THE JOURNAL OF BONE & JOINT SURGERY (BRITISH)

Open reduction, internal fixation and fibular autografting for neglected fracture of the femoral neck

Onkar N. Nagi, Mandeep S. Dhillon, Vijay G. Goni

From the Postgraduate Institute of Medical Education and Research, Chandigarh, India

Neglected fractures of the femoral neck, common in young adults in underdeveloped countries, may be complicated by nonunion or avascular necrosis (AVN). We treated 52 cases by open reduction, fixation by compression screw and a free fibular graft. The mean delay between injury and operation was 5.1 months. Of 40 fractures assessed at a mean of 58.8 months (24 to 153), 38 were found to be united and two, owing to surgical errors, were not. Seven of eight heads which were avascular before operation revascularised without collapse, while seven others developed AVN after the procedure. At the last follow-up considerable collapse was apparent in five femoral heads, and 11 hips had developed coxa vara. The fibular graft had fractured in four cases. The hip had been penetrated by the screw in six cases and by the graft in three. Hip function was excellent in seven patients, good in 21 and fair in seven. Five patients had poor results. Incorporation of the fibular graft was seen after four years: in many cases the graft had been almost completely resorbed.

We recommend this procedure for the treatment of neglected fractures of the neck of the femur in young adults to reduce resorption of the neck, AVN and nonunion.

J Bone Joint Surg [Br] 1998;80-B:798-804.
Received 5 January 1998; Accepted after revision 26 February 1998

Only a few published reports have dealt with intracapsular fracture of the femoral neck in young adults[1-8] and even fewer with neglected or mismanaged cases.[3,4,9-12] In underdeveloped countries, because of poverty, ignorance and lack of facilities, these fractures are often seen only after either a delay or improper treatment.[4,10,13]

O. N. Nagi, MS, MSc, FAMS, Professor and Head
M. S. Dhillon, MB BS, MS, MNAMS, Associate Professor
V. G. Goni, MB BS, MS, Assistant Professor
Department of Orthopaedic Surgery, Postgraduate Institute of Medical Education and Research, Chandigarh 160012, India.

Correspondence should be sent to Professor O. N. Nagi at HSQ-1, PGI Campus, Sector 12, Chandigarh 160012, India.

0301-620X/98/58703 $2.00

Previous authors have reported a poor prognosis in this age group: there is a high incidence of avascular necrosis (AVN) and nonunion.[1,4,7,8] Since considerable trauma is usually involved the mechanism of the injury is important.[14] Excision and osteotomy[15,16] are no longer the principal methods of treatment. The main aim is to retain the femoral head and to ensure that the hip is stable, painless and mobile. This may be achieved by accurate reduction, impaction and compression of the fracture, stabilisation by rigid internal fixation and some form of primary bone grafting.

A previous paper described the results obtained in the treatment of fractures of the femoral neck by free fibular grafting and cancellous screw fixation.[10] Of the 26 young adults included in the study, 16 were treated only after a delay. The encouraging results prompted this prospective study of neglected fractures of the femoral neck in patients under 50 years of age.

Patients and Methods

Between May 1981 and January 1994 we treated 52 consecutive cases of neglected intracapsular fractures of the femoral neck in young adults by open reduction, cancellous screw fixation and free fibular grafting. More than two years later, 40 patients were available for follow-up. These included eight patients from a previous study.[10,13] There were 34 men and six women, with a mean age of 35.1 years (14 to 50). The mean follow-up was 58.5 months (24 to 153). The right hip was involved in 19 and the left in 21. Eighteen patients had been injured in road-traffic accidents and 22 had fallen from a considerable height.

We recorded the mechanism of injury, the interval between injury and surgery, previous health status and outcome. The operative technique has previously been described.[10,13] A single compression screw and a cortical autograft were considered insufficient for adequate immobilisation in cases of delayed union and therefore a single hip spica was applied for six weeks after operation. Non-weight-bearing walking on crutches was allowed only after the cast had been removed. Full weight-bearing was delayed for three months, and in those with absorption of the neck or AVN for as long as six months, depending on progress.

Table I. Criteria for grading the results

	Clinical features				Radiological features			
Grade	Pain	Shortening (cm)	Hip ROM*	Walking ability	AVN	Nonunion	Coxa vara (degrees)	Number of cases
Excellent	None	<1	Full	Full	No	None	None	7
Good	None	1 to 2	Rotation/flexion restricted by 15°	Full	No or healed	None	<10	21
Fair	Intermittent	2 to 3	Rotation <50% Flexion 90° only	1 km without aids	AVN No segmental collapse	None	11 to 20	7
Poor†	Constant	>3	Marked restriction	None without aids	AVN with collapse	Present	>20	5

* range of movement
† presence of any two clinical plus one radiological criteria, or two radiological and one clinical criteria classified the result as poor

Table II. Details of the 40 patients and the results

Age (yr)	Gender		Side		Mean period of delay (mth)	Mean time to union (wk)	AVN		Nonunion	Coxa vara	Long screw	Long graft	Graft fracture
	M	F	L	R			Preop	Postop*					
14 to 19	3	0	2	1	10	14.0	3	0	0	1	1	1	0
20 to 25	5	1	3	3	5.8	18.4	1	1	1	4	1	0	1
26 to 30	3	1	2	2	2.4	17.0	1	1	0	2	1	0	0
31 to 35	4	2	4	2	6.1	16.3	1	2	0	0	1	0	0
36 to 40	9	1	4	6	7	17.0	1	1	0	3	1	1	2
41 to 45	4	0	3	1	3	17.7	1	2	1	1	1	1	1
46 to 50	6	1	3	4	1.6	15.4	0	1	0	0	0	0	0
Total	34	6	21	19	5.1	16.7	8	8	2	11	6	3	4

* includes two cases of preoperative AVN which did not improve

We recorded details of pain, range of hip movement, ability to work and leg-length discrepancy. The results were analysed by an independent reviewer (VGG) and classified as excellent, good, fair or poor (Table I). Anteroposterior and lateral radiographs of the hip were assessed and obliteration of the fracture site with trabecular bridging was taken as evidence of union. Changes in bone density, isolated patches of sclerosis or discrete rarefaction and subchondral cortical[17] depression were considered as diagnostic of AVN. At follow-up, improvement in bony texture, reformation of the trabecular pattern in a well-united fracture, absence of progressive subchondral collapse and incorporation of the fibula into the host bone were taken as radiological evidence of revascularisation.

Results

The detailed results are given in Table II. There was no statistically significant difference in the results of patients of varying age groups. The mean period of delay before surgery was 5.1 months (1.5 to 24) (Fig. 1). Two patients had previously been treated by a hip spica alone, while five others had undergone previous unsuccessful operations (Figs 2 and 3). Eight had radiological evidence of AVN before operation. In four (Fig. 2), the fibular graft had to be placed proximal to the lag screw because of previous implants.

The mean time to union in the 38 fractures which united was 16.7 weeks (12 to 24). Two patients developed nonunion due to the screw thread distracting the fracture. In another, the fibular graft fractured, presumably at the time of insertion. These three subsequently had total hip arthroplasty.

Seven of eight patients with a preoperative radiological appearance of AVN showed later evidence of revascularisation of the femoral head at a mean of 2.3 years after fibular grafting. One developed significant collapse of the head. Seven additional patients showed radiological changes of AVN in the head subsequent to the operation. At the last follow-up only four of these had obvious evidence of either collapse of the femoral head or incomplete revascularisation. Coxa vara, defined as a neck-shaft angle ranging from 90 to 115°, was seen in 11 hips after operation. The mean leg-length discrepancy was 2.9 cm (0.9 to 3.9). Fracture of the fibular graft was noted in four patients, in three of whom it healed uneventfully. There was one nonunion in which the graft fractured during insertion and gave rise to residual instability. It is not known whether this was the cause or the result of failure of fixation. In six patients, a screw penetrated the joint and in three the fibular graft. The screws were removed before the joint was mobilised. In patients with penetration of the graft the hips were mobilised and in all three the protruding tip of the fibula resorbed. Superficial wound infection seen in two patients resolved with wound toilet and antibiotics. After follow-up for eight years or more the fibular graft had incorporated in 13 out of 17 patients. CT of eight patients showed excellent reconstitution of the neck and evidence of graft incorporation into the host bone.

Seven results were excellent, 21 good, seven fair and five poor. The five poor results (12.5%) included patients with nonunion or AVN with segmental collapse, with or without

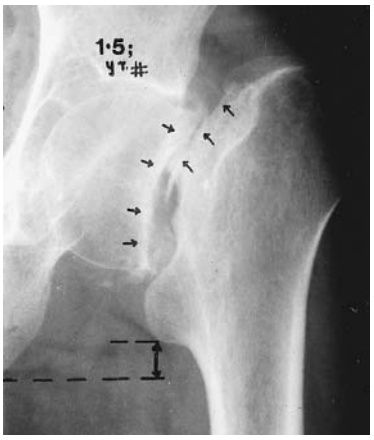

Fig. 1a

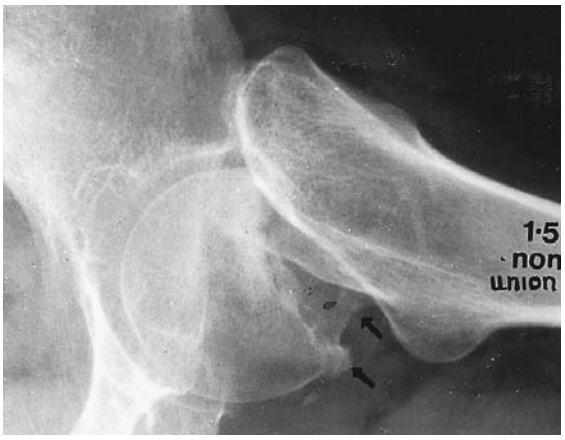

Fig. 1b

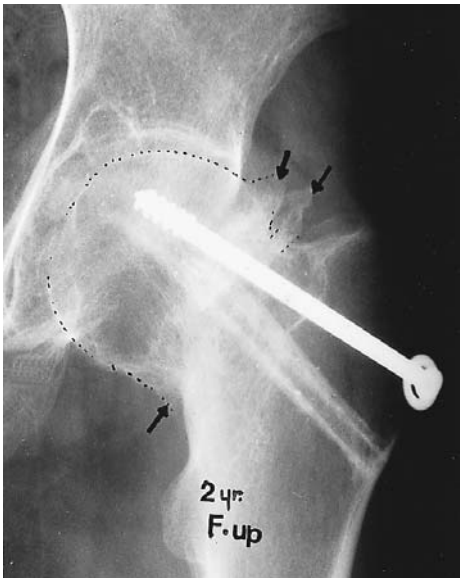

Fig. 1c

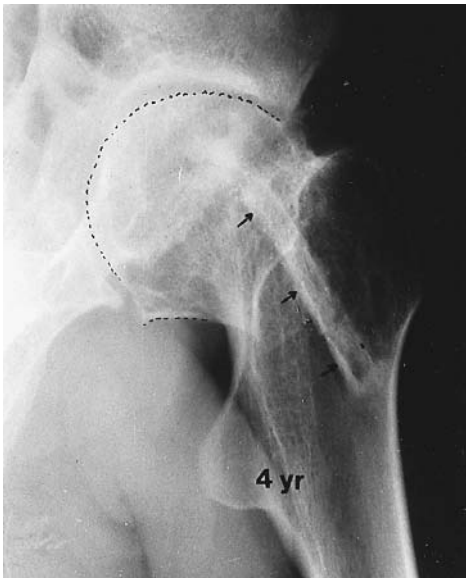

Fig. 1d

Anteroposterior (a) and lateral (b) radiographs of a fractured left femoral neck, 18 months after injury, showing nonunion with proximal migration. Two years after fibular grafting (c) the fracture is well-united and the limb-length discrepancy is minimal. After four years (d) there is no evidence of AVN and the fibula is partly resorbed.

coxa vara, shortening and restriction of activity. There was both nonunion and AVN in two. These five were regarded as failures and advised to undergo replacement arthroplasty. Three had a total hip replacement and two excision arthroplasty. The hips of the 28 patients (70%) with good or excellent results were regarded as nearly normal. In the seven patients in whom there were functional limitations the results were regarded only as fair.

Discussion

The few reports of neglected fractures of the femoral neck in young adults emphasise that the outcome is usually poor (Table III).[1,5,6] Early accurate reduction and fixation under compression have given good results,[8] but in underdeveloped countries early operation is not always possible. This can lead to problems of management.

It is desirable to try to salvage the femoral head in young adults, and this often calls for some form of bone graft. There are reports of the use of Phemister grafts,[18] vascularised[2,4] or muscle pedicle grafts,[19,20] and fibular grafts with or without osteotomy[9,11,15] (Table III), but none of these studies has been prospective or large enough to allow any conclusion about the best form of treatment.

Lifeso and Young[3] felt that valgus osteotomy gave acceptable results but concluded that nonunion in young adults was difficult to treat. Moreover, displacement osteotomy is no longer popular.[21,22] The best results come from some form of bone graft with stable fixation. Since Inclan[23] reported revascularisation of the ischaemic femoral head using banked allograft, a variety of bone grafts has been used to achieve union and revascularisation of the femoral head. In 23 cases in which a muscle pedicle graft had been delayed for more than three months after injury, Meyers,

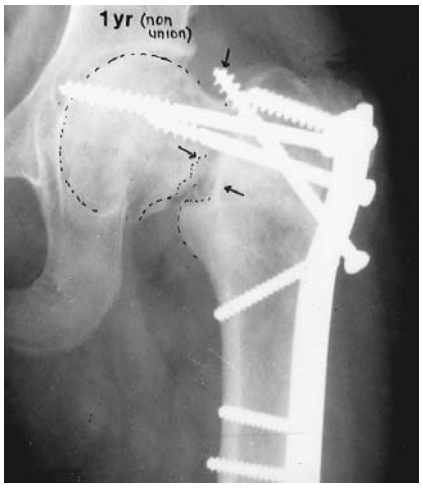

Fig. 2a

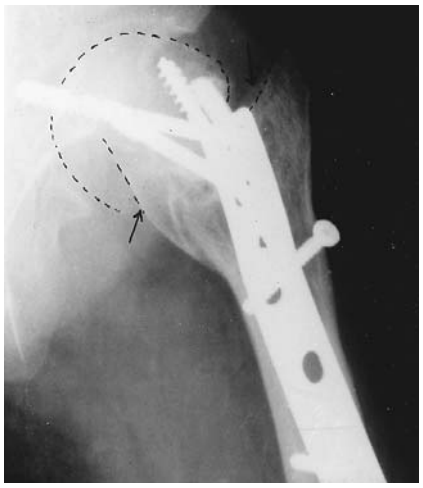

Fig. 2b

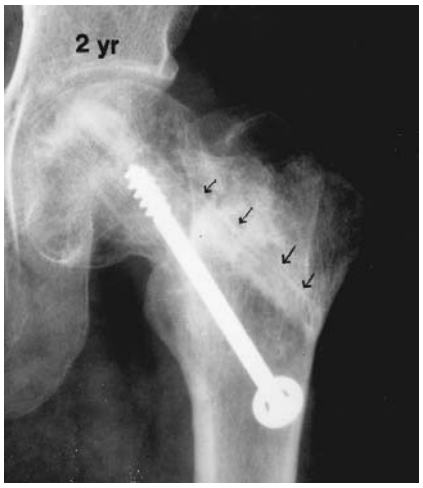

Fig. 2c

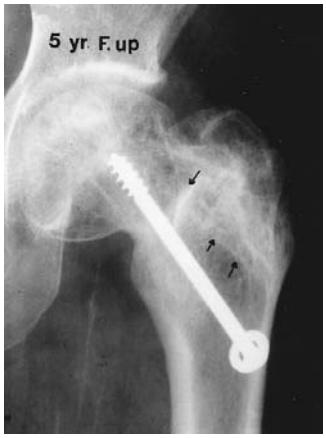

Fig. 2d

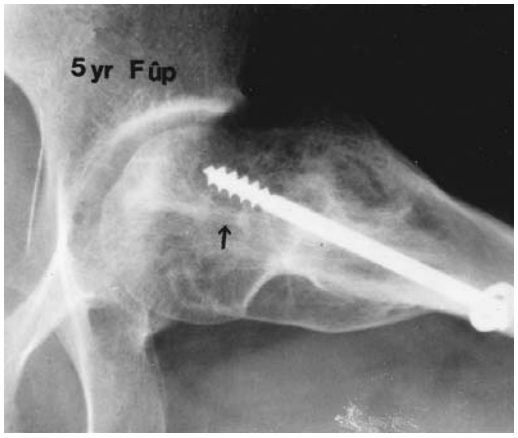

Fig. 2e

Anteroposterior (a) and lateral (b) radiographs showing frank nonunion one year after open reduction and complex internal fixation of a proximal fracture of the femoral neck. Two years after implant removal and fibular grafting, resorption of the fibula has begun (arrowed in c). Five years after the grafting there is excellent reconstruction of the neck and almost complete resorption of the fibula (d and e).

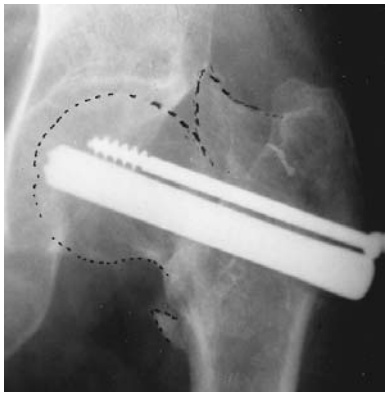

Fig. 3a

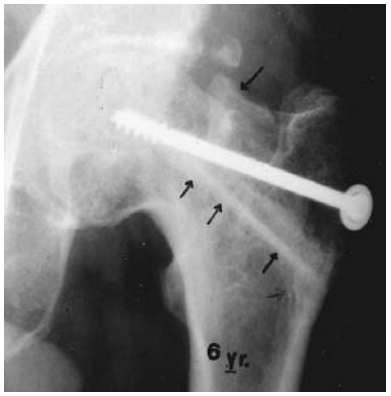

Fig. 3b

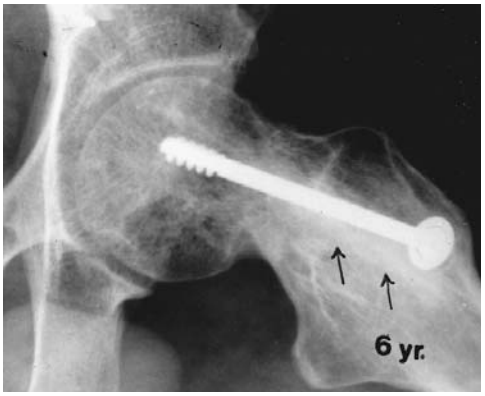

Fig. 3c

Anteroposterior radiograph (a) showing failed previous surgery using a Smith-Petersen nail and cancellous screw. Six years after implant removal and fibular grafting, the fracture is well-united and the neck reconstituted (b and c). The fibular graft is partly resorbed (arrowed in c).

Harvey and Moore[24] found nonunion in 75%. Baksi[19] and Johnson and Brock[25,26] reported a similar outcome. Excellent results have been obtained with open reduction and vascularised iliac-crest grafting,[4,27] but the procedure is technically demanding and few cases have been reported.

The incidence of AVN is between 8% and 30% after fracture of the femoral neck,[28] and is probably higher in neglected displaced cases. The radiological features of developing AVN are well known,[17,29] but without performing a bone scan it is difficult to say with certainty whether

Table III. Details of previous series of neglected fractures of the femoral neck in young patients

Author(s)	Number of cases	Number <60 yrs of age	Number with delay > 6 wks	Method of treatment*	AVN	Nonunion (%)	Comment†
McMurray[21]	27	24	24	McMurray osteotomy	-	-	Shortening, limp and decreased ROM
Henderson[30]	77	72	72	CR/OR and cortical bone graft	-	*20*	68% success
Inclan[23]	134	47	47(?)	CR+S-P nail+ bone graft	?	?	82% good
Patrick[31]	47	7	5	CR+S-P nail + fibular graft	12.8	*8.5*	21.3% OA owing to joint penetration by graft
King[15]	24	?	24	Subtrochanteric osteotomy + IF	?	*21*	79% success
Stewart and Wells[14]	100	?	100	Osteotomy + IF	?	*46*	High rate of nonunion including at osteotomy site
Bonfiglio and Voke[32]	77	?	77	CR+pinning+ Phemister graft	?	?	80% good
Meyers et al[24]	32	23	12	ORIF+muscle pedicle graft	?	*5*	40% nonunion in delayed and neglected fractures
Zinghi et al[22]	34	?	34	Osteotomy	2	*0*	Shortening and limp
Dooley and Hooper[9]	26	14	14	CR+nail-plate+ fibular graft	3	*2*	Recommend open reduction if closed reduction fails
Baksi[19]	17	15	15	ORIF+Meyers muscle pedicle graft	-	*0*	All united. 90% good result
Nagi et al[10]	16	16	16	ORIF+fibular graft	-	*0*	AVN improved in four cases
Huang[2]	16	16	16	CR/OR+IF+ Phemister graft	-	*0*	81% good result
Snyder et al[12]	1	1	1	ORIF+fibular graft	0	*0*	Union achieved in nine-year-old stress fracture
Lifeso and Young[3]	28	9	9	ORIF-3 osteotomy-6	2	*3*	44% good
Nagi et al[13]	17	17	11	ORIF+fibular graft	2	*0*	All patients were under 18 years of age
Hou et al[27]	5	5	5	ORIF+pedicled iliac-bone graft	0	*0*	All fractures united with excellent result
Leung and Shen[4]	15	15	4	ORIF+pedicled iliac-bone graft	0	*0*	Excellent result
Slater et al[11]	1	1	1	CR+cannulated screw+fibular graft	0	*0*	United without AVN
Present series	40	40		ORIF+fibular graft	5	*2*	87.5% successful

* CR, closed reduction; ORIF, open reduction and internal fixation
† OA, osteoarthritis, ROM, range of movement

revascularisation of the femoral head is occurring. We took the following signs to be indirect evidence of revascularisation of the femoral head: reconstitution of the trabecular pattern, incorporation of the fibula into the femoral head proximal to the fracture line, and little or no progression of structural collapse after a sufficiently long period of follow-up. These features correlated well with the clinical findings, although over time minor radiological changes may be seen. Our findings suggest that the fibular graft, by providing structural support and promoting union, indirectly contributes to revascularisation of the femoral head.

Table I illustrates the point scoring method which we used. Any patient with a total of three points (two clinical and one radiological, or one clinical and two radiological) was considered to have a poor result. From a functional point of view the results may not be considered acceptable in Western populations, but our rates of union were good. As long as the femoral head is saved and union achieved, shortening or marked coxa vara may be corrected by abduction osteotomy at a later stage.

The two main problems which we encountered were resorption and compromise of the vascularity of the femoral head. It is not possible to achieve accurate reduction of neglected fractures by closed methods, and repeated attempts at manipulation further harm the blood supply to the head of the femur. Careful open reduction causes only minimal additional insult to the blood supply.[13] A T-shaped incision in the anterior capsule will ensure that the arcade

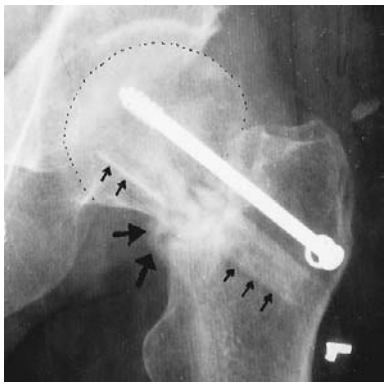

Fig. 4a

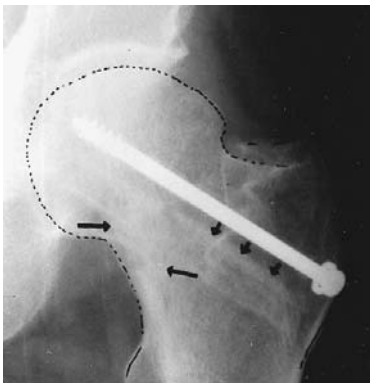

Fig. 4b

Fig. 4c

Anteroposterior radiograph showing fracture of the fibular graft (large arrow in a) nine weeks after operation. Ten years after the operation (b and c), there is excellent healing of the fracture and continuity of the trabecular pattern across the site of the fibular fracture (long arrows).

of vessels at the base of the neck is not damaged. This approach gives sufficient exposure for removal of the interposed fibrous tissue and allows accurate reduction. Additionally, in cases with posterior comminution, the anterior cortex acts as a hinge for reduction of the fragments.

Our choice of a cortical graft has certain advantages. The fibula is easy to harvest and, provided that sufficient care is taken, leads to minimal morbidity of the donor site.[13] The trifin shape of the fibula stabilises the fracture by preventing rotation, and the drilled holes in its surface may promote bony ingrowth. The graft acts as a 'biological Smith-Petersen nail'. The subchondral placement of the bone in avascular or osteopenic femoral heads may minimise structural collapse until revascularisation takes place. Where there is radiological evidence of AVN we deferred weight-bearing until union had taken place, which in some patients meant for up to six months. The use of the cortical graft may stabilise the neck if it is comminuted and allow reconstruction in cases of resorption. We believe that this is a biological fixation and that the bond between the 'implant' and the femur strengthens with time. In all our patients, after a sufficiently long follow-up period (in some instances more than six years), serial radiographs showed incorporation of the fibular graft into the femoral neck and head. This was noted particularly in the distal part of the neck. In one case (Fig. 4) the fibular graft fractured. The central part of the fibula ultimately became part of the primary compressive trabeculae of the femoral neck. This resorption or incorporation can occur only if the host bone in contact with the graft is vascularised.

Our prospective study shows that preservation of the femoral head in young patients with neglected fractures of the femoral neck is achievable. The fibular graft acts as a 'biological implant,' and its incorporation into host bone is evident after sufficient follow-up. Avascular heads may revascularise after union. Open reduction ensures good alignment of the fracture: the anterior approach minimises vascular insult. A postoperative spica adds stability. Despite being cortical, the fibula provides good bone graft which is almost completely incorporated into the host. Complications of leg-length discrepancy or coxa vara may be treated by abduction osteotomy once the fracture has united.

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

1. **Dedrick DK, Mackenzie JR, Burney RE.** Complications of femoral neck fracture in young adults. *J Trauma* 1986;26:932-7.
2. **Huang C-H.** Treatment of neglected femoral neck fractures in young adults. *Clin Orthop* 1986;206:117-26.
3. **Lifeso R, Young D.** The neglected hip fracture. *J Orthop Trauma* 1990;4:287-92.
4. **Leung PC, Shen WY.** Fracture of the femoral neck in younger adults: a new method of treatment for delayed and nonunions. *Clin Orthop* 1993;295:156-60.
5. **Kuslich SD, Gustilo RB.** Fractures of the femoral neck in young adults. *J Bone Joint Surg [Am]* 1976;58-A:724.
6. **Protzman RD, Burkhalter WE.** Femoral-neck fractures in young adults. *J Bone Joint Surg [Am]* 1976;58-A:689-95.
7. **Robinson CM, Court-Brown CM, McQueen MM, Christie J.** Hip fractures in adults younger than 50 years of age: epidemiology and results. *Clin Orthop* 1995;312:238-46.
8. **Swiontkowski MF, Winquist RA, Hansen ST.** Fractures of the femoral neck in patients between the ages of 12 and 49 years. *J Bone Joint Surg [Am]* 1984;66-A:837-46.
9. **Dooley BJ, Hooper J.** Fibular bone grafting for nonunion of fracture of the neck of the femur. *Aust NZJ Surg* 1982;52:134-40.
10. **Nagi ON, Gautam VK, Marya SKS.** Treatment of femoral neck fractures with a cancellous screw and fibular graft. *J Bone Joint Surg [Br]* 1986;68-B:387-91.
11. **Slater RN, Gore R, Slater GJ.** Free fibular bone grafting for femoral neck fractures: precise graft placement using a 'cannulated screw' technique. *J R Coll Surg Edinb* 1993;38:376-7.
12. **Snyder SJ, Sherman OH, Hattendorf K.** Nine year functional, nonunion of a femoral neck stress fracture: treatment with internal fixation and fibular graft: a case report. *Orthopaedics* 1986;9: 1553-7.
13. **Nagi ON, Dhillon MS, Gill SS.** Fibular osteosynthesis for delayed type II and type III femoral neck fractures in children. *J Orthop Trauma* 1992;6:306-13.
14. **Stewart MJ, Wells RE.** Osteotomy and osteotomy combined with bone-grafting for non-union following fracture of the femoral neck. *J Bone Joint Surg [Am]* 1956;38-A:33-49.

15. King T. Critical consideration of primary trochanteric osteotomy and internal fixation for recent intracapsular fractures of the femoral neck. *Aust NZ J Surg* 1950;19:177-97.

16. Wardle EN. Subcapital fractures of femoral neck: fixation by pin and graft. *Lancet* 1945;I:399-402.

17. Nordkild P, Sonne-Holm S. Necrosis of the femoral head following fracture of the femoral neck. *Injury* 1986;17:345-8.

18. Bonfiglio M, Bardenstein MB. Treatment by bone-grafting of aseptic necrosis of the femoral head and non-union of the femoral neck (Phemister technique). *J Bone Joint Surg [Am]* 1958;40-A:1329-46.

19. Baksi DP. Treatment of post-traumatic avascular necrosis of the femoral head by multiple drilling and muscle-pedicle bone grafting. *J Bone Joint Surg [Br]* 1983;65-B:268-73.

20. Meyers MH, Harvey JP Jr, Moore TM. Treatment of displaced subcapital and transcervical fractures of the femoral neck by a muscle-pedicle-bone graft and internal fixation. *J Bone Joint Surg [Am]* 1973;55-A:257-74.

21. McMurray TP. Ununited fractures of the neck of the femur. *J Bone Joint Surg* 1936;18:319-27.

22. Zinghi GF, Specchia L, Ruggieri N, Galli G. The role of osteotomy in the treatment of pseudarthrosis of the neck of the femur in younger patients. *Ital J Orthop Traumatol* 1985;11:341-8.

23. Inclan A. Late complications in fracture of the neck of the femur treated by nailing, bone grafting or both. *J Internat Coll Surg* 1946; 9:36-50.

24. Meyers MH, Harvey JP, Moore TM. Delayed treatment of subcapital and transcervical fractures of the neck of the femur with internal fixation and a muscle pedicle bone graft. *Orthop Clin North Am* 1974;5:743-56.

25. Johnson KD, Brock G. A review of reduction and internal fixation of adult femoral neck fractures in a county hospital. *J Orthop Trauma* 1989;3:83-96.

26. Johnson KD, Brock G. Letter to the Editor. *J Orthop Trauma* 1990; 4:105.

27. Hou SM, Hand YS, Liu TK. Ununited femoral neck fractures by open reduction and vascularized iliac bone graft. *Clin Orthop* 1993; 294:176-80.

28. Rogers LF. *Radiology of skeletal trauma.* 2nd edition, 1992, New York: Churchill Livngstone, 1992:1139-40.

29. Bayliss AP, Davidson JK. Traumatic osteonecrosis of the femoral head following intracapsular fracture: incidence and earliest radiological features. *Clin Radiol* 1977;28:407-14.

30. Henderson MS. Ununited fracture of the neck of the femur treated by the aid of the bone graft. *J Bone Joint Surg* 1940;22:97-106.

31. Patrick J. Intracapsular fractures of the femur treated with a combined Smith-Peterson nail and fibular graft. *J Bone Joint Surg [Am]* 1949; 31-A:67-80.

32. Bonfiglio M, Voke EM. Aseptic necrosis of the femoral head and nonunion of the femoral neck: effect of treatment by drilling and bone-grafting (Phemister technique). *J Bone Joint Surg [Am]* 1968; 50-A:48-66.