INTERTROCHANTERIC OSTEOTOMY FOR NON-UNION
OF THE FEMORAL NECK

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We report a series of 50 patients under 70 years of age who had an ununited femoral neck fracture treated by a Pauwels abduction osteotomy. At an average follow-up of 7.1 years, seven patients had required prosthetic replacement and 37 others were reviewed in detail. In these patients the Harris hip score averaged 91. Twenty-two hips showed radiographic evidence of avascular femoral head necrosis, but only three of these had been replaced.

For active patients with non-union of a femoral neck fracture, Pauwels osteotomy provides a high proportion of good results even in the presence of avascular necrosis of the head, providing there has been no collapse. If osteotomy fails, prosthetic replacement is still possible.

Non-union and avascular necrosis of the femoral head are the main complications of fracture of the femoral neck. In spite of improved operative techniques, non-union is still reported in some 10% to 20% of cases. The problem is essentially biomechanical, as demonstrated by Pauwels over 50 years ago (Fig. 1). For treatment he described an abduction osteotomy at intertrochanteric level, which converts shearing forces into compression (Pauwels 1935, 1965).

In such cases of non-union of the femoral neck, the current temptation is to perform prosthetic replacement, especially if there is also evidence of avascular necrosis. Arthroplasty can provide rapid pain relief and mobilisation, but the long-term results are not always perfect and a more conservative attitude is worth considering.

Revascularisation – though slow and restricted – has been demonstrated in avascular femoral heads (Phemister 1930; Sevitt 1964; Catto 1965), and many patients with radiographic signs of avascular necrosis have few clinical symptoms for many years (Lowell 1980). We have therefore performed Pauwels osteotomies for ununited fractures in patients under 70 years who are in good general condition, even in the presence of radiographic signs of avascular necrosis, providing the head had not collapsed severely. We have reviewed our results with special attention to those cases with evidence of avascular necrosis.

PATIENTS AND METHODS

From 1973 to 1985 we saw 72 patients with non-union of the femoral neck, 52 referred from elsewhere and 20 from our own department. Several of these fractures had redisplaced after primary treatment; these could not be expected to heal because of obvious instability. Such cases have not yet shown the classical features of non-union, but we included them in our study, as did Weber and Čech (1973).

Twenty patients were treated by prosthetic replacement, the indications being a ‘biological’ age of over 70 years, neurological disease, or severe collapse of the femoral head. One 24-year-old hemiplegic man with a non-union on his paralysed side had an arthrodesis and one 80-year-old woman in a poor general condition was treated conservatively.

The other 50 patients (27 women and 23 men) had an intertrochanteric abduction osteotomy as described by Pauwels (1935, 1965) and modified by Müller et al (1979). Their average age was 53 years (range 19 to 76) and the interval after fracture averaged 9 months (range 2 to 60).

Radiographs of all the original fractures were available and were classified according to Pauwels (1935) and Garden (1961). There were three Pauwels type 1 fractures, 16 type 2 and 31 type 3. By the Garden classification two were stage 1, three stage 2, 19 stage 3
Pauwels classification of femoral neck fractures. In type 1 the force across the hip joint results in compression at the fracture site, but in type 2 and type 3 the more vertical fractures sustain a shearing force which may lead to non-union.

**Table I.** Classification of avascular necrosis (Inoue and Ono 1979) at the time of osteotomy and at follow-up

<table>
<thead>
<tr>
<th>Stage</th>
<th>Radiograph</th>
<th>Before osteotomy</th>
<th>At follow-up*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal (abnormal scintigram)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Abnormal density or irregular density</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Irregular density and segmental collapse</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Severe deformity, osteoarthitis</td>
<td>0</td>
<td>6†</td>
</tr>
</tbody>
</table>

*last available radiographs (see text)
† three had hip replacement for severe symptoms, three were satisfied with the result

**Fig. 1**

Radiographs taken at the time of the osteotomy were scrutinised for signs of avascular necrosis and classified by the method proposed by Inoue and Ono (1979) for idiopathic avascular necrosis of the femoral head (Table I).

**Operation.** Our technique is shown in Figure 2. Careful pre-operative planning, with drawings from radiographs, is necessary. After operation partial weight-bearing (10 to 20 kg) is allowed for six weeks and crutches are used until radiographic union of both the osteotomy and the non-union is seen.

**Review.** At 3 to 13 years after operation, seven patients had died and two had failed to attend. The 41 patients with complete clinical and radiographic follow-up, were assessed by the hip scores of Harris (1969) and Merle d’Aubigné (1970), and by the subjective opinion of the patients. The records and radiographs of the nine other patients were studied, and the two who were unable to attend were interviewed by telephone.

The patients who at the time of osteotomy had radiographic signs of femoral head necrosis were considered separately. Results were also related to the patient’s age at osteotomy and to the time interval between the fracture and the osteotomy.

**RESULTS**

The mean follow-up after osteotomy was 7.1 years (range 3 to 13 years). Complications in the 50 patients included six cases of technical difficulty requiring re-operation, three cases of urinary infection, one of deep venous thrombosis and one deep infection with *Staphylococcus aureus* which led to ankylosis.
Seven hips (14%) had been replaced: three for persistent non-union, three for severe collapse of the femoral head after union of the original fracture and one (an alcoholic patient) whose plate had broken out (Table II).

The other 43 fractures (86%) had united in an average of 3.6 months (range 2 to 8), while the osteotomies had all healed in six weeks. Of these 43 patients, 37 had a full examination: the average Harris hip score was 91, 29 (78%) were good or excellent by the Merle d‘Aubigné score and 34 (92%) stated that they were satisfied or very satisfied. Three patients were dissatisfied. Examples of the radiographic changes are given in Figures 3 and 4.

Avascular necrosis. At the time of osteotomy, 22 patients (average age 51 years; range 19 to 65) had radiographic evidence of avascular necrosis. After osteotomy, three (14%) showed progressive and painful collapse of the femoral head necessitating hip replacement at 7, 30 and 63 months (Table II).

Of the other 19 patients with evidence of avascular necrosis at the time of osteotomy, 17 had a full follow-up examination: the Harris hip score averaged 85; the Merle d‘Aubigné score gave 13 (76%) good or excellent results and 15 (88%) were satisfied or very satisfied. Two patients were dissatisfied. The radiographic findings at follow-up are shown in Table I.

**Age and delay in treatment.** The results for different age groups and intervals between fracture and osteotomy are shown in Tables III and IV.

**DISCUSSION**

Pauwels classification of femoral neck fractures is two-dimensional; and lateral rotation of the leg will influence the apparent angle of the fracture. We therefore also used the Garden (1961) classification into four stages of displacement. The Pauwels classification is, however, useful for understanding the mechanism of the osteotomy and helps with the pre-operative planning.

Avascular necrosis of the femoral head has been shown to occur after a high percentage of femoral neck fractures. Sevitt (1964) found histological evidence of partial or total necrosis in 84% of 25 femoral heads. Frangakis (1966) found 45% avascular necrosis in a clinical study of 76 femoral neck fractures, with the highest percentages in ununited fractures and in the

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**Fig. 3a**

**Fig. 3b**

**Fig. 3c**

**Fig. 3d**

**Fig. 3e**

**Fig. 3f**

**Fig. 3g**

A femoral neck fracture in a 56-year-old man (3a) was treated by internal fixation (3b); the fracture displaced into varus (3c). An osteotomy was performed six months after the original fracture (3d), but because the blade was too long it was changed two months later; the fracture then healed (3e). Four years later the femoral head remained healthy (3f), and at 11 years (3g) the patient was satisfied and had a Harris hip score of 94.
Garden stages 3 and 4. Calandruccio and Anderson (1980) considered that the vascular damage at the time of the fracture decides whether or not necrosis will develop. Strømqvist and Hansson (1983), using tetracycline staining and isotope uptake studies, showed that the vascular damage may be increased during the operative fixation of a fracture. It is also recognised that overcorrection to more than 20° to 30° valgas, or malrotation, will affect the remaining vessels in the ligamentum teres and the joint capsule, and increase the chance of developing necrosis (Garden 1961; Frangakis 1966; Calandruccio and Anderson 1980). Revascularisation has been shown histologically (Phemister 1930; Sevitt 1964; Catto 1965) and by scintigraphy (Strømqvist et al. 1984), although it is a restricted process. If the artery of the ligamentum teres is intact, partial revascularisation of the foveal area of the head is possible. The contribution by vessels crossing the uniting fracture is limited but has been clearly recognised (Catto 1965; Sevitt 1964).

From these studies it appears that the primary treatment of a femoral neck fracture may influence the chance of developing avascular necrosis. It is difficult to decide whether a secondary procedure such as an osteotomy for non-union can do the same. In the cases we studied, at a minimum of two and an average of nine months after fracture, avascular necrosis may already have been present, without showing on the radiographs (stage 1 of Inoue and Ono 1979). Revascularisation on the other hand may also be in progress, although no contribution from a uniting fracture can be present. It is possible that any intact retinacular and ligamentum teres vessels have increased in size and number; if this is so, then valgas osteotomy is unlikely to further jeopardise the nutrition of the femoral head, and the uniting fracture will help support revascularisation.

Table I shows that four patients had developed radiographic signs of avascular necrosis during follow-up. It seems reasonable to assume that, at the time of
ostectomy, these hips had stage I necrosis, not visible on standard radiographs. Scintigraphy might have detected this, but is not routinely performed by us, since it would not change our indication for osteotomy. Six patients showed some progression of necrosis and collapse of the femoral head; three needed prosthetic replacement, but three had few or no complaints. This underlines the observation that even severe necrosis may be compatible with a satisfactory clinical situation.

Several authors have reported good early results after Pauwels osteotomies (Stewart and Wells 1956; Weber and Čech 1973; Marti and Raaymakers 1982; Lies and Scheuer 1983; Walcher and Wiesinger 1983; Wentzensen and Weller 1983; Huang 1986), but the influence of the osteotomy on the avascular process has not previously been studied in the long term.

We do not consider that pre-operative traction (Stewart and Wells 1956; Huang 1986) or autologous or homologous bone grafts (Dickson 1953; Stewart and Wells 1956; Huang 1986) are necessary; healing of the non-union can be expected after a Pauwels osteotomy on biomechanical grounds alone.

Radiographic signs of avascular necrosis in patients over 30 years of age are considered to be a contraindication for osteotomy by Walcher and Wiesinger (1983), but we agree with Weber and Čech (1973) that, provided there is no severe collapse, this type of osteotomy is still indicated.

In our whole series neither the age of the patient nor the length of time since the original fracture seemed to influence the result (Tables III and IV).

Some observations can be made on longer term degeneration. Patients without femoral head necrosis, or with completely re-ossefied heads without collapse, seem to retain a congruent joint with little or no further degenerative changes (Fig. 3). Some patients have necrosis with or without re-ossefication and develop partial or complete collapse of the head; this can occur up to 3 or 4 years later. Degenerative changes will then develop, but in many the clinical result is very satisfactory for years (Fig. 4). Finally, certain patients with progressive degenerative arthritis will require hip replacement at some stage; in our series this was necessary in only three cases.

We could find no reports of the results of total hip replacement performed for ununited fracture. The 20 patients we treated by prosthetic replacement can hardly be compared with our 50 cases of osteotomy; the former were either much older or impaired by neurological or other disease. However, at follow-up after total hip replacement at an average of 68 years of age (range 49 to 89), 10 of the 20 patients had died, one hip had been revised for aseptic loosening and the Harris hip score of the other nine hips averaged 66 (range 22 to 97).

We conclude that for patients under 70 years of age with an ununited fracture of the femoral neck, the Pauwels osteotomy produces many good results, even in the presence of avascular necrosis of the femoral head, providing the head has not collapsed severely.

Table II. Details of the seven patients with unsuccessful osteotomies and who came to total hip replacement

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age at osteotomy (years)</th>
<th>Cause of failure</th>
<th>Interval before THR (months)</th>
<th>Harris score at follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>49</td>
<td>Broken-out plate (alcohol abuse)</td>
<td>2</td>
<td>Died</td>
</tr>
<tr>
<td>F</td>
<td>61</td>
<td>Persistent non-union (technical problems and two re-operations)</td>
<td>21</td>
<td>58*</td>
</tr>
<tr>
<td>M</td>
<td>52</td>
<td>Collapsed head with osteoarthritis</td>
<td>30</td>
<td>85</td>
</tr>
<tr>
<td>F</td>
<td>53</td>
<td>Collapsed head with osteoarthritis</td>
<td>63</td>
<td>Died</td>
</tr>
<tr>
<td>F</td>
<td>59</td>
<td>Collapsed head with osteoarthritis</td>
<td>7</td>
<td>98</td>
</tr>
<tr>
<td>F</td>
<td>72</td>
<td>Persistent non-union (no re-operation)</td>
<td>3</td>
<td>94</td>
</tr>
<tr>
<td>M</td>
<td>50</td>
<td>Persistent non-union (one re-operation)</td>
<td>18</td>
<td>Died</td>
</tr>
</tbody>
</table>

* after revision of the prosthesis for fistula; the hip remained painful

Table III. Result related to age of patient at osteotomy. The number or score of those with avascular necrosis at the time of osteotomy is in parentheses

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Osteotomies</th>
<th>Hip replacement</th>
<th>Number</th>
<th>Mean Harris hip score</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥60</td>
<td>12 (3)</td>
<td>2 (0)</td>
<td>5 (2)</td>
<td>89 (90)</td>
</tr>
<tr>
<td>50 to 59</td>
<td>23 (12)</td>
<td>4 (3)</td>
<td>19 (8)</td>
<td>91 (81)</td>
</tr>
<tr>
<td>40 to 49</td>
<td>8 (3)</td>
<td>1 (0)</td>
<td>7 (3)</td>
<td>95 (81)</td>
</tr>
<tr>
<td>&lt;40</td>
<td>7 (4)</td>
<td>0 (0)</td>
<td>6 (4)</td>
<td>89 (93)</td>
</tr>
</tbody>
</table>

Table IV. Results related to the interval between original fracture and osteotomy

<table>
<thead>
<tr>
<th>Time interval (months)</th>
<th>Osteotomy (number)</th>
<th>Hip replacement (number)</th>
<th>Follow-up</th>
<th>Mean Harris hip score</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 6</td>
<td>20</td>
<td>3</td>
<td>14</td>
<td>89</td>
</tr>
<tr>
<td>6 to 12</td>
<td>18</td>
<td>3</td>
<td>13</td>
<td>91</td>
</tr>
<tr>
<td>&gt;12</td>
<td>12</td>
<td>1</td>
<td>10</td>
<td>92</td>
</tr>
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</table>

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REFERENCES


