TREATMENT OF POST-TRAUMATIC AVASCULAR NECROSIS OF THE FEMORAL HEAD BY MULTIPLE DRILLING AND MUSCLE-PEDICLE BONE GRAFTING

PRELIMINARY REPORT

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Twenty-nine patients with avascular necrosis of the femoral head after injury have been treated by operation. Multiple drilling of the femoral head was performed, necrotic bone removed and a muscle-pedicle bone graft implanted into the head and neck of the femur. In 17 of the patients the necrosis was associated with an un-united femoral neck fracture, in 11 it occurred after the fracture had united, and one case followed reduction of a dislocated hip.

The hips became painless soon after operation. The patients were young (average age 35 years), and full weight-bearing was not allowed for several months. The follow-up period ranged from 22 to 64 months. The results were excellent in 20 patients, good in five, fair in three and poor in one.

Avascular necrosis is a familiar complication of intracapsular fractures of the femoral neck, whether or not the fracture unites; it also may follow reduction of a traumatic dislocation of the hip. With the stress of weight-bearing the necrotic segment of bone is liable to collapse leading to painful degenerative arthritis of the hip (Bonfiglio and Bardenstein 1958).

Phemister (1949) advocated inserting a tibial bone graft into the necrotic bone in order to prevent collapse and to hasten revascularisation. This gave satisfactory results in 75 per cent of patients treated in the early asymptomatic stages of avascular necrosis (Stages 1 and 2, see below); but in the later stages the results were unpredictable (Bonfiglio and Bardenstein 1958; Bonfiglio and Voke 1968; Boettercher, Bonfiglio and Smith 1970; Marcus, Enneking and Massam 1973; Wang and Thompson 1976; Dunn and Grow 1977). Subarticular curettage of the necrotic bone and its replacement by cancellous bone had been studied by Merle d'Aubigné et al. (1965); they concluded that a free bone graft, being another piece of necrotic bone, was unlikely to prove successful.

Muscle-pedicle bone grafts, however, have been shown in animal experiments to preserve their vascularity and viability (Frankel and Derian 1962; Launois and Judet 1963; Medgyesi 1968). In humans such muscle-pedicle grafts (using the quadratus femoris muscle) have been reported to accelerate the union of intracapsular fractures of the femoral neck (J udet 1962; Meyers, Harvey and Moore 1973).

MATERIAL

Twenty-nine patients with avascular necrosis of the femoral head after injury were operated upon. Twenty-eight of these had sustained intracapsular fractures of the femoral neck; in 11 the necrosis occurred after union of the fracture, in the remaining 17 there was non-union. In one patient the necrosis followed reduction of a dislocated hip.

The ages of the patients varied from 12 to 60 years, the average being 35 years. There were 15 men and 14 women. In 17 patients the right hip was affected, in 12 the left. Avascular necrosis was confirmed by clinical, radiological and histological examination.

Clinical evaluation (see Table I) was based on the hip rating system used at the Hospital for Special Surgery (Salvati and Wilson 1973); their four parameters were pain, the ability to walk, range of movement and muscle power, and function, each of which could score from 0 (the worst) to 10 (the normal). This system was applied to all 29 patients after operation, but before operation it was omitted for the 17 patients with avascular necrosis and non-union, since in them the symptoms of necrosis could not be dissociated from those of the fracture.

Radiological assessment was based on the stages of necrosis as described by Marcus et al. (1973). Three patients in this series were in Stage 1 (asymptomatic but with slight mottled increase of density), 15 were in Stage 2 (still asymptomatic, but with the area of necrosis demarcated by a rim of increased density), four were in

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Stage 3 (with intermittent pain and the crescent sign in the lateral film), five were in Stage 4 (with a painful limp and distinct flattening of the femoral head), and two were in Stage 5 (with symptoms and signs of degenerative arthritis); none was in Stage 6 (with long-standing degenerative arthritis so severe that the evidence of the initiating necrosis has been obscured).

The diagnosis of avascular necrosis was confirmed in all cases by histological examination of the subarticular bone obtained from the femoral head during operation.

**METHOD**

The muscle-pedicle bone grafts used in this series were from three sources. In 21 cases the quadratus femoris, attached to a segment of intertrochanteric crest and the adjacent bone, was used; the bony portion was two centimetres wide and 1.5 centimetres deep (Figs 1 and 2). In six cases the gluteus medius insertion with the corresponding portion of the greater trochanter was used (Fig. 3); and in the remaining two cases the sartorius origin into the anterior superior iliac spine and the notch below it, together with a portion of the corresponding segment of the ilium, was used (Fig. 4).

**Operative technique**

**With united fractures.** A posterior approach was used in those patients in whom the fracture had united and in whom a quadratus femoris or a gluteus medius pedicle graft was being used; the same approach was employed in the patient whose necrosis had followed dislocation.

First, the muscle-pedicle graft was prepared. Then the common tendon of the gemelli and the obturator internus (transfixed with a silk suture) was detached close to its insertion and retracted medially. Next, the posterior capsule was opened, using an inverted T-shaped incision. Through this aperture the posterior and superior aspects of the femoral head were examined for evidence of articular softening, erosions or flattening; any marginal osteophytes were removed. A longitudinal gutter 1.5 centimetres wide and 1.5 centimetres deep was then cut over the posterior surface close to the superior border of the femoral head and neck, and encroaching one centimetre into the articular surface (see Figs 1 and 3). Through this gutter multiple holes were drilled in the femoral head and pieces of necrotic bone (usually sclerotic, but sometimes soft) were removed; in one instance (Case 15) a single loose sequestrum was removed.

The prepared muscle-pedicle bone graft was then trimmed to fit the gutter. The gutter was undermined and the graft placed therein, avoiding tension or torsion of the muscle pedicle. The graft was lightly impacted with a punch (a Moore's pin had at first been used for fixation, but this was found to be unnecessary). The gemelli and obturator internus were reattached to their original insertion, thus covering the graft; these muscles were also sutured to the quadratus femoris or the gluteus medius thus providing the graft with additional security.

Where a sartorius muscle-pedicle bone graft was used (Fig. 4), the operation was performed through an anterior approach which included division of the straight head of the rectus femoris. The drilling and removal of necrotic bone were performed through an anterior gutter into which the graft was then inserted. The straight head of rectus femoris was reattached and also sutured to the transferred sartorius muscle.

**With un-united fractures.** When necrosis was associated with an un-united fracture, again a posterior approach was used, but the patient was placed on a fracture table and the technique described by Meyers et al. (1973) was employed. The bone ends were cleaned of fibrous tissue.

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**Figure 1**—A quadratus femoris muscle-pedicle bone graft is seen prepared. The multiple drill holes into the femoral head through the gutter are shown. The gemelli and obturator internus are seen detached and retracted medially. **Figure 2**—A quadratus femoris muscle-pedicle bone graft has been placed into the prepared gutter. **Figure 3**—A gluteus medius muscle-pedicle bone graft is seen prepared. The multiple drill holes into the femoral head through the gutter are shown. **Figure 4**—A sartorius muscle-pedicle bone graft is seen prepared. The multiple drill holes into the femoral head through the gutter are shown. The straight head of rectus femoris is seen divided near its origin.
and the sclerosed surfaces freshened. Through the fracture surface multiple drill holes were made into the head ensuring thorough decompression. The fracture was reduced, free bone grafts packed between the bone ends, and fixed with three Moore’s pins. The muscle-pedicle graft (quadratus femoris or gluteus medius) was inserted as already described and usually fixed with a Moore’s pin. Radiography was not needed during the operation.

In all cases, after the wound had been closed a plaster boot with a derotation bar was applied to the affected side.

After-care
Soon after operation guarded non-weight-bearing exercises of the affected hip were begun. At two weeks from operation the stitches were removed, and at four weeks more vigorous active hip movements were encouraged, though with the patient still in bed. Patients with united fractures (and the patient with a dislocated hip) were allowed up at six to eight weeks after operation, but those in whom the fracture had been un-united were not allowed up for 12 weeks. A weight-relieving caliper was applied for a time and full weight-bearing not resumed until five or six months from operation; after un-united fractures this period was sometimes extended to eight months.

RESULTS
The patients were assessed clinically and radiologically both before and after operation (Table I). The follow-up period ranged from 22 to 64 months, the average being 38 months.

Radiological healing was judged by diminution of density of the affected portion of the femoral head, restoration of the trabecular pattern, healing of the crescent sign, of cystic areas and of the fracture line, as well as improvement in the shape of the flattened femoral head. If, despite apparent healing of the necrotic area, the head remained flat and the joint space narrow with persistent osteophytes, these cases were considered not to be improved, even radiologically.

The following criteria were used to grade the results:
Excellent—no pain in the hip, little or no functional restriction, a hip rating of 32 to 40, and a femoral head which radiologically looked normal or had healed Stage 1 to 3 lesions; Good—no pain in the hip, walking normal or only slightly restricted, some limitation of movement or function, a hip rating of 24 to 31, and radiologically healed Stage 3 to 5 lesions; Fair—intermittent pain in the hip, considerable limitation of movement, a hip rating of 16 to 23, and little radiological evidence of healing; Poor—constant pain, unsound ankylosis or grossly limited movement, a hip rating of 15 or less and no radiological healing. In this present series 20 patients were classified as excellent and two examples are shown in Figures 5 to 10; five patients were classified as good (Figs 11 and 12), three as fair and one as poor. The 12 patients in whom pre-operative evaluation was possible gained an average of seven points in their hip rating.

Complications
Two patients had stitch infections and three patients irritation from Moore’s pins. In one patient a pin was extruded and in another a pin penetrated into the pelvis. Five patients developed 10 to 20 degrees of coxa vara following union of a previously un-united femoral neck fracture. In nine patients restriction of movement was thought to result from inadequate physiotherapy after operation, but periartricular calcification was not encountered. Six of the patients with gluteus medius pedicle grafts had weakness of abduction of the hip due to diminution in length of the lever arm.

![Fig. 5](image1)
![Fig. 6](image2)
![Fig. 7](image3)

Case 1. Figure 5—Radiograph showing an un-united transcervical fracture of the neck of the femur with a partially absorbed neck and with increased density of most of the femoral head. A solitary “cystic area” can be seen (Stage 2 necrosis). Figure 6—Three months after operation the radiograph shows diminution of the area of density of the femoral head and advanced union of the fracture site. Two Moore’s pins are seen; a third pin was removed because it was being extruded. Figure 7—Sixty-two months after operation the radiograph shows that most of the dense areas of the femoral head have been replaced by coarse bony trabeculae and the fractured neck has united satisfactorily; mild coxa vara is present.
TREATMENT OF POST-TRAUMATIC AVASCULAR NECROSIS OF THE FEMORAL HEAD

Table I. Evaluation before and after operation

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† Radiographic stage of Marcus et al. (1973).
Case 3. Figure 8—Radiograph showing a wide area of the femoral head infarcted and separated from the healthy bone by a radiolucent zone two to three millimetres wide two years after union of a transcervical fracture treated by Moore's pins. Mild flattening of upper part of the femoral head is seen (Stage 3 necrosis). Figure 9—Four months after operation the radiograph shows the infarcted area has been partly replaced by coarse bony trabeculae and the radiolucent zone is bridged by new bone. A portion of the graft is visible over the femoral neck fixed by a Moore's pin. Figure 10—A radiograph 42 months after operation shows satisfactory healing of the infarcted area with a more normal trabecular pattern and with less flattening of the femoral head. Traces of residual density in the femoral head are still visible perhaps due to the laying down of new bone on dead trabeculae.

One patient (Case 26) took weight too early and this probably led to flattening of the femoral head, so that he had to be rated "fair" rather than "good". And in one patient (Case 15) a gluteus medius pedicle graft became displaced during an epileptic convulsion soon after operation.

DISCUSSION

Relief of pain was a feature soon after operation in every patient in this series; the probable cause was decompression of the necrotic area achieved by multiple drilling. Presumably the drill holes also facilitated revascularisation of the necrotic areas, thereby permitting the absorption of dead bone and the deposition of new bone. The relief of pain long after the operation was almost certainly a consequence of this revascularisation. Because the muscle-pedicle bone graft is vascular, its radiological density does not differ from that of normal bone; consequently it could rarely be delineated on the radiograph.

Sometimes sclerosed areas were seen in radiographs of the femoral head after operation, indicating incomplete removal of dead bone; usually these areas were gradually replaced by bone of normal texture during the ensuing year.

The patients in this series were not allowed to take full weight for a period of five to eight months after operation. This time interval is important, for in other series treated by drilling and Pemister grafting the time required before weight-bearing was more than twice as long (Bonfiglio and Bardenstein 1958; Marcus et al. 1973; Dunn and Grow 1977). It seems likely that the vascularity, viability and osteogenic properties of muscle-pedicle bone grafts account for healing being more rapid than when free grafts are used. It is of course realised that, even with rapid healing, if the femoral head was already significantly deformed before operation then further joint degeneration cannot be ruled out.

Of the different muscle-pedicle bone grafts used in this series the quadratus femoris graft seemed the most vascular, for blood dripped continuously from its cut surface. Moreover, unlike the gluteus medius graft, its use did not significantly weaken the hip.
ACKNOWLEDGEMENTS

I am grateful to the Principal and Superintendent of the NRS Medical College and Hospital, Calcutta for giving me permission to publish these results, to Professor A. K. Das for correction of this manuscript, and to Dr S. K. Dutta for drawing the diagrams.

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