Original Clinical Article

JOURNAL OF CHILDREN'S ORTHOPAEDICS

Fibular strut graft for nonunited femoral neck fractures in children

A. Elgeidi
A. El-Negery

Abstract

Purpose To evaluate the clinical and radiological outcomes of using fibular strut grafts as a fixation device for non-united femoral neck fractures in children with or without subtrochanteric valgus osteotomy.

Methods A total of 12 children with non-united femoral neck fractures (nine males and three females) with an average age of 8.2 years (5 to 12) were managed, and functional results evaluated, between July 2013 and July 2015. The mechanisms of injury were fall from a height in ten patients and road traffic accident in two cases. Nine cases of femoral neck nonunion followed failed internal fixation and three cases were neglected fractures. Six cases were treated by fibular strut graft and subtrochanteric valgus osteotomy with contoured plate and six cases were treated by fibular strut graft and hip spica.

Results The mean follow-up period was 20.4 months (12 to 36). Union was achieved in all 12 cases by a mean of 3.5 months (2.5 to 6). All patients were satisfied at five months. For final analysis of clinical and radiographic results, the Ratliff's classification was used. We classed 11 cases as good results and one case as fair.

Conclusions Fibular strut grafts are a reliable option for treatment of pseudo-arthrosis in femoral neck fracture nonunion in children. It is successful in restoration of femoral neck length in children with non-united femoral neck fractures.

Cite this article: Elgeidi A, El-Negery A. Fibular strut graft for non-united femoral neck fractures in children. *J Child Orthop* 2017;11:28-35. DOI 10.1302/1863-2548.11.160221

Keywords: fibular strut graft; nonunion; femoral neck fractures; subtrochanteric osteotomy; hip spica

Mansoura School of Medicine, Mansoura, 35516 Egypt

Correspondence should be sent to: Adham Elgeidi, PO Box 95 Mansoura, University Mansoura, Egypt 35516.
Email: elgeidi@doctors.org.uk

Introduction

Femoral neck fractures in children and adolescents are not common.[1] They represent less than 1% of all paediatric fractures.[2] This low incidence could be attributed to the thick and strong periosteum cover and to the tough bone of children. As a result, most of these fractures (80% to 90%) are due to high-energy trauma.[1,2] Despite their rarity, these fractures are associated with high rates of chondrolysis, avascular necrosis (AVN), nonunion, early closure of physis, coxa vara and leg length discrepancy.[3]

The diagnosis of femoral neck fractures in children may be difficult in certain situations, such as when it is associated with more serious injuries like abdominal, thoracic or head injuries. It is difficult to draw a clear-line between fresh and neglected cases; however, any case which has not received active orthopaedic treatment for three weeks should be considered a neglected case.[4] Nonunion of femoral neck fractures is either due to failed internal fixation or neglected cases. The primary cause of nonunion is failure to obtain or maintain an anatomic reduction. Fractures of the femoral neck are classed as nonunited when there is a lack of radiographic evidence of union six months after the fracture.[5]

The aim of this retrospective study was to evaluate the clinical and radiological outcomes of using fibular strut grafts as an internal fixation device for non-united femoral neck fractures in children with or without subtrochanteric valgus osteotomy.

Patients and Methods

This was a retrospective study of 12 children (nine males, three females), with a mean age of 8.2 years (5 to 12), who had isolated nonunited femoral neck fractures. All were admitted to Mansoura University Hospital, Egypt, for operative intervention over a two-year period between July 2013 and July 2015. All fractures were older than six months with an evident gap with or without resorption on radiographs. All children were treated by fibular strut grafts with or without subtrochanteric valgus osteotomy and were followed up for a minimum of 12 months. The aim of surgery was to heal the nonunion, restore the length of the femoral neck and lower limb by using fibular strut grafts with subtrochanteric valgus osteotomy

JOURNAL OF CHILDREN'S ORTHOPAEDICS

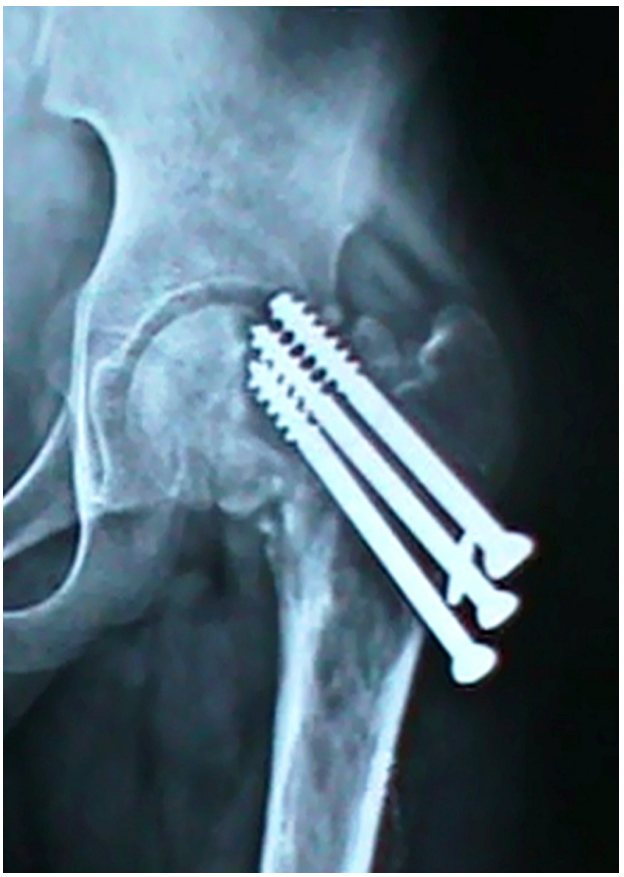

Fig. 1 Nonunited femoral neck fracture with neck-shaft angle less than 110°.

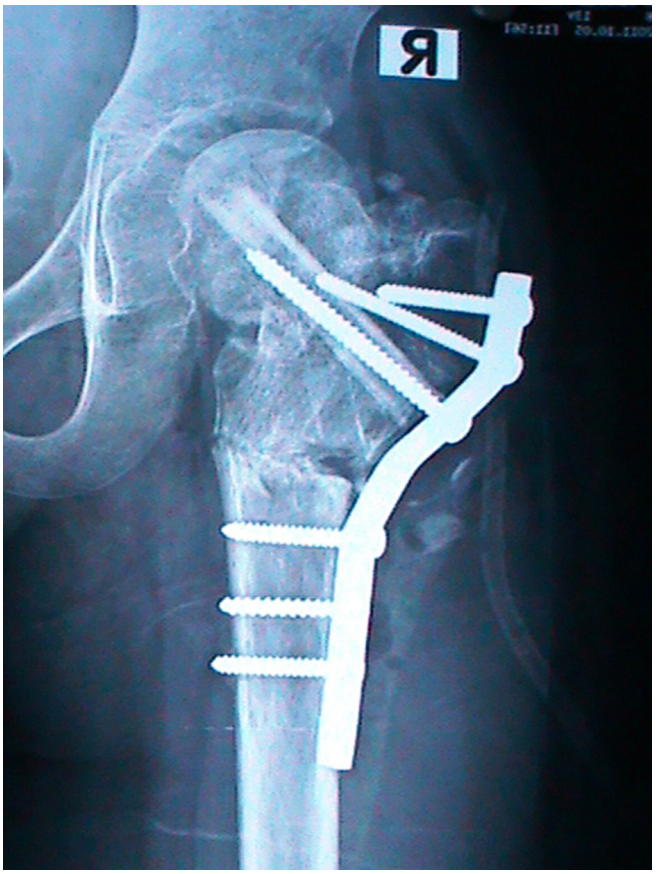

Fig. 2 Fibular strut grafts with subtrochanteric valgus osteotomy.

if the neck-shaft angle was less than 110° (Figs 1 and 2) and without osteotomy if the neck-shaft angle was greater than 110° (Figs 3 to 5).

Nine cases of femoral neck nonunion were following failed internal fixation and three cases were neglected fractures where fracture diagnosis was missed in the context of other severe injuries in a poly-traumatised child. The mechanisms of injury were fall from a height in ten patients and road traffic accident in two cases where the child on the street was directly hit by a car. Clinical evaluation revealed six cases with limb-length discrepancy with a mean shortening of 3.2 cm (2.5 to 4.5). In all these cases neck-shaft angle was less than 110°.

Plain radiographs were taken: an anteroposterior (AP) view of both hips in 15° internal rotation and a frog leg lateral position. Plain films were studied thoroughly to detect signs of AVN, proximal migration of the femur, degree of neck resorption, inclination of fracture lines (Pauwel's angle) and the neck-shaft angle. The lateral view was taken to detect retroversion.

Fractures were classified according to the Delbet's:[6] type I, physeal separation; type II, transcervical; type III, basi-cervical; and type IV, cervico-trochanteric. Using this classification system, all cases were classified as type II.

The Ratliff's classification was used to identify AVN:[7] type I, global AVN; type II, epiphyseal AVN; and type III, metaphyseal AVN. AVN was present pre-operatively in two cases. In both cases the fracture was missed and did not receive treatment. The fracture was grossly displaced with neck-shaft angle less than 110°. One was classified as Ratliff I while the second was Ratliff III.

Exclusion criteria included: chronically ill children, e.g. rheumatoid arthritis or diabetes mellitus; children aged older than 14 years; type I and IV fractures; fractures of less than six months; or pathological fractures.

Surgical technique

Surgery was carried out with the patient in a supine position, under general anaesthesia, using an image intensifier and a standard operating table when osteotomy is considered and a traction table when osteotomy was not done.

We considered that open reduction might represent overtreatment with an unnecessary incision. Therefore, in all cases, traction achieved closed reduction of the femoral neck fracture to an accepted alignment. Non-forceful

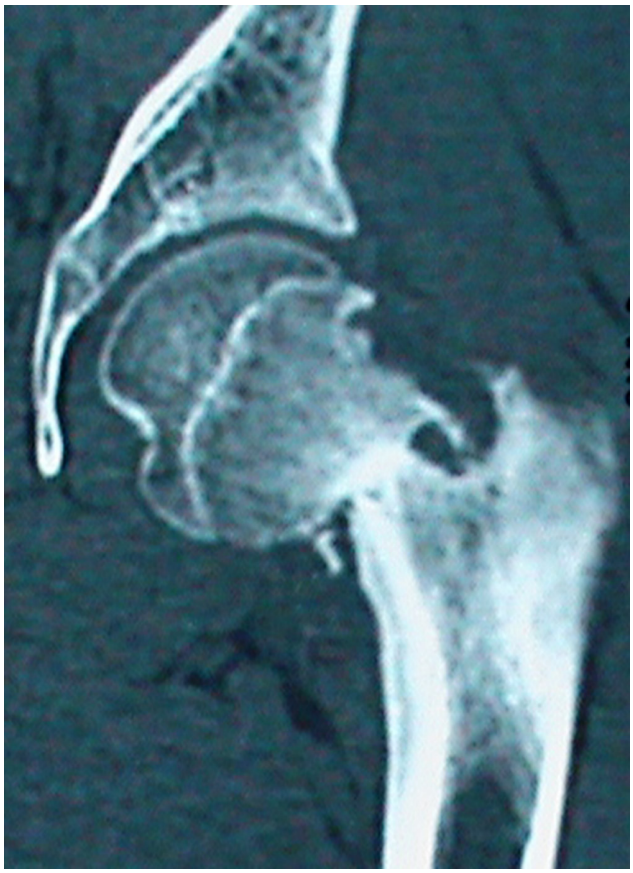

Fig. 3 Nonunited femoral neck fracture with neck-shaft angle greater than 110°.

Fig. 4 Fibular strut grafts without subtrochanteric valgus osteotomy (anteroposterior view).

manipulations were done. Flexion with gentle traction and external rotation was done to disengage the fragments, and then slow extension and internal rotation was carried out to achieve reduction. Reduction was confirmed with AP and lateral views, based on the Garden alignment index. On AP view, valgus is more mechanically acceptable. On the lateral view, ante-version should be maintained while avoiding any posterior translation.

The surgical exposure was a lateral approach and a straight skin incision was made over the greater trochanter and proximal femur. The vastus lateralis was cut in an L-shaped manner and elevated subperiosteally. The fracture site was not exposed in any patient. In cases with nonunion due to fixation failure, the implants previously used to fix the neck fracture were removed.

A guidewire was inserted in the centre of the neck in both AP and lateral views and used as a guide for insertion of the fibular graft (Fig. 6). After the guidewire has been positioned satisfactorily, reaming over the guidewire was done using the distal part of the triple reamer of dynamic hip screw (8 mm) (Fig. 7). A fibular graft was harvested from the ipsi-lateral leg using a posterolateral approach as described by Nagi and Dhillon.[8] The periosteum over

Fig. 5 Fibular strut grafts without subtrochanteric valgus osteotomy (lateral view).

the lateral border of the fibula was cut and a 10-cm long segment of bone was exposed. In order to avoid troublesome bleeding, we did not strip the periosteum from the medial aspect. We also removed only the lateral two-thirds of the bone, ensuring that we stayed subperiosteally, and

JOURNAL OF CHILDREN'S ORTHOPAEDICS

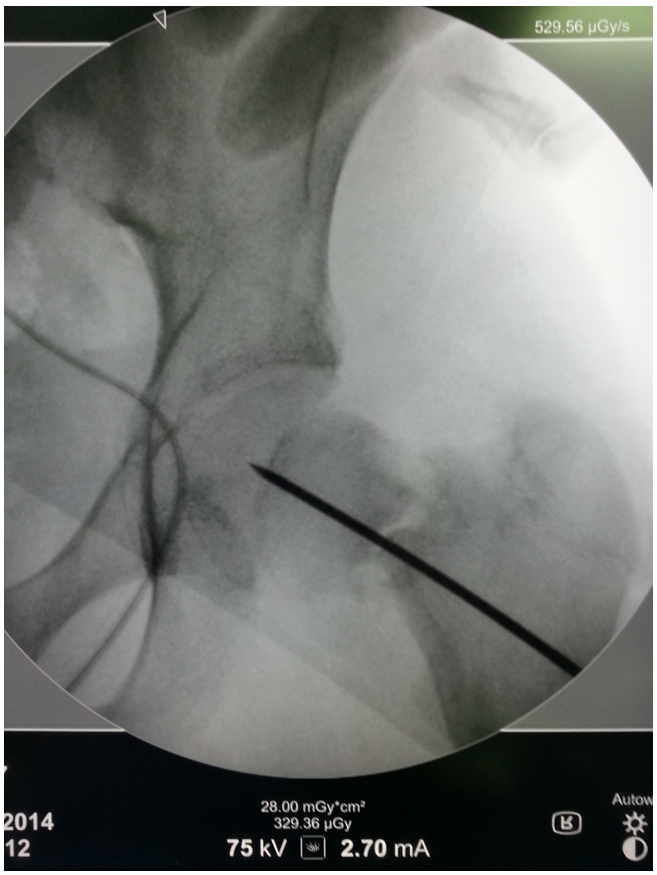

Fig. 6 Guide wire inserted in the center of the femoral neck.

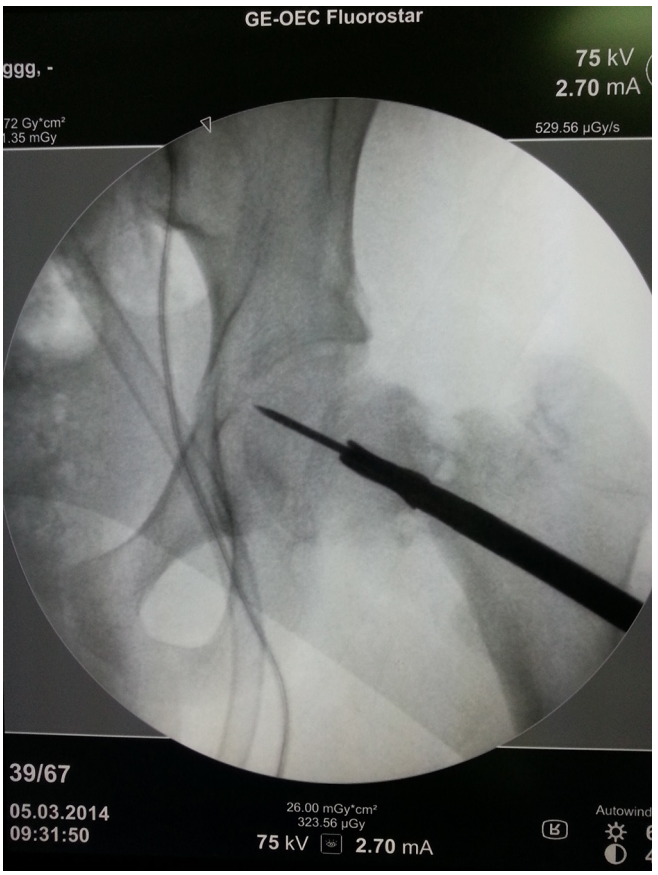

Fig. 7 Reaming over the guide wire using the distal part of the triple reamer of dynamic hip screw.

left behind a tube of soft tissue and periosteum that could be stitched back. The bone was cut with an oscillating saw, leaving the inter-osseous border intact. Careful resuturing of the periosteal tube and leaving behind the intact inter-osseous border allowed a better regrowth of the bone, did not affect ankle stability and minimised bleeding from vessels in the area of the interosseous membrane. Bone (10 cm in length) was taken out and drill holes using a 2.5 mm drill bit were made at regular intervals 2 cm apart on its surfaces for incorporation of the graft. The leading edge of the graft was bevelled for about 1 cm and impacted over the guidewire into the femoral neck using a graft impactor to a subphyseal position (Figs 8 to 10). When a child was aged more than ten years (three cases), we penetrated the physis and placed the fixation across the epiphysis. In older children with little growth potential remaining, achievement of stability and avoidance of complications associated with late displacement do outweigh the sequlae of premature physeal closure.

In cases that needed valgus osteotomy, the proximal limb of osteotomy was transverse and lies just above the lesser trochanter while the distal limb was oblique meeting the proximal limb at the medial cortex of the femur making a triangle. The wedge was closed and fixed with a contoured small plate.

In cases without valgus osteotomy, the patient was placed in a hip spica to immobilise the hip joint with flexion of 15°, abduction of 15° and neutral rotation. The spica was a one-leg cast that allowed the child to walk with crutches.

Post-operative care

Patients were allowed to sit up in bed on the first post-operative day. The dressing was changed on the third post-operative day and all patients were discharged. Sutures were removed on day 14 and hip spica was removed after six to eight weeks, according to the radiographic picture.

Post-operative plain radiographs were done after discharge and on monthly intervals until union.

A rehabilitation program was performed according to the age of the patient and the radiographic evaluation of the healing process of osteotomy and nonunion site. Gait with partial weight-bearing with crutches was allowed under the supervision of a physiotherapist. Gait with full weight-bearing was allowed only after consolidation of pseudo-arthrosis, confirmed by a radiographic check-up (average 3.5 months).

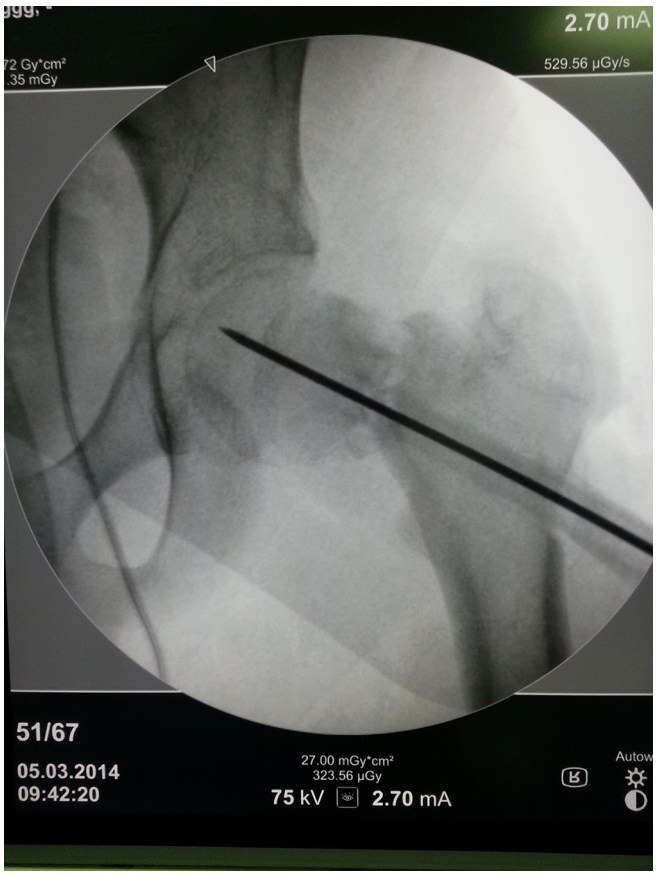

Fig. 8 Graft impacted over the guidewire to a subphyseal position.

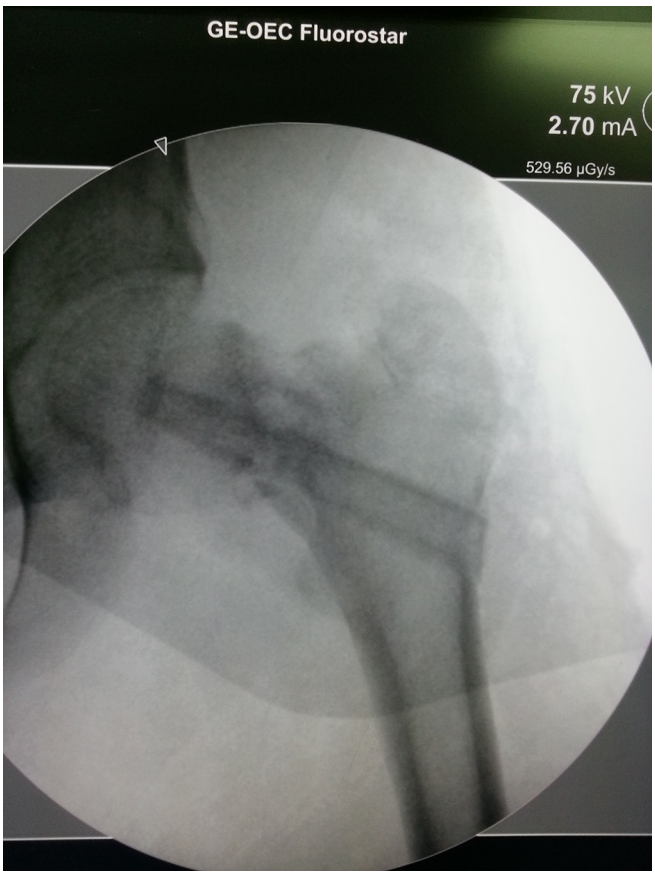

Fig. 9 Final position of the fracture and the graft into the femoral neck (anteroposterior view).

For the two cases with pre-operative radiological evidence of AVN, we deferred weight-bearing until union had taken place, which meant for up to six months.

Results

A total of 12 children were included (nine males (75%), three females (25%)) with non-united trans-cervical femoral neck fractures. Nine of them had failed previous internal fixation while the remaining three were untreated. All were treated with closed reduction and internal fixation using fibular strut grafts. Six cases underwent subtrochanteric valgus osteotomy to correct neck-shaft angle less than 110°; the other six were immobilised in a hip spica.

The injuries were due to high-energy trauma, nine falling from a height and three road traffic accidents.

The mean age of the patients was 8.2 years (5 to 12).

The surgical procedure was performed under general anaesthesia, with an operative time of 90 to 120 minutes and a fluoroscopy time of 90 seconds.

Follow-up was determined for all cases and no patient in the series was lost to follow-up. The mean follow-up period was 20.4 months (12 to 36). Union was achieved in all 12 cases (100%) by a mean of 3.5 months (2.5 to 6). Healing was achieved both clinically and radiologically. Clinical healing was defined as pain-free full weight-bearing without assistance. Radiological healing was determined by the presence of bridging trabeculae across the fracture and osteotomy sites on both AP and lateral views. All patients were satisfied at five months.

The functional results were assessed as good, fair and poor in relation to pain, movement, activities and radiographic alterations according to Ratliff's criteria.[7] We classed 11 cases (91.6 %) as good results and one case (8.4%) as fair.

There was no post-operative AVN, coxa vara or chondrolysis. Five patients were followed up for more than two years with no deterioration in results and no leg length discrepancy, chondrolysis or coxa vara.

There were no intra-operative complications recorded in our series. One patient had a superficial wound infection that responded to repeated dressings and intravenous antibiotics for seven days with no detrimental effect on the final outcome. All patients were post-operatively monitored for complications related to harvesting of the ipsilateral fibular bone graft. Pain was the most common donor-site morbidity in three patients (25%) that settled

JOURNAL OF CHILDREN'S ORTHOPAEDICS

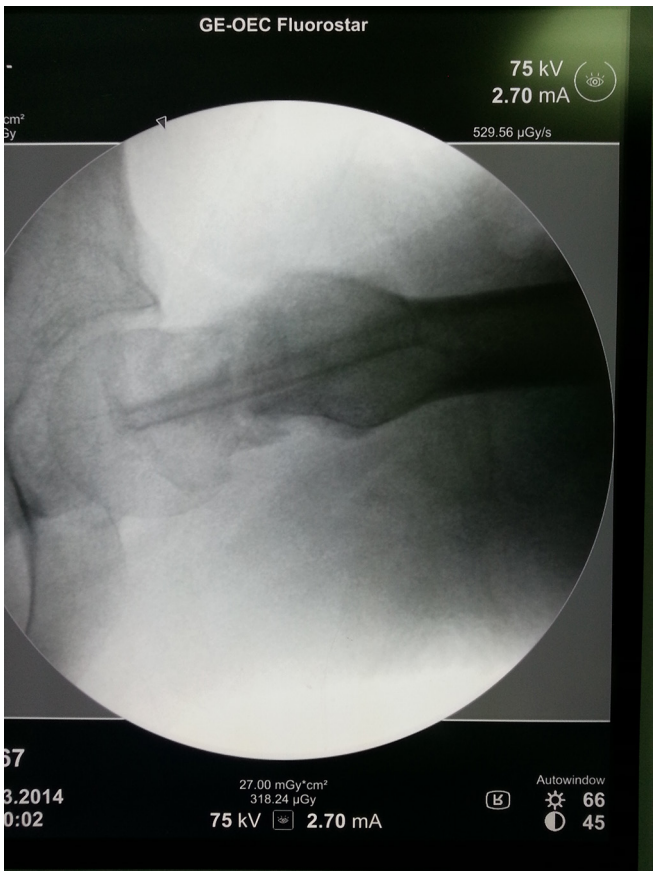

Fig. 10 Final position of the fracture and the graft into the femoral neck (lateral view).

down over a period of two months. Two patients had weakness of the extensor hallucis longus which gradually recovered over four months.

The results are summarised in Table 1.

Table 1 Results.

	Age (yrs)	Gender	Follow-up (mths)	Union (mths)	Surgery	Functional Outcome
1	9	F	20	3	FG & VO	Good
2	5	M	30	3.5	FG	Good
3	6	M	24	3	FG	Good
4	8	F	36	4	FG & VO	Good
5	7	M	30	3.5	FG	Good
6	8	M	18	4	FG & VO	Good
7	10	M	24	3	FG	Good
8	11	M	12	3	FG & VO	Good
9	9	M	8	6	FG & VO	Fair
10	8	M	10	3.5	FG	Good
11	12	F	15	3	FG & VO	Good
12	6	M	18	4	FG	Good

FG, Fibular graft; VO,Valgus osteotomy

Discussion

Fractures of the femoral neck in children are rare compared with femoral neck fractures in adults and are caused by high-energy trauma as the femoral neck of children is dense and hard, but their complications are many.[1,8,9] Early diagnosis and proper anatomic reduction and internal fixation of femur neck fractures in children should be performed whenever feasible because conservative treatment carries a high risk of failure. Loss of reduction commonly occurs in traditionally applied hip spica.[10,11] Femoral neck nonunion in children, either in neglected cases or in cases with failed internal fixation, is a difficult surgical problem to deal with. In our small series, all cases of pseudo-arthrosis occurred in transcervical fractures where the retinacular vessels are more vulnerable to injury. Lam[12] and Forlin et al[13] also reported such occurrences.

The predominance of pseudo-arthrosis may be related to a combination of factors: high-energy trauma; kinking of blood vessels and forceful manipulations during closed reduction; difficulty to achieve anatomic reduction; and failure to maintain stability of the reduction during treatment.[10,13-16] McDougall advocates care in the reduction and manipulation procedures to avoid damage to the femoral neck vessels.[17] A number of parameters determine the final outcome: the time interval between the injury and the definite management; accuracy of reduction; and stability of fixation. The risk of AVN increases with increased time to reduction.[18] The quality of reduction and rigidity of fixation are the major determinants of the outcome in terms of bone union and AVN.[19,20]

With regard to the surgical treatment, several options were tried for treatment of femoral neck nonunion in children. In our study, closed reduction and fibular grafts with or without valgus osteotomy achieved a good outcome.

Controversy exists in the literature whether to perform open or closed reduction. Many reports advocate open reduction to ensure proper excision of the pseudo-arthrosis, freshening of the fracture, anatomic reduction and to avoid damaging intracapsular vessels.[21-23] Damany et al,[24] in a meta-analysis of 18 articles on fracture neck femur of 564 patients, showed an overall nonunion rate of 8.9%. They found that with open reduction the rate of nonunion increased to 11.2% compared with 4.7% for fractures treated with closed reduction.[24] In the authors' experience, gentle gradual accurate closed reduction is possible without too much nor too many manipulations that could affect the vascularity. We also believe that if we could optimise the mechanical and biological environment around the nonunion site, the fibrous psudo-arthrosis will eventually go onto a solid bony union. In our series, we had bony consolidation of 100%.

In our series, we had only two cases with delay in the consolidation. Our results were also supported by similar results by Forlin et al[13] and Touzet et al.[25]

Fibular grafts can act as a combination of fixation device and bone graft augmenting union during reconstruction of the femoral neck and head. Fibular grafting has been recommended for neglected or nonunited femoral neck

fractures.[20,21] For neglected cases, internal fixation alone is likely to have high failure rate.[21] The literature reports many techniques to augment the fixation and to enhance biology and mechanics in neglected / non-united fractures in young adults. They range from the use of vascularised muscle pedicle, vascularised iliac crest or vascularised fibula to non-vascularised cortical tibial or free fibular strut graft (single or double).[19,20,26]

Vascularised pedicle grafts have shown excellent results with quite satisfactory functional results and lasting in a very high percentage of cases; however, this technique is highly technical and requires microsurgical facilities and experience.[20] In our experience, free fibula strut is easy to harvest and, provided that sufficient care is taken, leads to minimal morbidity at the donor site.

According to Nagi et al,[21] fibular graft was used alone in the treatment of femoral neck nonunion in children as we did in our series. They reported a high success rate; however, this method could not deal with femoral neck nonunion with coxa vara or limb shortening except if accompanied with inter-trochanteric valgus osteotomy to restore neck-shaft angle, limb length and abductor moment arm.[21]

Excellent results of valgus inter-trochnateric osteotomy have been reported in relatively young patients with femoral neck nonunion. These results encouraged other surgeons to do this type of osteotomy for non-united femoral neck fractures in children. Valgus osteotomy acts as a biological stimulus for the healing of these fractures, promoting osteogenesis as a result of conversion of shearing forces to compressive forces across the fracture site. The osteotomy is relatively easy to perform, cost-effective and provides good stability for the fracture.[5] Coxa vara and shortening can be corrected simultaneously.[27] We performed the osteotomy when the neck-shaft angle was less than 110° with the aim of correcting neck and limb length and at the same time to support fibular graft fixation.

The superior results in our patients may be attributed to many factors. First, closed reduction by gentle manipulation avoids jeopardising the already compromised blood supply to the femoral head. Second, fibular graft provides sufficient osteo-conductive and osteo-inductive potential, acts as a reliable biological implant for revascularisation and its trephine shape adds to the rotational stability.[19,20] Third, the application of hip spica or subtrochanteric osteotomy can achieve more stable fixation until the fibula gets incorporated.

In our series, there were two cases with pre-operative AVN that did not interfere with healing but caused a delay in consolidation. These two cases were grossly displaced with neck-shaft angles less than 110° and were non-treated. Despite both being aged under ten years (eight and nine), we crossed the physis with the fibula to ensure a subchondral placement. This may be necessary to achieve stability and avoid head collapse till revasularisation takes place. Both were kept non-weight-bearing till bony union occurred at four and six months. One case (eight years) was followed up for three years with no leg length shortening nor deterioration of the results. We believe that the sequelae of premature physeal closure and trochanteric overgrowth are much less than those of nonunion, AVN and head collapse. Many authors propose that the pre-operative presence of AVN is not a contraindication for osteotomy because revascularisation often overcomes collapse of the femoral head.[28,29]

In our series, we had no cases of post-operative AVN. This could be attributed to the previous factors. Adding the subphyseal placement of the fibular graft in avascular femoral heads may minimise the structural collapse until re-vascularisation takes place. The drill holes we did in the fibula help in the early incorporation of the graft and also act as a channel for revascularisation of the fracture site.

In our series, the functional results according to Ratliff` s criteria were 11 cases (91.6%) as good and one case (8.4%) as fair. This good outcome may be due to many factors: proper closed reduction; fibular strut grafting; secure fixation by spica or subtrochanteric osteotomy; and the presence of only two cases with pre-operative AVN.

There are some limitations of our study. First, the relatively small number of included patients. Second, the relatively short follow-up duration for the incorporation of the fibular graft. Third, the disadvantages of subtrochanteric osteotomy are larger skin incisions and more soft-tissue dissection. Further studies are needed to confirm our findings in a larger cohort and to compare our results with different therapeutic modalities.

Fibular strut grafts with or without valgus osteotomy in non-united femoral neck fractures in children are cost-effective and technically less demanding and associated with good outcomes. Valgus osteotomy produces favourable biomechanical conditions for the healing of fractures; it can also simultaneously correct shortening and coxa vara.

Received 22 October 2016; accepted after revision 19 December 2016.

COMPLIANCE WITH ETHICAL STANDARDS

FUNDING STATEMENT

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.

ETHICAL STATEMENT

This article does not contain any studies with animals performed by any of the authors. Informed consent was obtained from all individual participants included in the study.

REFERENCES

1. **Miller WE.** Fractures of the hip in children from birth to adolescence. *Clin Orthop Relat Res* 1973;92:155-188.

2. **Ratliff AH.** Fractures of the neck of the femur in children. *J Bone Joint Surg [Br]* 1962;44-B:528-542.

3. **Chung SM.** The arterial supply of the developing proximal end of the human femur. *J Bone Joint Surg [Am]* 1976;58-A:961-970.

4. **Aroro A, Aggarwal AK.** Neglected pediatric femoral neck fractures. In: Jain AK, Kumar S, eds. *Neglected Musculoskeletal Injuries*. New Delhi: Jaypee Brothers Publishers, 2010:199-217.

5. **Khan AQ, Khan MS, Sherwani MK, Agarwal R.** Role of valgus osteotomy and fixation with dynamic hip screw and 120° double angle barrel plate in the management of neglected and ununited femoral neck fracture in young patients. *J Orthop Traumatol* 2009;10:71-78.

6. **Delbet cited by Colonna PC** (1929) Fractures of the neck of the femur in children. *Am J Surg* 6:793–797.

7. **Ratliff AH.** Traumatic separation of the upper femoral epiphysis in young children. *J Bone Joint Surg [Br]* 1968;50-B:757-770.

8. **Nagi ON, Dhillon MS.** Management of neglected / ununited fractures of the femoral neck in young adults. *Curr Orthop* 2003;17:394-402.

9. **Canale ST, Bourland WL.** Fracture of the neck and intertrochanteric region of the femur in children. *J Bone Joint Surg [Am]* 1977;59-A:431-443.

10. **Ingram AJ, Bachynski B.** Fractures of the hip in children; treatment and results. *J Bone Joint Surg [Am]* 1953;35-A:867-887.

11. **Bali K, Sudesh P, Patel S, et al.** Pediatric femoral neck fractures: our 10 years of experience. *Clin Orthop Surg* 2011;3:302-308.

12. **Lam SF.** Fractures of the neck of the femur in children. *J Bone Joint Surg [Am]* 1971;53-A:1165-1179.

13. **Forlin E, Guille JT, Kumar SJ, Rhee KJ.** Complications associated with fracture of the neck of the femur in children. *J Pediatr Orthop* 1992;12:503-509.

14. **Colonna PC.** Fracture of the neck of the femur in childhood. *Ann Surg* 1928;88:902-907.

15. **Azam MQ, Iraqi A, Sherwani M, et al.** Delayed fixation of displaced type II and III pediatric femoral neck fractures. *Indian J Orthop* 2009;43:253-258.

16. **Durbin FC.** Avascular necrosis complicating undisplaced fractures of the neck of femur in children. *J Bone Joint Surg [Br]* 1959;41-B:758-762.

17. **McDougall A.** Fractures of the neck of the femur in childhood. *J Bone Joint Surg [Br]* 1961;43-B:16-28.

18. **Shrader MW, Jacofsky DJ, Stans AA, Shaughnessy WJ, Haidukewych GJ.** Femoral neck fractures in pediatric patients: 30 years experience at a level 1 trauma center. *Clin Orthop Relat Res* 2007;454:169-173.

19. **Mittal R, Banerjee S.** Proximal femoral fractures: principles of management and review of literature. *J Clin Orthop Trauma* 2012;3:15-23.

20. **Jaiswal A, Pruthi KK, Goyal RK, et al.** Evaluation of osteosynthesis with dual fibular bone grafting for neglected femoral neck fractures. *J Clin Orthop and Trauma* 2013;4:58-69.

21. **Nagi ON, Dhillon MS, Gill SS.** Fibular osteosynthesis for delayed type II and type III femoral neck fractures in children. *J Orthop Trauma* 1992;6:306-313.

22. **Song KS.** Displaced fracture of the femoral neck in children: open versus closed reduction. *J Bone Joint Surg [Br]* 2010;92-B:1148-1151.

23. **Gautam VK, Anand S, Dhaon BK.** Management of displaced femoral neck fractures in young adults (a group at risk). *Injury* 1998;29:215-218.

24. **Damany DS, Parker MJ, Chojnowski A.** Complications after intracapsular hip fractures in young adults. A meta-analysis of 18 published studies involving 564 fractures. *Injury* 2005;36:131-141.

25. **Touzet P, Rigault P, Padovani JP, et al.** [Fractures of the neck of the femur in children (author's transl)]. *Rev Chir Orthop Reparatrice Appar Mot* 1979;65:341-349. (In French)

26. **Barnes R, Brown JT, Garden RS, Nicoll EA.** Subcapital fractures of the femur. A prospective review. *J Bone Joint Surg [Br]* 1976;58-B:2-24.

27. **Magu NK, Rohilla R, Singh R, Tater R.** Modified Pauwels' intertrochanteric osteotomy in neglected femoral neck fracture. *Clin Orthop Relat Res* 2009;467:1064-1073.

28. **Mueller ME.** The intertrochanteric osteotomy and pseudarthrosis of the femoral neck. 1957. *Clin Orthop Relat Res* 1999;363:5-8.

29. **Raaymakers EL, Marti RK.** Nonunion of the femoral neck: possibilities and limitations of the various treatment modalities. *Indian J Orthop* 2008;42:13-21.