BONE GRAFTING FOR PROTRUSIO ACETABULI
DURING TOTAL HIP REPLACEMENT
A REVIEW OF THE WRIGHTINGTON METHOD IN 61 HIPS

PHILIP HIRST, MAX ESSER, JOHN C. M. MURPHY, KEVIN HARDINGE

From the Centre for Hip Surgery, Wrightington

Total hip replacement has been very successful in patients with painful, stiff hips associated with protrusio acetabuli, but the heat of polymerisation of methylmethacrylate cement may cause necrosis of the thin medial wall with consequent danger of migration of the cup. Since 1968 at Wrightington, thin slices of the head of the femur have been used as bone grafts to reinforce the acetabulum.

We have reviewed 61 hips in 51 patients at an average of 4 years 3 months after operation. Grading for severity is discussed and the degree of physiological remodelling of the medial wall of the acetabulum after grafting assessed. There was an average of about 4 mm of remodelling, but this varied considerably; most took place within the first year. In no case was there relapse of the protrusio.

Protrusio acetabuli, from whatever cause, is due to a stress fracture of the medial wall of the acetabulum. In the early stages this heals so that a bony defect is not apparent on the radiographs; but later, in severe cases, the bone is severely fragmented. If total hip arthroplasty is attempted, technical difficulties with this inadequate medial wall may be encountered. Bone grafting of the deficient medial wall at operation for total hip replacement is valuable, producing bone healing and remodelling. We describe the technique in use at Wrightington and review our results.

Radiographic anatomy. Sotelo-Garza and Charnley (1978) measured the distance between the medial wall of the acetabulum and the pelvic brim (the iliopectineal line) to grade protrusio acetabuli, estimating the position of lines where they were masked by the femoral head. They recognised three grades: Grade I, 1 to 5 mm, mild protrusion; Grade II, 6 to 15 mm, moderate; and Grade III, over 15 mm, severe. It can be difficult to delineate the pelvic brim in some cases and the position of the medial wall of the acetabulum is difficult to establish when there is fragmentation and absence of bone, but all such cases should fall within Grade III.

Edelstein and Murphy (1983) emphasise two anatomical features on a normal anteroposterior radiograph. The acetabular line is the medial wall of the acetabulum, appearing as a smoothly curving line of cortical density and forming the curved line of the teardrop (X–X in Fig. 1). The ilio-ischial line represents the quadrilateral surface of the acetabulum which is projected tangentially to the x-ray beam. It is a discrete white cortical line.

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Table I. Grading of protrusio acetabuli according to the distance between the acetabular line and the ilio-ischial line (see text)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Men</th>
<th>Women</th>
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<tbody>
<tr>
<td>I</td>
<td>3-8 mm</td>
<td>6-11 mm</td>
</tr>
<tr>
<td>II</td>
<td>8-13 mm</td>
<td>12-17 mm</td>
</tr>
<tr>
<td>III</td>
<td>Over 13 mm with fragmentation</td>
<td>Over 17 mm with fragmentation</td>
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</tbody>
</table>

which is vertical or slightly oblique and forms the straight line of the teardrop (Y-Y in Fig. 1). Armbruster et al. (1978) found that in adult men the acetabular line is on average 2 mm lateral to the ilio-ischial line, but in women it is, on average, 1 mm medial.

Thus, protrusio acetabuli can be diagnosed in men when the acetabular line is 3 mm or more medial to the ilio-ischial line, and in women when the acetabular line is 6 mm or more medial to the line. Using these lines and criteria, the three grades of severity can be defined as in Table I. In Figure 2, an anteroposterior radiograph of a woman's pelvis, the right hip shows 10 mm displacement and is in the upper range of Grade I (mild); in a male pelvis this would be Grade II displacement. On the left are Grade III changes, severe protrusion with fragmentation.

PATIENTS AND METHODS

From 1966 to 1982 at Wrightington Hospital, 1402 total replacement operations were performed for hips showing protrusio acetabuli (Table II) and 87 included a bone graft for the acetabulum. Of these, 61 hip replacements (Table III) in 51 patients have been followed up for 17 months to 16 years (an average of 4 years 3 months) and had adequate radiographs. There were 45 women (89%). Two of the other 26 patients had died from unrelated causes within 18 months of operation, 14 had inadequate

Table II. The diagnosis in 1402 hips showing protrusio acetabuli

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number</th>
<th>Per cent</th>
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</thead>
<tbody>
<tr>
<td>Idiopathic osteoarthritis</td>
<td>961</td>
<td>65.3</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>380</td>
<td>27.1</td>
</tr>
<tr>
<td>Paget's disease</td>
<td>56</td>
<td>4.0</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
<td>11</td>
<td>0.8</td>
</tr>
<tr>
<td>Fracture</td>
<td>14</td>
<td>1.0</td>
</tr>
<tr>
<td>Psoriatic arthropathy</td>
<td>6</td>
<td>0.4</td>
</tr>
<tr>
<td>Still's disease</td>
<td>7</td>
<td>0.4</td>
</tr>
<tr>
<td>Sepsis</td>
<td>3</td>
<td>0.2</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>Perthes' disease</td>
<td>4</td>
<td>0.3</td>
</tr>
<tr>
<td>Acromegaly</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>Rheumatoid arthritis and Paget's disease</td>
<td>2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

radiographs and failed to attend for special review, while 10 had been lost to follow-up. The age of the 51 patients ranged from 27 to 82 with a mean of 61.4 years.

The pre-operative and immediate postoperative anteroposterior radiographs were measured and the degree of protrusio estimated; the latter figures form the baseline for the follow-up study. The wire marker of the cup provides a reference line for measurement of the thickness of the floor of the acetabulum, which includes the cement, the bone graft and the remains of the original medial wall. Variation in magnification was corrected by reference to the apparent size of the prosthetic femoral head diameter (real size always 22.5 mm), so that the true thickness of the acetabular floor in millimetres is the
distance between the wire marker to the medial limit of the floor multiplied by 22.5 divided by the measured diameter of the prosthetic femoral head. The postoperative remodelling, causing reduced thickness of the medial wall of the acetabulum, was measured in this way to the nearest 0.5 mm.

The incidence of early complications was obtained from the routine pro forma completed at the time of leaving hospital, and of late complications from the clinical notes. Clinical function was assessed by the six-digit scales of Merle d'Aubigné and Postel as modified by Charnley (1972) and used to determine improvement as a result of the arthroplasty.

Technique of operation. The standard trochanteric osteotomy technique of Charnley (1979) or the direct lateral approach of Hardinge (1982) is used. The femoral head is the source of cancellous graft; after dislocation, an oscillating saw is used to slice the head into 2 mm discs.
(Fig. 3). The acetabulum is prepared with curettes and any fibrous tissue is carefully removed. The thickness of the floor can easily be gauged; it is often nothing more than a thin membrane.

The discs of bone graft are prepared by removing the cortical rim of each with scissors; the remaining cancellous wafers are then pressed into the floor of the acetabulum until sufficient thickness has been achieved, using three to five slices in layers. The wafers are usually thin enough to mould and conform to the acetabular floor and this conformity can be improved by using a dome pusher (Fig. 4). The aim is to place the cup into the prepared acetabulum so that it has full bony cover. To improve cement fixation, 6 mm holes are drilled into the periphery of the acetabulum, particularly at the superior aspect (Fig. 4). A flanged acetabular cup is useful since it provides extra fixation around the rim of the acetabulum.

Cement is placed directly onto the grafts and pressurised with the dome pusher. The cup is then pushed firmly onto the cement to achieve a good bond. The remainder of the arthroplasty is performed in a standard manner. Postoperatively the patients lie supine during their stay in hospital, with their legs maintained in abduction by a triangular pillow for the first five days. Standing and assisted walking is permitted at two days using elbow crutches to provide protected weight-bearing. Patients leave hospital, usually at 12 to 14 days, when they are able, unaided, to get in and out of bed, up and down from a chair, and up stairs using their elbow crutches. Elbow crutches are used for six weeks after discharge from hospital. This is our standard regime for total hip arthroplasty, no special concession being made for the graft in the medial acetabular wall.

RESULTS

Clinical assessment before and after operation showed that on the six-digit scale of Merle d'Aubigné and Postel the average pain score improved from 3 to 5.8, function from 2.3 to 4.5 and range of movement from 2.6 to 5.1.

Complications. One patient had a deep venous thrombosis (1.6%) but none had pulmonary emboli. One patient had superficial infection and one a postoperative haematoma, but there were no deep infections. One patient required a pacemaker after an acute myocardial infarction.

In six cases (10.2%) there was non-union or fibrous union of the trochanter. Two patients (3.2%) had dislocation, one requiring revision of the position of the components, the other becoming stable after closed reduction.

One cup appears to show aseptic loosening and will require revision. Another has already been revised for this reason; in this case the medial wall of the acetabulum was composed of thick cancellous bone by the time of revision, providing an excellent bed for the new cup. There has been no case with progression of protrusion. Three cups show non-progressive demarcation in Zone 1 (DeLee and Charnley 1976) and one shows some degree of wear at 14 years.

Radiographs. The pre-operative films showed that two hips (3%) were in Grade I, 33 in Grade II (54%) and 26 in Grade III (43%). The initial postoperative film provided the baseline data for subsequent progress which was followed regularly until remodelling had ceased. Table IV shows the amount of remodelling in Grade II and Grade III hips. Though the figures are not statistically significant it can be seen that those hips with Grade III protrusion tend to remodel more than Grade II hips.

Table IV. Mean and range of remodelling in millimetres seen after bone grafting for protrusio acetabuli in rheumatoid and osteoarthritic hips

<table>
<thead>
<tr>
<th></th>
<th>Rheumatoid arthritis</th>
<th>Osteoarthritis</th>
</tr>
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<tbody>
<tr>
<td>Number of hips</td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>Grade II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>3.5</td>
<td>0.5 to 8</td>
</tr>
<tr>
<td>Grade III</td>
<td>11</td>
<td>4.5</td>
</tr>
<tr>
<td>Both</td>
<td>3.95</td>
<td>0.5 to 14.5</td>
</tr>
</tbody>
</table>
There was no obvious difference between patients with rheumatoid arthritis and those with osteoarthritis. Remodelling was also seen in protrusio secondary to Paget's disease and ankylosing spondylitis, by mean values of 3.4 mm and 2.3 mm respectively, but too few cases were seen for valid analysis. The scatter of results was considerable, and measurement of the thickness of the graft itself proved impossible because of the difficulty of defining the bone-cement interface. Some general conclusions were possible.
1. The more severe the protrusio, the greater the potential for remodelling.
2. The floor can remodel only as far as the cement, so that unless the bone graft crosses the ilio-ischial line, the cement will prevent further remodelling to this line.
3. Remodelling never crossed the ilio-ischial line.
4. Any cement pushed through the graft or alongside it will prevent remodelling; this should be avoided.

DISCUSSION

Moderate and severe degrees of protrusio acetabuli weaken or severely compromise the medial wall. An arthroplasty using cement against this weak medial wall must provide poor containment which could lead to breakdown (Salvati, Bullough and Wilson 1975). It is generally accepted that acrylic cement, to be effective in bonding the implant to the skeleton, must be applied intimately to bone to prevent movement and consequent absorption histiocytosis (Charnley 1979).

Similarly, bone grafts should be intimately opposed to the host bed and sufficiently compressed to allow incorporation to take place. Bone grafting as part of total hip replacement has been described by Heywood (1980) and McCollum, Nunley and Harrelson (1980), who have shown incorporation but not remodelling of the medial wall. In the thin fragmented medial acetabular wall of hips with protrusio acetabuli, the graft needs to be malleable to conform to the irregular bed. Bone wafers meet this requirement better than a single massive bone graft. Discs or wafers are superior to bone paste because they can stick to each other under compression and offer resistance during the introduction of the bolus of cement.

This cement bolus polymerises by exothermic reaction, heat being generated gradually in amounts proportional to the rate of polymerisation. This heat is at
first stored in the cement mass and is gradually released by heat flow through the mass to the surrounding structures. The use of large amounts of cement increases the potential for thermal damage to the thin bone of the medial acetabulum (Jeffersiss, Lee and Ling 1975). The bone discs reduce heat necrosis of the deeper layers and also act as a filler, enabling the cup to be brought out to the face of the acetabulum and reducing the volume of cement needed to restore Shenton's line (Figs 5 to 7). In addition, the grafts constitute an efficient barrier which stops the cement from penetrating deeply to a position where it might prevent incorporation and remodelling; moreover, the discs have the advantage of being malleable.

Incorporation of the grafts means that a much more satisfactory bone bed will be available for any future revision operation (Figs 8 to 11). The new bone is remodelled according to Wolff's law; most occurs in the first six months and, although at first the graft diminishes in size, this generally ceases by 12 to 18 months (Figs 12 and 13). Techniques which rely on cement without bone grafts tend to splint the acetabular cup in a displaced position. The Ring prosthesis has been reported to allow remodelling to occur (Sharp, Porter and Duke 1984), but in their small series two patients had pain from loosening.

It may be asked why such a small proportion of patients with protrusio acetabuli at Wrightington have been grafted. This was because Sotelo-Garza and Charnley (1978) concluded that grafting had little to offer; the results were no different from those with cement alone. Grafts were therefore not used between 1971 and 1976, but from 1980 to 1982, 43 of 192 hips with protrusio acetabuli (22.3%) have been grafted.

We generally use bone grafts only with Grade II and Grade III hips; these account for about 55% of hips with protrusio treated at this hospital (Sotelo-Garza and Charnley 1978). Now that we recognise the potential for remodelling we would advocate that all Grade III hips and most Grade II hips should have bone grafts as part of their total replacement.

Conclusions. Bone grafting a deficient medial wall in cases of protrusio acetabuli having a having a cemented arthroplasty is advised for Grade II and Grade III hips. The graft acts as a spacer, allowing correct lateralisation of the cup; becomes incorporated into the floor of the acetabulum, allowing remodelling; and protects the thin medial wall from the thermal effects of cement polymerisation. No extra complications resulted from this addition to the technique of total hip replacement.

REFERENCES


