT-PRESERVING OPERATIONS FOR IDIOPATHIC AVASCULAR NECROSIS OF THE FEMORAL HEAD

RESULTS OF CORE DECOMPRESSION, GRAFTING AND OSTEOTOMY

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We have reviewed 54 hips in 46 patients from 2 to 14 years after a joint-preserving operation for idiopathic avascular necrosis of the femoral head. The choice between core decompression (17 hips), bone grafting (18), rotation osteotomy (15) or varus osteotomy (4) was determined by the stage and location of the area of necrosis.

The overall success rate was unexpectedly low at 60%. Core decompression and bone grafting by our techniques gave poor long-term results, but those of rotation or varus osteotomies, performed with care for the correct indications, were better. The indications for each procedure are discussed: osteotomy is best when the area of necrosis is shallow and localised in the medial or anterior portion of the femoral head.

Idiopathic avascular necrosis of the femoral head (IANF) can be regarded as a progressive disease; once ischaemic necrosis has occurred within the femoral head, collapse will follow and eventually lead to destruction of the joint (Merle d'Aubigné et al. 1965). Since IANF commonly involves adults in their 20s, 30s and 40s (Jacobs 1978; Springfield and Enneking 1978), total hip replacement is best avoided (Dorr, Takei and Conaty 1983). If possible, necrosis should be detected early by bone scintigraphy and magnetic resonance imaging, and should then be treated by a joint-preserving operation such as core decompression (Hungerford and Zizic 1978; Ficat and Arlet 1980), bone grafting (Meyers 1978; Springfield and Enneking 1978), transtrochanteric rotation osteotomy (Sugioka 1978; Sugioka, Katsuki and Hotokebuchi 1982), or intertrochanteric femoral osteotomy (Merle d'Aubigné et al. 1965; Kerboul et al. 1974).

In our department from 1968 to 1983, 62 hips in 54 patients were treated by joint-preserving operations for IANF. The four procedures listed above were used in accordance with the indications which are described later. These patients constituted 29% of those presenting with IANF; the remainder either had no treatment or a joint replacement.

We have reviewed the clinical and radiological results of these joint-preserving operations in order to evaluate their efficacy and the validity of our indications for their use.

INDICATIONS AND OPERATIVE PROCEDURES

In our series of 62 hips we used core decompression, bone grafting, transtrochanteric rotation osteotomy (Sugioka 1978) or varus femoral osteotomy according to the stage of IANF at presentation. We used the classification of Inoue and Ono (1979) and carried out the following procedures at each of the four stages.

In Stage I, the silent stage, there are neither symptoms nor radiographic changes in the femoral head, but a definite abnormality is found on bone scintigraphy, which is often performed for contralateral symptoms. Core decompression is indicated in order to make a definitive histological diagnosis and also to prevent the disease from progressing (Fig. 1). When a tentative diagnosis of IANF had been made, core decompression was performed under general anaesthesia by an anterolateral approach with image-intensifier control. After capsulotomy, an 8 mm biopsy needle was introduced from the anterolateral into the superior portion of the femoral head. The lesion could be accurately penetrated, and it was hoped that vascular connective tissue would subsequently advance to enter the necrotic area (Takaoka et al. 1981). This core decompression was expected to prevent the disease from progressing and to facilitate repair processes (Hungerford and Zizic 1978; Ficat and Arlet 1980; Wang et al. 1985).

In Stage II, the earliest symptomatic stage of IANF, the radiographs show abnormal density in the femoral
head with no collapse or minimum collapse. For this stage we performed bone grafting through the same anterolateral approach as for core decompression (Fig. 2). The exposed head was fenestrated and the necrotic bone, especially in the weight-bearing area, was thoroughly curetted. Cancellous bone obtained from the ipsilateral iliac crest was then tightly impacted into the cavity with the aim of repairing the weight-bearing area and so reconstructing the bony structure of the femoral head.

In Stage III, the intermediate stage, radiographs show irregular density with obvious collapse. One of two types of osteotomy were considered: either a transtrochanteric rotation osteotomy (Sugioka 1978) or a varus femoral osteotomy.

Transtrochanteric rotation osteotomy was considered to be indicated when the posterior one-third of the femoral head was not involved, as described by Sugioka (1978). His original technique was followed in detail, the osteotomised fragments being fixed by three large screws, after anterior rotation of the femoral head by 60° to 90° (Fig. 3). In a few patients, varus angulation of 15° to 20° was added.

For cases in which the lateral portion of the femoral head remained intact and could be expected to provide over one-third of the weight-bearing surface after varus angulation, we used the transtrochanteric femoral osteotomy devised by Nishio and Sugioka (1973). The curved plane and the varus displacement are shown in Figure 4; this allows the intact lateral part of the femoral head to become the weight-bearing area (Sugioka et al. 1980). About 20° to 30° of varus are obtained. One advantage of this procedure over the usual wedge osteotomy is that it produces minimal shortening of the limb. Both types of osteotomy are devised to prevent further collapse and restore joint function by a change in the weight-bearing surface of the head.

For Stage III IANF with extensive infarction, patients underwent endoprosthetic replacement of the femoral head. In Stage IV, the advanced stage, with severe deformity and secondary osteoarthritis, total hip replacement was the treatment of choice. Thus, no hips with Stage IV or severe Stage III disease were treated by joint-preserving operations.

After any of the four joint-preserving operations, the involved leg was elevated in balanced suspension for 2 to 4 weeks, while assisted active movements of the hip were encouraged. After this the patient was non-weight bearing on crutches for 3 to 6 months.

MATERIALS AND METHODS
We were able to review 46 patients, and personally examine 54 hips at least two years after a joint-preserving operation for IANF. There were 20 women and 26 men. The patients' ages at operation ranged from 15 to 59 years, with an average of 33 years. Follow-up ranged from 2 to 14 years, with an average of 4 years. In 28 patients, avascular necrosis had been associated with steroid administration; 18 had no predisposing cause. Of the 54 hips, 17 were treated by core decompression, 18 by bone grafting, 15 by rotation osteotomy and four by varus osteotomy.

Of the 46 patients, 28 had bilateral IANF (60%). Of these, eight had bilateral joint-preserving operations, nine had a unilateral prosthetic replacement, and 11 remained untreated on the contralateral side.

Function was assessed according to the Merle d'Aubigné hip score (1970), with up to six points for each
RESULTS

Clinical evaluation. The pre-operative hip score differed in each of the treatment groups. In the core decompression group, the mean pre-operative score was 16.1, and the postoperative score was 14.3. In the bone grafting group these figures were 13.9 and 15.6, in the rotation osteotomy group 12.6 and 13.7, and in the varus osteotomy group 11.5 and 16.2. All cases with a hip score of 14 points or less had painful symptoms and decreased walking ability as a result of progressive collapse of the femoral head.

The percentage success (15 points or more) in each group was 53% for core decompression, 72% for bone grafting, 60% for rotation osteotomy and 100% in the four cases of varus osteotomy (Table I). The unexpectedly low postoperative score for rotation osteotomy was accounted for by five hips with postoperative complications such as femoral neck fracture and necrosis of the femoral head.

Radiographic results. We focused on progressive collapse and osteoarthritis changes. Postoperative collapse of the head by more than 2 mm was found in 53% of the core decompression group, in 39% of the bone grafting group, 40% of the rotation osteotomy group and in none of the varus osteotomy group (Table II). Thus, radiological results correlated well with clinical evaluation, showing that the original aims of the operations, to prevent collapse and restore function, were linked, and had not been achieved in a high proportion of cases. The overall radiological success rate was 60%, an unexpectedly low figure.

Osteoarthritic changes were found in 18% of hips after core decompression, 11% after bone grafting, 20% after rotation osteotomy and in none after varus osteotomy.

Results in relation to the natural history of IANF. To evaluate the influence of the operations on the natural course of IANF, we compared our results with those for

Table I. Clinical results of joint-preserving operations on 54 hips with IANF recorded by the Merle D’Aubigné (1970) scoring system

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number of hips</th>
<th>Excellent (18-17)</th>
<th>Good (16-15)</th>
<th>Fair (14-13)</th>
<th>Poor (under 12)</th>
</tr>
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<tbody>
<tr>
<td>Core decompression</td>
<td>17</td>
<td>9 53</td>
<td>0 0</td>
<td>2 12</td>
<td>6 35</td>
</tr>
<tr>
<td>Bone grafting</td>
<td>18</td>
<td>8 44</td>
<td>5 28</td>
<td>4 22</td>
<td>1 6</td>
</tr>
<tr>
<td>Transtrochanteric rotation osteotomy</td>
<td>15</td>
<td>5 33</td>
<td>4 27</td>
<td>2 13</td>
<td>4 27</td>
</tr>
<tr>
<td>Varus osteotomy</td>
<td>4</td>
<td>1 25</td>
<td>3 75</td>
<td>0 0</td>
<td>0 0</td>
</tr>
</tbody>
</table>

Table II. Radiographic results of joint-preserving operations for IANF compared with a historical control series (Inoue and Takaoka 1981)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number of hips</th>
<th>No collapse</th>
<th>Collapse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of hips</td>
<td>Number</td>
<td>Per cent</td>
</tr>
<tr>
<td>Core decompression</td>
<td>17</td>
<td>8 47</td>
<td>9 53</td>
</tr>
<tr>
<td>Bone grafting</td>
<td>18</td>
<td>11 61</td>
<td>7 39</td>
</tr>
<tr>
<td>Rotation osteotomy</td>
<td>15</td>
<td>9 60</td>
<td>6 40</td>
</tr>
<tr>
<td>Varus osteotomy</td>
<td>4</td>
<td>4 100</td>
<td>0 0</td>
</tr>
<tr>
<td>Natural history</td>
<td>37</td>
<td>6 16</td>
<td>31 84</td>
</tr>
</tbody>
</table>

Fig. 5
Radiographs of a 33-year-old man after renal transplantation, with steroid-induced avascular necrosis of the left femoral head. Figures 5 and 6 – Pre-operative anteroposterior and lateral views show a circumscribed area of necrosis in the anteromedial portion of the head. The hip score was 13 (pain 4, mobility 6, gait 3). Figure 7 – Anteroposterior radiograph 4 years 10 months after bone grafting. The area of necrosis was circumscribed by a sclerotic margin (arrows) and reduced in size. The hip score was 16 (pain 5, mobility 6, gait 5).
Radiographs and specimen from a 40-year-old woman, with systemic lupus erythematous who had steroid-induced avascular necrosis in the right femoral head. Figures 8 and 9 show a large area of necrosis (arrows) involving the centre of the head, but sparing the posterior one-third. The score was 14 (pain 4, mobility 6, gait 4). Figure 10 – Radiograph 1 year 3 months after a 70° anterior rotation osteotomy (some of the fixation screws have been removed). The femoral head showed no collapse and the hip score was 17 (pain 6, mobility 6, gait 5). The arrows indicate the area of necrosis now located anteromedially. Figure 11 – Radiograph 3 years after operation, showing slight collapse of the weight-bearing area. There was severe pain on walking and the hip score was 9 (pain 2, mobility 5, gait 2). Prosthetic replacement was required. Figure 12 – A coronal section of the resected femoral head shows both the old lesion inferomedially and an area of further necrosis in the new weight-bearing portion, with a subchondral fracture.

37 untreated affected hips in 30 patients, which had been observed serially for 4 to 10 years by Inoue and Takaoka (1981). Thirty-one of these hips (84%) had progressed into collapse, only six (16%) retaining normal shape during follow-up (Table II). In our core decompression group, 53% of the hips had collapsed. This procedure, therefore, did not appear to be very effective although the treated and untreated groups were not exactly comparable. Our other treatment groups did seem to have benefited from their joint-preserving operation when results are compared with the natural course of IANF.

**The size of necrotic lesions.** In all cases where the joint-preserving operation succeeded, the necrotic lesion became progressively reduced in size. If the area of necrosis is defined as that within the sclerotic demarcation lines seen on a radiograph, then both bone grafting and rotation osteotomy appeared to have considerably reduced the size of the area of necrosis by the time of our latest review (Figs 5, 6, and 7). However, the rotation osteotomy group included two cases in which further necrosis was seen in the new weight-bearing section of the head. These were the only cases in the whole series of 54 hips in which the necrotic area became enlarged after a joint-preserving operation.

**Complications.** In the core decompression and bone grafting groups the femoral head was weakened by the drill hole or the curettage. This led to collapse in three hips (18%) of the core decompression group, and in five hips (28%) of the bone graft group.

Rotation osteotomy was accompanied by postoperative complications in five of the 15 cases. The femoral neck fractured in three hips (20%) in the subcapital region proximal to the osteotomy: these were considered to be stress fractures. As mentioned above further necrosis in the new weight-bearing section occurred in two hips (Figs 8 to 12). In these two hips a 70° anterior rotation had been performed with careful attention to preservation of the nutrient vessels to the head. Two other hips in this group suffered late varus deformity at the osteotomy site, but without serious symptoms. These complications of rotation osteotomy presented from one
year two months to two years six months after operation. The five hips with serious complications needed salvage procedures such as prosthetic replacement.

In the varus osteotomy group, there were no complications (Figs 13, 14 and 15).

Factors influencing the results. The assessment of the size and location as well as the stage of IANF is indispensable for the proper selection of an operation. In our series we selected the surgical procedures on the basis of the stage of the lesion, but noticed that the results were often more dependent upon the size of the necrotic area. In order to verify this hypothesis, we postulated that the ratio of the area of necrosis to that of the whole of the femoral head in the anteroposterior view was a parameter of the actual volume of necrosis. This ratio was calculated as shown in Figure 16.

The relation between the radiographic success rate and the ratio of involvement was investigated for 37 hips in Stages II and III, selected because the area of necrosis was well demarcated (Table III). In cases with 50% or more of head involvement the success rate was 27%, and in cases with 49% or less it was 91%. This difference was statistically significant at p < 0.001. This finding indicates that the results of the joint-preserving operations were determined much more by the size of the necrosis than by the stage of the disease or the chosen surgical procedure.

Table III. Ratio of involvement of the femoral head related to the radiographic result in 37 joint-preserving operations for IANF

<table>
<thead>
<tr>
<th>Area of necrosis</th>
<th>Number of hips</th>
<th>No collapse</th>
<th>Collapse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Per cent</td>
<td>Number</td>
</tr>
<tr>
<td>50% or more</td>
<td>15</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>49% or less</td>
<td>22</td>
<td>20</td>
<td>91</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 16.1, \ p < 0.001 \]

Another risk factor in the rotation osteotomy group was a centrally located necrosis, which, especially on the lateral radiograph, deeply involved the centre of the head. This made for poor results, although there was an intact area in the posterior one-third of the head. Of the seven hips with such a deeply situated area of necrosis, operation on six (86%) resulted in failure (see Figs 8 to 11). The other eight hips in this treatment group all had successful results.

Thus both the size and the location of the area of necrosis proved to be important factors in the results, and revision of the indications for each of the procedures may be necessary to take these risk factors into account. From our results, steroid administration, the bilateral or unilateral involvement of hips, or the presence of avascular necrosis in other joints were not important for the outcome. In bilateral cases, hip replacement on one side (nine hips) did not improve the result of a joint-preserving operation on the contralateral hip. Bilateral joint-preserving operations in eight patients gave the same results as in unilateral cases, with 10 out of the 16 (63%) proving successful.
DISCUSSION

Many joint-preserving operations have been devised for the treatment of IANF (Merle d’Aubigné et al. 1965; Meyers 1978; Sugioka 1978; Springfield and Enneking 1978; Ficat and Arlet 1980; Ganz and Büchler 1983). Each of these authors has recorded satisfactory results for his own procedure in his own hands. However, such satisfactory results have not been generally reproduced by other surgeons, and replacement surgery is often preferred.

Surgical indications. Our experience has shown that to use the stages of IANF without attention to the size and location of the necrosis has pitfalls.

In an untreated series of cases of IANF (Inoue and Takaoka 1981) 84% progressed to collapse. In our series the incidence of collapse was reduced to 40% after joint-preserving operations. Although their efficacy cannot be clearly established on the basis of this difference, we believe that the indications we used were generally valid. Further improvement in surgical results may follow the use of risk factors such as the size of the necrosis (more than 50% involvement of the head) and the depth of the lesion. Multivariate analysis may be needed to select the best joint-preserving operation.

Joint-preserving operations. Our study showed that core decompression was more useful in diagnosis than in treatment. Any therapeutic benefit was at the cost of reducing the mechanical strength of the femoral head.

Bone grafting (using non-vascularised bone) gave good clinical results, but in most cases there was progressive collapse of the femoral head, though the procedure seemed to prevent rapid deformation. The long-term efficacy of this procedure is doubtful, and a vascularised bone graft has been tried in a few centres (Judet, Judet and Gilbert 1981; Ganz and Büchler 1983). It is too early to evaluate this procedure since its indications are not yet established.

We found that Sugioka’s transtrochanteric rotation osteotomy needed great care as to indications and patient selection as well as much technical skill. Insufficient fixation or delayed union at the osteotomy led to poor results, and any complications resulted in disaster, which could only be salvaged by joint replacement. This procedure is only suitable for highly experienced hip surgeons. The cause of further necrosis of the head is unknown; it may be partly inevitable, but femoral neck fracture and varus deformity can be avoided by rigid fixation with a hip plate.

Varus osteotomy seems to be a safe and effective procedure, but our cases were too few to verify this, and the indication is limited to the femoral head with an intact lateral portion.

Bilateral IANF. The rate of bilateral IANF has been reported to be 50% to 80% (Patterson, Bickle and Dahlin 1964; Merle d’Aubigné et al. 1965; Boettcher et al. 1970; Fisher and Bickle 1971; Jacobs 1978), so most patients presenting with IANF should be regarded as being affected on both sides.

In our experience joint-preserving operations may be indicated for bilateral involvement. However, such patients need longer hospitalisation, an average of six months in our series. They often request a replacement operation on the second side after a joint-preserving procedure on the first. We feel that, in bilateral cases, only femoral heads in Stage I or II should be considered for joint-preserving operations.

Selection and indications. We were not fully satisfied by the overall results of joint-preserving operations. We feel that they should be limited to hips with relatively small and shallow areas of necrosis. Regardless of the stage of IANF, cases with extensive involvement of the head should not have joint preservation. When operation is indicated, we prefer Sugioka’s osteotomy for the hip with circumscribed necrosis at Stages II or III, and varus osteotomy where the lateral head is intact. Sound fixation with a hip plate is advisable. There is only a limited indication for bone grafting, which seems to lead to a slowly progressive joint destruction. Further development and earlier application of joint-preserving operations for IANF are clearly desirable.

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FEMORAL NERVE BLOCK FOR FEMORAL SHAFT FRACTURES IN CHILDREN: BRIEF REPORT

J. S. DENTON, M. P. R. A. MANNING

Femoral shaft fractures are common in childhood and, particularly if resulting from a road traffic accident, often associated with head injuries which may preclude the administration of general anaesthesia or opiate analgesics. Even in the absence of a head injury, recent ingestion of food may impose a delay of several hours before general anaesthesia. An effective local anaesthesia technique for manipulating these fractures in children has not, as far as we know, previously been described. We report our experience of femoral nerve block as a means of procuring local anaesthesia for this purpose.

Technique. The child is examined to see what injuries other than the femoral fracture have been sustained. Special note is made of the neurovascular state of the limb. The child is usually very distressed at this stage and, provided that there is no significant head injury or other contra-indication, intravenous morphine is given without delay (0.125 mg/kg estimated body weight); this is sufficient to provide sedation within a few minutes.

Next, the femoral nerve block is administered, using 0.5% bupivacaine in a dose of 1.5 mg/kg estimated body weight. The femoral artery as it emerges from under the inguinal ligament is used as a landmark; the femoral nerve lies immediately lateral to the artery at this point. The bupivacaine is instilled with a 23 gauge needle, pulling back on the syringe after insertion or adjustment of position in order to ensure that the artery has not been punctured (if blood is withdrawn, the needle is removed and re-positioned slightly more laterally). This quantity is sufficient to provide excellent local anaesthesia of the injured femur within 10 minutes. During this time, radiographs are taken—a simple and comfortable procedure. Skin traction and a Thomas splint are then applied in the conventional manner. Again, the femoral nerve block ensures that this is a painless procedure. Up to eight hours of effective analgesia is usual with this technique, and during this time check radiographs are taken in the ward. Subsequently, one or two further injections may be indicated if oral analgesia is inadequate or should a change of splint be required because of swelling of the leg. The ring of the splint does not significantly hinder access to the femoral nerve and there is usually no difficulty in undertaking a further injection with the splint in place.

Results and discussion. To date, we have used this technique with complete success on 20 children with fractures of the femoral shaft. We have not experienced any failures of anaesthesia and have been impressed by its remarkable calming effect on the child. We have experienced no complications, apart from inadvertent puncture of the femoral artery on two occasions. This has not been followed by any untoward sequelae, perhaps because of the small gauge of the needle.

We have found femoral nerve block such a successful technique that we now use it electively in all closed fractures of the femoral shaft in children.