ROTATIONAL OSTEOTOMY FOR NON-TRAUMATIC AVASCULAR NECROSIS OF THE FEMORAL HEAD

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We reviewed 41 hips in 40 patients at three to 11 years (average 6.3 years) after Sugioka transtrochanteric rotational osteotomy for non-traumatic avascular necrosis of the femoral head. The clinical results were excellent or good in 23 hips (56%) and the radiological success rate was 56%. Failure was due to fracture of the femoral neck, nonunion of the osteotomy, secondary collapse, or osteoarthritis. Nonunion and femoral neck fracture were more common after the use of the large screws described by Sugioka than with AO blade plates. Secondary collapse was significantly more common when less than one-third of the posterior articular surface was intact ($p = 0.002$). Postoperative degenerative changes were seen in cases with stage III avascular necrosis.

We conclude that success depends to a large extent on the amount and stage of necrosis of the femoral head, but that careful technique and the use of AO hip plates may increase the likelihood of a satisfactory result.

Non-traumatic avascular necrosis of the femoral head (ANFH) is usually progressive, with collapse of the head eventually leading to osteoarthritis (Merle d'Aubigné et al 1965; Ohzono et al 1991). It is most common in middle-aged adults and treatment by cemented total hip arthroplasty (THA) results in a high rate of loosening in the younger patients (Chandler et al 1981; Cornell, Salvati and Pellicci 1985; Saito et al 1989; Sarmiento et al 1990). Revision of these failures of THA is even less satisfactory than primary replacement (Pellicci et al 1985; Engelbrecht et al 1990). For these reasons, THA is not always a good option; joint-preserving operations should be considered whenever possible.

The Sugioka transtrochanteric rotational osteotomy is theoretically an ideal method of replacing the necrotic segment in the superior weight-bearing region, but the reported results have been inconsistent (Sugioka 1978,

1984; Sugioka, Katsuki and Hotokebuchi 1982; Tooke, Amstutz and Hedley 1987; Masuda et al 1988; Saito, Ohzono and Ono 1988; Kinnard and Lirette 1990). The main reasons for the failure of this operation are postoperative fracture of the femoral neck, nonunion of the osteotomy, progression to collapse, and osteoarthritic change.

We considered that the success rate might be improved by more efficient selection of patients and better technique. Accordingly, we have reviewed our clinical and radiological results after transtrochanteric rotational osteotomy, using two methods of fixation.

PATIENTS AND METHODS

From 1980 to 1988 at Osaka University Hospital we performed transtrochanteric rotational osteotomy for non-traumatic ANFH on 47 hips in 46 patients. We were able to follow 41 hips in 40 patients for more than three years (range 3 to 11; mean 6.3). There were 28 men and 12 women, with an average age of 36 years (22 to 58) at operation. In 26 of these hips ANFH was steroid-induced, in 11 it was secondary to excessive alcohol consumption and in four it was idiopathic.

All 41 hips fulfilled the diagnostic criteria for ANFH proposed by the Japanese investigation committee of the Ministry of Health and Welfare (Ono et al 1986; Ohzono et al 1991). On their radiographic classification, all were type 1-C. On the Ficat and Arlet (1980) system of staging, eight hips were in stage II and 33 in stage III. The

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Fig. 1

Fig. 2

Fig. 3

Radiographs of a 22-year-old woman with systemic lupus erythematosus and steroid-induced ANFH in the right hip. Figures 1 and 2 – Anteroposterior and lateral views show type I-C changes at stage II. On the lateral view, 39% of the posterior articular surface was intact and 28% of the head was involved. Figure 3 – Radiograph six years after a 70° rotational osteotomy fixed with an AO blade-plate. There is no collapse, and the clinical result was excellent.

operation was indicated for hip pain when one-third or more of the posterior articular surface was intact on a lateral radiograph, and also, in younger patients, when one-quarter to one-third of the posterior articular surface was intact in stage II or III cases (Sugioka 1984).

In 25 hips we used Sugioka's original procedure, fixing the osteotomy with two or three large screws. In the other 16 hips, we used a transtrochanteric surgical approach, making considerable effort to preserve the posterior vessels of the neck. In these cases the osteotomised and rotated proximal fragment was fixed with an AO blade-plate and reattached to the osteotomised greater trochanter with an AO cancellous screw and wires (Figs 1 to 3). The usual angle of the hip plates was 120°, but in three hips we used 110° plates to produce some varus angulation. The blade of each plate was introduced into the femoral head through the inferior part of the femoral neck.

The femoral head was rotated to displace the necrotic segment anteriorly and to bring the intact portion of the head to the weight-bearing region. The angle of anterior rotation ranged from 60° to 100°. Five hips were placed in varus angulation of 15° to 20°. The 60° to 100° of rotation provided sufficient intact surface in all but the one case in which reoperation was performed.

Postoperatively, the leg was placed in balanced suspension for three weeks and assisted active exercises were encouraged. Non-weight-bearing on crutches was then advised for six months, followed by partial weight-bearing on one crutch for another six months.

Clinical assessments were made according to the Merle d'Aubigné hip scoring system (Merle d'Aubigné and Postel 1954) which allots up to six points each for

Fig. 4

Diagram showing the method of measuring necrosis on the lateral view and recording it as a percentage of the femoral head (SN, necrotic area; SI, intact area).

pain, mobility and gait. We recorded an excellent result for scores of 17 or 18, a good result for 15 or 16, a fair result for 13 or 14, and a poor result for 12 points or less. Our radiological assessment made particular note of progression to collapse and osteoarthritic change. We defined radiological success as an intact femoral neck, union of the osteotomy, no collapse of the newly created weight-bearing region, and no narrowing of the joint space.

We measured the necrotic area from the accurate pre-operative lateral views as described by Sugioka et al (1982), calculating the percentage of articular involvement (Sugioka 1978). The area of necrosis was measured by a digital planimeter, (X-plan 360i, Ushikata, Japan) and the necrotic area calculated as a percentage of the whole femoral head in each case (Fig. 4). These

measurements were related to the likelihood of secondary collapse.

Statistical analysis of the data was performed by Fisher's exact probability test and Student's *t*-test. Probability values of less than 0.05 were considered significant.

RESULTS

The mean pre-operative score was 11.4 points. Two years after surgery the mean score was 14.6, with excellent or good results in 26 hips (63%). At the final follow-up, at an average of 6.3 years, the mean score had fallen to 13.5 points and 23 hips (56%) had excellent or good results (Table I).

28 hips (68%) at two years. After this, there was secondary collapse in two hips and a joint space narrowing without collapse in three others. This left only 23 radiologically successful hips at the latest follow-up.

Risk factors for secondary collapse. The incidence of secondary collapse did not correlate with the method of fixation (Table II), being greatest in hips in stage III and in those in which the femoral heads had been rotated to more than 80°. These differences were not statistically significant. The rate of secondary collapse was significantly higher in the six hips in which less than one-third of the posterior articular surface was intact (83%, $p = 0.002$).

Of the 35 hips with one-third or more of the posterior articular surface intact, the incidence of secondary

Radiographs of a 51-year-old man with alcohol-associated ANFH in the left hip. Figure 5 - Six months after surgery, the osteotomy is united. Figure 6 - One year 11 months after surgery the femoral neck fractured. A hemiarthroplasty was then performed.

Fig. 5

Fig. 6

Table I. Clinical results in 41 transtrochanteric rotational osteotomies of the hip, using the Merle d'Aubigné scoring system (see text) (number, per cent)

Follow-up	Excellent (17-18)	Good (15-16)	Fair (13-14)	Poor (<12)
Two years	11 27	15 37	7 17	8 19
Mean 6.3 years	11 27	12 29	3 7	15 37

Complications. There were six postoperative fractures of the femoral neck without major trauma and one nonunion of the osteotomy within two years (Figs 5 and 6), all in the 25 hips fixed by screws. These cases were salvaged by bipolar hemiarthroplasty for the neck fractures, and by hip-plate fixation for the nonunion.

Secondary collapse was seen in nine hips within three years of the osteotomy, and narrowing of the joint space was found in three hips at various intervals after surgery. Of these 12 hips, five have been treated successfully by bipolar hemiarthroplasty for stage III (four hips) and THR for stage IV (one hip); the other seven are under consideration for this operation.

Radiology. The radiological results were satisfactory in

Table II. Relationship between the incidence of secondary collapse and various factors

Factor	Secondary collapse			
	Number	Number	Per cent	p-value*
Method of fixation				
Large screws	25	6	24	NS
AO blade-plate	16	4	25	
Stage				
II	8	0	0	NS
III	33	10	30	
Angle of rotation				
$\geq 80^\circ$	23	7	30	NS
$< 80^\circ$	18	3	17	
Intact posterior articular surface				
$\geq \frac{1}{3}$	35	5	14	0.002
$< \frac{1}{3}$	6	5	83	
Necrotic area on lateral view				
$\geq 45\%$ of the head	14	4	29	0.07
$< 45\%$ of the head	21	1	5	

* of difference

collapse was higher (29%) in those with necrosis of 45% or more than in those with less than 45% of the head involved (5%), but this difference was not significant ($p = 0.07$) (Table II).

Osteoarthritic changes. There was narrowing of the joint space in three stage III hips after several years of follow-

up (Table III). Some hips which had been radiologically successful developed severe osteophyte formation without joint space narrowing, or any collapse (Figs 7 to 10), and the incidence of such osteophyte formation was significantly higher in stage III hips (Table III). These hips retained good flexion and abduction movements, but showed severe limitation of internal rotation (Table IV) and had moderate disability.

improper selection of patients and inadequate surgical skill or methods of fixation. The three major complications are femoral neck problems including fracture and nonunion of the osteotomy, progressive degeneration and collapse of the newly created weight-bearing region, and late osteoarthritic change.

Anterior rotation of the femoral neck may place considerable strain on the underlying trabecular architec-

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Radiographs of a 40-year-old man with alcohol-associated ANFH in the right hip. Figures 7 and 8 – Pre-operative views show type I-C and stage III changes. Only 34% of the posterior articular surface is intact. Figure 9 – Radiograph one month after a 90° rotation osteotomy showing the newly created weight-bearing region. Figure 10 – At 11 years after surgery there is no progression to collapse but there is massive osteophyte formation. The hip score was 14 (pain 5, mobility 5, gait 4), with severe limitation of internal rotation.

DISCUSSION

Sugioka's osteotomy was introduced as an effective treatment for some cases of ANFH, but many authors reported success rates lower than those of the originator (Sugioka 1978, 1984; Sugioka et al 1982; Tooke et al 1987; Masuda et al 1988; Saito et al 1988; Kinnard and Lirette 1990). Possible reasons for this difference include

ture, which is poorly adapted to the new load-bearing conditions, and may lead to fracture of the femoral neck. Unfortunately, adequate remodelling may take a long time, and we were aware of the need for a more solid method of fixation and mechanical reinforcement of the neck. We therefore used AO hip plates instead of the screws in our last 16 cases; the problem of fracture of the

femoral neck was thereby eliminated. Sugioka (1984) reported a very low rate of femoral neck fracture and nonunion, but this may have been the result of a long period of bed rest (six to eight weeks) and very careful after-treatment. It appears that this long period of recovery can be shortened by the use of hip plates. Kinnard and Lirette (1990) considered the use of compression hip screws but although these may be useful in promoting bony union, it has not yet been established that the thread of a lag screw can withstand the derotational forces on the rotated head. Another merit of the use of AO plates is that they allow for varus positioning when this is indicated.

Table III. The incidence of osteoarthritic change related to the pre-operative stage of ANFH

Stage	Number	Joint space narrowing			Osteophyte formation		
		Number	Per cent	p-value	Number	Per cent	p-value
II	8	0		0.05	0		0.03
III	33	3	9		13	39	

The risk factors for progressive collapse after the operation have been identified by Sugioka (1984): a necrotic lesion in the weight-bearing region after surgery, involvement of more than two-thirds of the articular area on the pre-operative lateral radiograph, hips in Sugioka stages III and IV, and steroid-induced ANFH. Our use of plates did not prevent secondary collapse in nine of our 16 cases. The presence of an extensive necrotic lesion in the weight-bearing region after surgery may result from inadequate rotation or varus angulation.

We have not been able to explain secondary collapse of the newly created weight-bearing region. The incidence was higher in hips with a necrotic area of 45% or more, but was no different in hips in which less than one-third of the posterior articular surface was intact. The cause may be a stress fracture of the peninsula-shaped intact portion in the weight-bearing region. We found no definite link with the pre-operative stage of the lesion or with steroid-induced ANFH.

We saw no new collapse after the third postoperative year; all late deterioration of hip function resulted from osteoarthritis, and this was seen more often in stage III hips. Degenerative changes may result from the joint incongruity produced by rotation of the femoral head. We now believe, however, that rotational osteotomy should be performed only in stages I and II, before collapse of the head has become evident.

Although the extent of necrosis is a critical factor, it is sometimes difficult to evaluate this on early radiographs. In such cases MRI is useful to assess the site and extent of necrosis, especially in the sagittal plane.

The value of this joint-preserving operation can only

be determined by comparison with the natural history of ANFH. All our cases were of type 1-C (Japanese investigation committee) which is known to have a high incidence (94%) of collapse and progression to osteoarthritis. It therefore seems that Sugioka's osteotomy can be an effective method of joint preservation. We are not fully satisfied, however, with our 56% clinical success rate, although this may partially result from the learning curve for this operation. The skilful performance of the technique, the proper selection of patients, surgery in early stages, and solid fixation by AO hip plates may all improve the results.

Table IV. Limitation of internal rotation related to osteophyte formation in hips with radiological success

Osteophyte formation	Number	Internal rotation	
		Mean*	Range
None or mild	11	-10.5°	-30° to 10°
Moderate or severe	12	20.0°	5° to 60°

* $t = 5.24^\circ$, $p < 0.001$

Conclusions. Good clinical and radiographic results can be expected from careful transtrochanteric rotational osteotomy for ANFH in stages I and II when more than one-third of the posterior articular surface is intact. Hips which show more extensive necrosis are probably best treated by prosthetic replacement.

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