We present the long-term results of simple varus intertrochanteric osteotomy for osteonecrosis of the femoral head. We followed 26 hips in 20 patients, with a mean age at the time of surgery of 36 years, for a mean of 12.5 years. The mean varus angulation was 23°.

The outcome in 19 of the hips (73%) was good or excellent; seven (27%) had a fair or poor result, with four needing some form of prosthetic arthroplasty.

Simple varus intertrochanteric osteotomy is indicated, even if the extent of the capital infarct comprises more than 50% of the diameter of maximum radial distance from the circumference, provided that after operation the medial necrotic lesion measures less than two-thirds of the weight-bearing area, and the superolateral bone is normal.

Many studies have assessed the nature of various types of osteotomy in the treatment of osteonecrosis of the femoral head. Results of varus osteotomy have been reported with varying rates of failure. Our aim was to evaluate the long-term results of simple varus intertrochanteric osteotomy.

Patients and Methods

Between January 1979 and June 1991, we performed varus intertrochanteric osteotomy on 23 patients for the treatment of osteonecrosis of the femoral head. Three patients were lost to follow-up in the early postoperative period, leaving 26 hips in 20 patients available for study. There were 17 men and three women with a mean age at the time of surgery of 36 years (25 to 50). The mean duration of follow-up was 12.5 years (7 to 19).

The diagnosis of osteonecrosis was made on the clinical history, physical examination and radiological appearance. A total of 12 patients had a history of corticosteroid administration for such conditions as systemic lupus erythematosus (4), nephritis (3), bronchial asthma (2), hepatitis (2) and multiple sclerosis (1); five had a history of heavy alcohol intake. In the remaining three, no potential risk factors for osteonecrosis were found. At the time of operation, all 20 patients complained of severe pain in the hip while walking. None had undergone a previous operation on the joint.

To be considered for osteotomy, the patients had to have a range of hip flexion of at least 90° and 25° of abduction. The necrotic lesion was assessed radiologically on preoperative anteroposterior (AP) and Lauenstein lateral views. Five hips were classed as stage II, 19 as stage III, and two as stage IV, according to the Steinberg classification. From 1985, we have used MRI to confirm the diagnosis.
Operative technique. The operations were carried out by senior surgeons specialising in hip surgery. The patient was positioned in the lateral decubitus position with the limb draped free on the table. A 15 cm lateral incision was made from the greater trochanter, exposing the lesser trochanter and lateral surface of the femoral shaft. Capsulotomy was not carried out. Two Kirschner wires were inserted as osteotomy guides (Fig. 1a), one at a right angle to the femoral shaft and the other in the direction to be taken by the seating chisel. Intraoperative radiography or fluoroscopy confirmed the position of the chisel and the amount of varus angulation. A power saw was used to transect the femur from the lateral cortex towards the lesser trochanter.

A planned bony wedge was resected from the proximal fragment (Fig. 1b). To secure the osteotomy in its altered position of varus, a spline was used in three hips, a Wainwright-Hammond plate in six, and an AO 90° double-angle blade-plate in 17. The amount of varus angulation varied between 15° and 40° (mean 23°). No other changes of position, such as flexion or rotation, were made. The necrotic area was moved medially and inferiorly so that it was no longer the centre of weight-bearing in the femoral head. Each osteotomy was designed to gain 25% or more on the postoperative lateral head index (LHI) as measured by radiography (Fig. 2).

Table I. Relationship between the clinical results of simple varus osteotomy and various radiological factors for 26 hips with osteonecrosis of the femoral head

<table>
<thead>
<tr>
<th>Factor</th>
<th>Excellent and good groups (n = 19)</th>
<th>Poor and fair groups (n = 7)</th>
<th>p value</th>
</tr>
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<tbody>
<tr>
<td>Stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>5</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>III</td>
<td>14</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>0</td>
<td>2</td>
<td></td>
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<tr>
<td>Varus angulation (degrees)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>15</td>
<td>4</td>
<td>NS</td>
</tr>
<tr>
<td>&gt;25</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Combined necrotic angle (degrees)</td>
<td></td>
<td></td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>&lt;200</td>
<td>17</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>&gt;200</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Postoperative improvement in LHI (%)</td>
<td></td>
<td></td>
<td>&lt;0.007</td>
</tr>
<tr>
<td>&gt;25</td>
<td>16</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Joint-space narrowing</td>
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<tr>
<td>No progression of collapse</td>
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<td>2</td>
<td></td>
</tr>
<tr>
<td>Progression of collapse</td>
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<td>5</td>
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<tr>
<td>Change in necrotic lesion</td>
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<td></td>
<td>&lt;0.002</td>
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<tr>
<td>Reduction in size or sclerosis</td>
<td>17</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No reduction in size, no sclerosis</td>
<td></td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Diagrams showing the technique of simple varus osteotomy. Figure 1a – Kirschner wires were inserted as osteotomy guides with α being the planned varus correction angle. Figure 1b – After insertion of the chisel, an osteotomy was carried out perpendicular to the femoral shaft using a power saw, followed by a proximal osteotomy by which the wedged fragment was resected.
and full weight-bearing was usually allowed at eight to 12 weeks.

**Clinical evaluation.** Using the Harris hip-scoring system, hips with a score of 90 to 100 points were classified as excellent, with 80 to 89 points as good, 70 to 79 points as fair and less than 70 points as poor. The radiographs were analysed by two of the authors (HI and TM). The extent and location of necrotic lesions were assessed by the method described by Shimizu et al. As we did not use MRI until 1985, 13 of the hips were evaluated by plain radiography to define the lesions. The extent was classified as grade A if the maximum radial distance from the circumference was less than 25% of the diameter of the circle. The necrosis was considered to be grade B if the distance was between 25% and 50% and grade C if it was greater than 50%. The location was classified as grade a if the lesion occupied less
than the medial one-third of the weight-bearing portion, grade b if it was between one-third and two-thirds, and grade c if it was greater than two-thirds (see Fig. 5). The other radiological features analysed included the preoperative Steinberg stage, the amount of varus correction, the combined necrotic angle described by Kerboul et al., the postoperative LHI described by Masuda et al., the progression of collapse or narrowing of the joint space and the reduction in size or sclerotic change of the necrotic lesions at the final follow-up. In hips without clear radiological sclerotic lines of demarcation, preoperative coronal and transverse MRI scans were reviewed to assess the margins between the living and necrotic bone which were used to determine the LHI and the total necrotic angles.

Statistical analysis of the data was carried out using Fisher’s exact test. P values of less than 0.05 were considered significant.

Results

The outcome was excellent in six hips, good in 13, fair in four, and poor in three. Overall, 19 of the 26 hips (73%) showed good or excellent results (Figs 3 and 4). Of the seven hips (27%) with a fair or poor result, four needed total hip replacement or a hemiprosthesis arthroplasty. In the excellent and good groups, the mean preoperative Harris hip score was 46 points (26 to 75), and at the time of follow-up, had improved to 85 points (80 to 100). Figure 5 summarises the extent and location of the necrosis before and after operation; eight of nine hips in which the necrotic location was converted from grade c to grade b showed an excellent or good result. By contrast, six of ten hips (60%) in which it remained grade c after osteotomy, had fair or poor results. The relationship between the clinical result and various radiological factors is shown in Table I. Radiographs in the excellent and good groups showed a necrotic angle of less than 200°, a postoperative LHI of more than 25%, no sign of progression of collapse or narrowing of the joint space, and a positive reduction in size or sclerotic change in necrotic lesions.

The relationship between limping at the time of the final follow-up and the degree of varus angulation in the group of 19 hips with an excellent or good outcome was assessed. In the four hips with varus angulation of more than 25°, three limped at the latest follow-up. This was a significantly higher rate than for the remaining 15 hips with varus angulation of less than 25°; only three of these patients limped at the latest follow-up (Fisher’s exact test, p < 0.04). Of the 11 hips in nine patients who had received continuous corticosteroids, nine (82%) belonged to the excellent and good outcome groups, which indicated that the continuous use of corticosteroids was not a risk factor.

Complications. There were no intraoperative complications. Two patients developed nonunion of the osteotomy; one had a second operation at one year with a bone graft, and progressed to union, and the other needed total hip arthroplasty. There were no other complications.

Discussion

Several studies have advocated varus intertrochanteric osteotomy for hips in which a lateral intact area of the
femoral head can be placed into the acetabular weight-bearing portion by osteotomy.\textsuperscript{1,21-23,26,27} Merle d’Aubigné et al\textsuperscript{1} reported good clinical results in 47 (80\%) of 59 stage-II or stage-III hips which had had Pauwels’ varus or combined varus and rotation osteotomy and had been followed up for eight years. They concluded that osteotomy arrests the progress of collapse and recommended it for hips with no marked collapse and limited lateral spread of the necrotic zone.

Kerboul et al\textsuperscript{22} emphasised that the purpose of osteotomy was to move the necrotic part of the femoral head from the zone of maximum pressure in favour of a normal posterolateral area. They stated that when the superolateral and posterior surfaces of the femoral head remained normal, good results were obtained in 83\% of the patients after varus flexion osteotomy at five years. They predicted success if the AP radiograph showed an arc of at least 20° of sound surface lateral and superior to the lesion. Our own findings confirm that if necrotic lesions are limited medially and the lateral part of the femoral head remains intact, good long-term results can be obtained by simple varus osteotomy.

Wagner and Zeiler\textsuperscript{23} described a technique of intertrochanteric double osteotomy. Their results were not significantly better than those obtained with other osteotomies, which may be attributed to the extensive necrotic lesions and preoperative osteoarthritis in their series of patients. They stated that a necrotic focus is rarely confined to a limited medial area of the femoral head, and that varus osteotomy is not indicated for the treatment of idiopathic osteonecrosis. Some of our patients, however, did have limited medial necrotic lesions with normal healthy bone and articular surface laterally. We found that the normal lateral portion of the femoral head can be brought round to the medial weight-bearing portion.

Maistrelli et al\textsuperscript{24} reported the results of 106 intertrochanteric osteotomies in which varus angulation was carried out in 25 hips and valgus angulation in 81. Of these, 61 (58\%) hips showed excellent or good results after a mean of 8.2 years (4 to 15). The merits of valgus osteotomy were discussed, but no significant difference was found between the varus and valgus groups. In necrotic hips with normal lateral bone, the main weight-bearing area is almost covered with medially displaced normal bone by simple varus osteotomy which is the most important benefit of this procedure.

Jacobs et al\textsuperscript{25} reported good or excellent results in 16 of 22 hips (73\%) using intertrochanteric osteotomy at a mean follow-up of five years; 11 of the 22 patients had a varus osteotomy, of whom ten had varus extension or flexion, and one a valgus extension procedure. The results closely correlated with the size of the necrotic lesion. They also reported a relatively high incidence of limp in the patients with varus osteotomy. In our study a limp at the time of follow-up was found in only three of 15 patients (20\%) in whom the varus correction angle was within 25°. In hips within this degree of correction a limp was sometimes found for some months after the osteotomy, but it usually improved within a year. Excessive varus angulation should be avoided and should not exceed 25°.

Saito et al\textsuperscript{26} reported an overall rate of success of 60\% in 54 hips with a variety of joint-preserving operations. The number with a varus osteotomy was relatively small, but they reported no complication in this group compared with those who had either core decompression, bone grafting or rotation osteotomy. In these, progression of the collapse and fracture of the femoral neck occasionally occurred.

Sugioka described a technique of transtrochanteric anterior rotational osteotomy for osteonecrosis in 1978. Sugioka et al\textsuperscript{30} reported their results in 1992 which were excellent in 236 of 274 hips (86\%) at a mean follow-up of 11 years. Successful results using this technique have been described by several other Japanese surgeons.\textsuperscript{15,25,29} Masuda et al\textsuperscript{25} stated that good results can be expected in hips with an LHI of more than 25\% after operation. In the USA, however, successful results have not been obtained with this technique.\textsuperscript{16,17,20} Sugioka’s osteotomy has been described as technically demanding\textsuperscript{13,16,17,20} and Eyb and Kotz\textsuperscript{27} reported high rates of complications and failure. Atsumi and Kuroki\textsuperscript{15} pointed out that a valgus position of the femoral head was responsible for these problems. Mont et al\textsuperscript{28} described good or excellent results in 28 of 37 hips (76\%) treated by corrective intertrochanteric osteotomy at a mean follow-up of 11.5 years; 11 of the 37 patients had a varus osteotomy, 20 had a varus/flexion, and six had a varus/extension procedure. Their results correlated closely with the size of the necrotic lesion; in the group with a preoperative necrotic angle of less than 200°, good or excellent results were obtained in 27 of 31 hips (87\%). Their results were positively influenced by the continuous use of high doses of corticosteroids, but these drugs did not affect the results in our patients. The reasons for this difference are not clear, but in our study no patient was continuously given high dosages (60 to 80 mg/day) of steroids.

At operation, it is often difficult to obtain the precise angulation planned. Kerboul et al\textsuperscript{27} reported that the angulation after osteotomy was exactly that desired in only 45\% of their operations. In our study, using intraoperative AP radiography or fluoroscopy, varus angulation was predicted relatively easily by measuring the angle of the guiding Kirschner wires in relation to the femoral shaft (Fig. 1). In hips which require correction in flexion or extension in addition to varus angulation, we recommend transtrochanteric anterior or posterior rotational osteotomies.

During radiological follow-up, a reduction in size and sclerotic change in the necrotic area were found in 17 of the 19 successfully treated hips, indicating a repair process. Sugioka et al\textsuperscript{30} reported that necrosis can heal when mechanical stress is withdrawn from the necrotic lesion, and varus osteotomy is indicated if the intact area occupies a large part of the superolateral portion.

The success of osteotomy is closely related to the extent and location of necrotic lesions.\textsuperscript{1,13,15-33} Recent studies show that MRI depicts a clear margin between living and
dead bone. Shimizu et al classified necrotic lesions, depicted by MRI, to predict prognosis and reported that eight of 13 hips (62%) with grade B and grade C, nine of ten hips (90%) with grade C and grade c, four of 31 hips (13%) with grade b and 17 of 24 hips (71%) with grade c had collapsed within 32 months. In our study, one of nine hips (11%) in which grade c had been converted to grade b by osteotomy and six of ten hips (60%), in which the location remained grade c after osteotomy, showed fair or poor results. These data support the results of Shimizu et al. Moreover, three of the six hips which showed progression of collapse during the follow-up period were initially detected between 1979 and 1982 and had grade-C necrosis and grade-c location after operation, and were thus poor candidates for varus osteotomy.

Simple varus osteotomy converts the location of a necrotic lesion medially and maintains an improvement compared with the natural history described by Shimizu et al. Moreover, even if the extent of the lesion is grade C, osteotomy is indicated in cases of a postoperative grade-b necrotic location with superolateral normal bone. 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
7. Chandler HP, Resnick FT, Wixson RL, McCarthy JC. Improved cementing and grade-c location after operation, and were thus poor candidates for varus osteotomy.