Segmental collapse occurs in the early stage of avascular necrosis (AVN) of the femoral head, and is associated with a poor prognosis. Since it develops at a relatively young age, the long-term outcome after total hip replacement is a major concern. We have compared the long-term results of pedicle bone grafting (PBG) with those of transtrochanteric rotational osteotomy (TRO). In the PBG group there were 23 men (27 hips) and three women (4 hips) with a mean age at the time of surgery of 38 years and a mean follow-up of 13 years. In the TRO group there were 44 men (55 hips) and 19 women (22 hips) with a mean age at the time of surgery of 39 years and a mean follow-up of seven years. Failure was defined as a need for total hip replacement or a Harris hip score below 70.

The long-term results were similar for the two groups. The survival rates at five and ten years were 85% and 67%, respectively, in the PBG group, and 71% and 61%, respectively, in the TRO group, according to Kaplan-Meier survivorship analysis. In the TRO group patients in stage II had significantly better results than those in stage III.


Avascular necrosis (AVN) of the femoral head is a condition of unknown aetiology which most commonly affects young people. Predisposing factors include the administration of steroids and alcohol abuse. Embolism, decompression sickness, coagulopathy, and venous congestion have also been proposed as aetiological factors.1-5

The natural history is favourable when the necrotic area is small.6-11 In the early stage, with little collapse, therapeutic options include core decompression,12-15 bone grafting,16-22 intertrochanteric osteotomy,23-26 and transtrochanteric rotational osteotomy.27-33 However, when the necrosis involves a large part of the weight-bearing area there is collapse of the femoral head.6-11 The resulting destructive arthritis may be treated by bipolar or total hip arthroplasty.34-37 Most patients requiring surgery are young adults aged between 20 and 50 years. The longevity of the replacement arthroplasty is a major consideration.35 Joint-preserving surgery such as core decompression,12-15 free or pedicle bone grafting,38-40 varus or valgus osteotomy,27-33 and the transtrochanteric osteotomy of Sugioka et al41-46 is available. The place of core decompression remains controversial. Curettage of the necrotic area and replacement by a pedicle bone graft are useful when the necrotic area is small. Transtrochanteric rotational osteotomy (TRO) as reported by Sugioka30,32 and Sugioka et al46 preserves the femoral head by anterior or posterior rotation when more than one-third of the joint surface is intact.

Between 1983 and 1989 we treated patients with AVN of the femoral head by pedicle bone grafting (PBG) as described by Leung and Chow47 using grafts which included the superficial or deep circumferential iliac vessels.19,48 Even with good results over more than ten years, osteoarthritis ensued.17 In 1989 we therefore began to use TRO as described by Sugioka.30-32,46

We now present and compare the results of PBG and TRO in the treatment of AVN of the femoral head.

Patients and Methods

Pedicle bone grafting. The indications for PGB were stage-II and type-I-C or type-II necrosis according to the Japanese investigation criteria for AVN of the femoral head7 (Fig. 1). The stage of necrosis was classified according to Ficat and Arlet.49 PGB was performed by two surgeons (HI, YH) using a technique described by Iwata et al.19 The graft from the iliac crest was inserted through the neck of the femur.

Twenty-six patients (31 hips) underwent PBG between 1983 and 1985 and were followed for more than ten years. There were 23 men (27 hips) and three women (4 hips) with
unilateral involvement in four patients and bilateral involvement in 22. Five patients had bilateral procedures. Two were converted to total hip and bipolar arthroplasty respectively and one died seven years after surgery. Thus, 23 patients (28 hips) were available for final review (Table I). The vascular connection was the superficial circumflex iliac vessels except in six patients in whom the deep circumferential iliac vessels were used. The mean age at the time of surgery was 37.9 years (25 to 53), and the mean follow-up was 13 years (10 to 15). The osteonecrosis was idiopathic in five patients (7 hips), steroid-induced in 40 (46 hips), and alcohol-associated in 21 (24 hips). Type I-C AVN was found in 62 hips, type II in 12 and type I-B in 3; 34 hips were in stage II of the disease and 43 were in stage III. Exercises aimed at increasing the range of movement of the hip were started in the third week after operation. At 12 weeks partial weight-bearing (10 kg) and at 24 weeks full weight-bearing were allowed. Crutches were used for one year.

**Transtrochanteric rotational osteotomy.** The operation was performed by one surgeon (YH) or supervised by him using the original technique described by Sugioka and Sugioka et al. The indications for TRO were stage III or less, type I-C and type II, with a healthy area of the femoral head which measured 36% or more in Lauenstein’s view (Fig. 2).

Between January 1989 and July 1995, 65 patients (79 hips) were operated on, of whom 63 (77 hips) were included, in this study (Table I). Two patients (two hips) with follow-up of less than five years were excluded. In ten patients who underwent conversion to total hip or bipolar arthroplasty within five years, the clinical results and radiological evaluation were recorded up to the time of conversion. There were 44 men (55 hips) and 19 women (22 hips) with unilateral involvement in 11 cases and bilateral in 55. The mean age at the time of surgery was 39 years (19 to 64), and the mean follow-up was seven years (5 to 11). The pathogenesis was idiopathic in five patients (seven hips), steroid-induced in 40 (46 hips), and alcohol-associated in 21 (24 hips). Type I-C AVN was found in 62 hips, type II in 12 and type I-B in 3; 34 hips were in stage II of the disease and 43 were in stage III. Exercises aimed at increasing the range of movement of the hip were started in the third week after operation. At 12 weeks partial weight-bearing (10 kg) and at 24 weeks full weight-bearing were allowed. Crutches were used for one year.

The clinical evaluation of both groups was based on the Harris hip score and the degree of patient satisfaction, clas-
Pedicle bone grafting. At the end of ten years 28 hips were intact. Conversion to total hip or bipolar arthroplasty had been required in two because of progressive collapse. In one patient collapse occurred within one year of surgery requiring bipolar arthroplasty, and in another total hip replacement was performed nine years after surgery. One further patient died from unrelated causes. All of these patients were considered to have unsatisfactory results.

The mean Harris hip score before surgery was 69 points. At five years after surgery, 62 hips (81%) were rated ‘excellent’ or ‘good’, five (6%) as ‘fair’ and ten (13%) as ‘poor’. At final review the corresponding figures were 52 (68%), 8 (10%), and 17 (22%), respectively.

In the radiological evaluation before surgery, 28 hips (90%) had been graded as stage II. At five years 13 (42%) were stage II and at final review, 11 (35%) (Fig. 4). At final review, 16 hips (52%) were in stage IV; these had shown progression of the osteoarthritis at five years. The survival rates at five and ten years without failure, as calculated according to the Kaplan-Meier method, were 85% and 67%, respectively (Fig. 5).

There was no difference in the results of the early and later cases, before and after the establishment of the exact surgical technique. There were no major postoperative complications, such as deep infection or fracture. Skin necrosis in the inguinal area, requiring secondary suture, occurred in three patients. Injury to the lateral femoral cutaneous nerve was noted at final review in eight patients. At final review 11 patients were satisfied, ten dissatisfied and five undecided. Return to work occurred at a mean of 175 days (76 to 380) after operation; 12 of the 23 men and one of the three women were still working at their original place of work.

**Transstrochanteric rotational osteotomy.** The mean preoperative Harris hip score was 64 points. At five years after operation it was 84 points and at final review 82 points (Table III). Early deep infection occurred in one patient, trochanteric fracture in five, pseudarthrosis in one and progressive collapse in five, requiring total hip or bipolar arthroplasty in eight. At five years after surgery, 62 hips (81%) were rated ‘excellent’ or ‘good’, five (6%) as ‘fair’ and ten (13%) as ‘poor’. At final review the corresponding figures were 52 (68%), 8 (10%), and 17 (22%), respectively.

In the radiological evaluation, before operation 34 hips (90%) were considered to have unsatisfactory results. At five years after operation it was 84 points and at final review 82 points (Table III). Early deep infection occurred in one patient, trochanteric fracture in five, pseudarthrosis in one and progressive collapse in five, requiring total hip or bipolar arthroplasty in eight. At five years after surgery, 62 hips (81%) were rated ‘excellent’ or ‘good’, five (6%) as ‘fair’ and ten (13%) as ‘poor’. At final review the corresponding figures were 52 (68%), 8 (10%), and 17 (22%), respectively.

The overall results in the patients with a preoperatively intact area of the posterior articular surface measuring more
Radiographs of a 35-year-old man treated by PBG, showing preoperative a) AP and b) lateral views and postoperative c) AP and d) lateral views 12 years after PBG. The radiological classification was type I-C and stage II. The pre- and postoperative Harris hip scores were 75 and 100 points, respectively. He returned to his original occupation five months after surgery.

Survival rates of the PBG group according to the Kaplan-Meier method. At five and ten years the survival rates in the PBG group were 85% and 67% and in the TRO group 71% and 61%, respectively. The difference between the groups was not statistically significant (log-rank test, p = 0.16).
Radiographs of a 32-year-old man treated by TRO, showing preoperative a) AP and b) lateral views of the right hip and c) postoperative AP and d) lateral views seven years after TRO. The radiological classification was type I-C and stage II. Pre- and postoperative Harris hip scores were 72 and 98 points, respectively. He returned to his original occupation eight months after surgery.

Survival rates of the TRO group in stages II and III according to the Kaplan-Meier method. At ten years the rates were 79% and 45%, respectively. Patients in stage II had significantly better results (log-rank test; p = 0.034).
than 40% were significantly better than those in whom this was less than 40% (p = 0.01). No difference was noted between the early and later periods, before and after the establishment of the exact surgical technique, but the results were better in patients operated on by surgeons with greater experience of TRO (p = 0.04). At final review, 30 were satisfied, 25 dissatisfied, and eight undecided. Return to work occurred at a mean of 159 days (63 to 322); 32 men and two women were still working at their original place of work after ten years.

Discussion

The long-term prognosis of AVN of the femoral head is poor when the extent of necrosis is large and in such cases surgical intervention is usually required. Total hip arthroplasty has the advantages of providing relief from pain and minimising socio-economic costs with an early return to work. The results of total hip and bipolar hemiarthroplasty are good. Xenakis et al presented an overall survival of the prosthesis of 93% at a mean follow-up of 11.2 years. The problems of long-term durability and subsequent need for revision surgery, however, jeopardise its use in younger patients. Lachiewicz and Desman reported a survival rate of 52% in patients with a bipolar arthroplasty. Hartley et al reported a high rate of revision, 21%, because of wear of polyethylene and osteolysis.

Nevertheless, the indications for joint-preserving surgery are also controversial. When compared with total hip arthroplasty, the results of PBG and TRO are inferior with respect to relief from pain and durability. In our study, the postoperative period before returning to work was 175 and 159 days, respectively, a significant loss of employment, and approximately 50% of these patients became permanently unemployed. An investigation of the economic consequences of suspended employment in the patients should be carried out.

A weakness of our study was the difficulty of comparing the results of PBG and TRO retrospectively because of differences in the peroperative management. Both the stage of the disease and the extent of necrosis may give conflicting indications. In our study most of the patients in both groups were in stages II or III and the necrotic area was significantly larger in the TRO group than in the PBG group (Table I). A much higher percentage of the patients treated by TRO required total joint replacement. This may reflect the fact that more of the TRO patients were in stage III.

We have followed most patients in both groups for more than five years and all operations were performed or supervised by one surgeon (YH). Therefore, we were able to compare the PBG and TRO groups with regard to the clinical and radiological outcome and the degree of satisfaction. The results were similar in both groups. Similar results have also been reported using free pedicle iliac bone and fibular bone grafts (Table IV) possibly because the number of cases and length of follow-up in some series was small. Soucacos et al reported excellent results in 184 hips with vascularized fibular grafts but Judet and Gilbert reported good results in only 52% of 60 patients with a mean follow-up of 18 years. They concluded that the procedure may arrest or delay the progress of the condition and that it should be used in young patients without severe osteoarthritic changes in the hip.

The reported results following TRO for AVN are shown in Table V. When comparing the TRO patients in our series in stages II and III, the results of the former were better and it therefore seems important not to delay surgery. Moreover, the results of TRO were significantly better when the weight-bearing area of the femoral head was more than 40% of the total surface after surgery. If the intact area of the transposed articular surface was less than 36%, the success rate was 93%, but if it was less than 20%, the success rate was only 29%. Accordingly, surgery should be planned carefully so that an adequate weight-bearing area is obtained.

Within ten years of femoral head-preserving surgery, approximately one-third of patients show progressive collapse and osteoarthritis and require arthroplasty. A comparison of the long-term cost-effectiveness of primary and revision hip arthroplasty compared with patients with poor results of femoral head-preserving surgery which has been converted to arthroplasty, is required. The long-term results were either good or excellent in two-thirds of cases after both PBG and TRO. As noted by Dean and Cabanela, ethnic differences may influence the results of TRO.
results were significantly better in patients operated on by surgeons with more experience of TRO, emphasising the technically demanding nature of this procedure.28,51 Many complications including early failure of internal fixation, progression of varus deformity, trochanteric and cervical fracture, and further collapse of the head, have been reported after TRO.28,45,51 In our study most complications, such as varus deformity due to failure of fixation or subtrochanteric fracture, occurred early in the series.28 Many authors have developed fixation devices to minimise early failure of fixation.41,52

In order to obtain the best clinical and radiological results, considerable surgical skill and strict adherence to the indications for surgery are required. In our study, the results obtained after PBG and TRO were similar. As a therapeutic plan in a young patient, even when collapse of the femoral head has progressed (stage III), anterior or posterior TRO, is our first choice. Further follow-up is required to record the progression of osteoarthrosis.

We thank Professor Hans Wingstrand and Dr Kiyoharu Kawabe for their instructions and assistance with the preparation of the manuscript. We also thank Professor Youich Sugio for his technical advice.

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


