Double-elevating osteotomy for late-presenting infantile Blount's disease

THE IMPORTANCE OF CONCOMITANT LATERAL EPIPHYSIODESIS

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We reviewed 34 knees in 24 children after a double-elevating osteotomy for late-presenting infantile Blount's disease. The mean age of patients was 9.1 years (7 to 13.5).

All knees were in Langenskiöld stages IV to VI. The operative technique corrected the depression of the medial joint line by an elevating osteotomy, and the remaining tibial varus and internal torsion by an osteotomy just below the apophysis. In the more recent patients (19 knees), a proximal lateral tibial epiphysiodesis was performed at the same time.

The mean pre-operative angle of depression of the medial tibial plateau of 49° (40° to 60°) was corrected to a mean of 26° (20° to 30°), which was maintained at follow-up. The femoral deformity was too small to warrant femoral osteotomy in any of our patients. The mean pre-operative mechanical varus of 30.6° (14° to 66°) was corrected to 0° to 5° of mechanical valgus in 29 knees. In five knees, there was an undercorrection of 2° to 5° of mechanical varus. At follow-up a further eight knees, in which lateral epiphysiodesis was delayed beyond five months, developed recurrent tibial varus associated with fusion of the medial proximal tibial physis.

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Blount,¹ in his classic article in 1937, described two types of tibia vara: infantile, which appears before the age of four years and adolescent (late-onset) which appears after five years of age. If the infantile type is not treated early, depression of the proximal medial tibial plateau can occur, with tibial varus and internal torsion.²⁻⁵ Some authors have also described anterior bowing of the proximal tibia⁶ and distal femoral valgus.⁷

Langenskiöld and Riska² were the first to propose in 1964 elevation of the medial tibial plateau for late-presenting infantile Blount's disease. Subsequent case reports were published by Siffert,⁸ Støren,⁹ and Sasaki et al.¹⁰ Larger series by Gregosiewicz et al¹¹ (13 knees) and Schoenecker et al⁷ (seven knees) popularised this technique. The tibial varus was corrected by a valgus tibial osteotomy, either simultaneously or at a separate operation. Gregosiewicz et al¹¹ used the wedge of bone removed from the tibial valgus osteotomy to maintain the elevated medial condyle and coined the term double-elevating osteotomy.

The aetiology of Blount's disease remains unknown. However, inhibition of growth of the medial proximal tibial physis due to increased pressure in a varus knee can occur.^{2,5,6} This results in delayed ossification of

the medial tibial epiphysis and metaphysis. In late-presenting infantile Blount's disease, the inhibition of growth may result in abnormal endochondral ossification and premature medial physeal arrest.⁸ This is probably why a single valgus osteotomy before the age of four years is successful in 60% to 75% of patients, while in older children repeat osteotomies are needed in 60% to 65% of cases.^{3,5} Although Langenskiöld and Riska,² Schoenecker et al⁷ and Sasaki et al¹⁰ advised that concomitant epiphysiodesis should be performed when undertaking a double-elevating osteotomy, it is not routinely advised by other authors.^{8,9,11}

Between 1994 and 2000, we performed a double-elevating osteotomy on 24 children (34 knees) and now present our results.

Patients and Methods

All procedures were performed or supervised by the senior author (EBH).

The first series of 11 patients (15 knees) was treated between 1994 and 1997. Recurrent tibial varus because of closure of the medial tibial physis necessitated a delayed (three to 12 months after the osteotomy) epiphysiodesis of the lateral proximal tibia and fibula in all 15 knees. It became obvious that closure of the medial growth plate was inevitable and there-

Fig. 1

Diagram of the relevant radiological angles: a) mechanical axis, b) the distal lateral femoral angle, c) the angle of depression of the medial plateau of the tibia and d) the tibial varus angle.

fore a concomitant lateral epiphysiodesis was performed in the second series of 13 children (19 knees) who were treated between 1998 and 2000.

The mean age of patients at the time of surgery was 9.1 years (7 to 13.5). Seventeen were girls and seven were boys. Fifteen (63%) children were obese and above the 95th percentile weight for age. Nine (eight patients) of the 34 knees had undergone a previous valgus osteotomy. Ten patients (42%) had bilateral infantile tibia vara. Six of the 14 patients with unilateral involvement had adolescent (late-onset) Blount's disease in the contralateral knee.

Clinical details. All patients had severe genu varum and displayed a lateral thrust on walking. They tested positive for the Stiffert-Katz sign, that is, stable in extension, but unstable posteromedially in 20° of flexion.¹² On prone examination all had an abnormal foot-thigh angle, with 0° to 40° of internal tibial torsion.

At follow-up the following clinical parameters were assessed: limb alignment, leg-length discrepancy using a tape measure and blocks, the range of knee movement, knee stability and tibial rotation.

Fig. 2

Radiograph at union showing the lateral tibial epiphysiodesis.

Radiology. The mechanical axis was assessed on long-leg standing radiographs with the patella pointing forwards. These views were taken pre-operatively, after removal of the plaster at union, every six months for the first year post-operatively and at final follow-up. In patients with a severe varus deformity only one limb could fit on a radiographic plate for the mechanical axis view. The immediate post-operative view with the limb in plaster was performed with the patient supine.

Pre-operative anteroposterior radiographs of both knees (supine) were undertaken to assist with Langenskiöld staging while pre- and post-operative lateral radiographs of the tibia were taken in order to assess anterior bowing.

Staging according to Langenskiöld and Riska² was performed on the anteroposterior radiograph of the knee. All the knees were in stages IV to VI (10 stage IV, 6 stage V and 18 stage VI).

The relevant radiological angles are illustrated in Figure 1. The mean pre-operative mechanical varus was 30.6° (14° to 60°). The angle of the medial tibial plateau, i.e. the angle between the medial and lateral tibial plateau, had a normal value of 20° to 30°.⁸ The mean pre-operative angle of depression of the medial tibial plateau was 49° (40° to 60°).

Table I. Radiological parameters (°; range) of 34 knees pre-operatively, post-operatively at union and at follow-up

Parameters	Pre-operative (°)	Post-operative (°)	Follow-up (°)
Mechanical axis	30.6 varus (14 to 66)	29 knees: 0 to 5 valgus 5 knees: 2 to 5 varus†	21 knees: 0 to 5 valgus 5 knees: 2 to 5 varus† 8 knees: 5 to 10 varus‡
ADMTP*	49 (40 to 60)	26 (20 to 30)	25 (20 to 30)
Tibial varus angle	102 (90 to 135)	29 knees: 77.4 (75 to 85) 5 knees: 87 to 90†	21 knees: 80 (75 to 85) 5 knees: 87 to 90† 8 knees: 92 (90 to 97)‡

* ADMTP, angle of depression of the medial tibial plateau

† undercorrected

‡ late epiphysiodesis

Table II. Radiological parameters (°; range) of 15 knees (treated from 1994 to 1997) pre-operatively, post-operatively at union and at follow-up. Epiphysiodesis was performed three to 12 months after the osteotomy

Parameters	Pre-operative (°)	Post-operative (°)	Follow-up (°)
Mechanical axis	32 varus (14 to 66)	12 knees: 0 to 5 valgus 3 knees: 2 to 5 varus†	4 knees: 0 to 5 valgus 3 knees: 2 to 5 varus† 8 knees: 5 to 10 varus‡
ADMTP*	53 (40 to 60)	23 (20 to 30)	25 (20 to 30)
Tibial varus angle	106 (90 to 135)	12 knees: 77 (75 to 85) 3 knees: 87 to 90†	4 knees: 80 (75 to 85) 3 knees: 87 to 90† 8 knees: 92 (90 to 97)‡

* ADMTP, angle of depression of the medial tibial plateau

† undercorrected

‡ late epiphysiodesis

Table III. Radiological parameters (°; range) of 19 knees (treated from 1998 to 2000) pre-operatively, post-operatively at union and at follow-up. Concomitant epiphysiodesis performed

Parameters	Pre-operative (°)	Post-operative (°)	Follow-up (°)
Mechanical axis	31 varus (15 to 50)	17 knees: 0 to 5 valgus 2 knees: 2 to 5 varus†	17 knees: 0 to 5 valgus 2 knees: 2 to 5 varus‡
ADMTP*	46 (40 to 60)	27 (20 to 30)	26 (20 to 30)
Tibial varus angle	99 (90 to 120)	17 knees: 79 (75 to 85) 2 knees: 87 to 90†	17 knees: 79 (75 to 85) 2 knees: 87 to 90‡

* ADMTP, angle of depression of the medial tibial plateau

† undercorrected

‡ late epiphysiodesis

The medial and lateral tibial angles described by Paley and Tetsworth¹³ are formed by the mechanical axis of the tibia and a line across the tibial plateaux. In late-presenting infantile Blount's disease the medial tibial angle does not separate the depression of the medial tibial plateau from the tibial varus. We therefore used a tibial varus angle to measure the true tibial varus, independent of the depression of the medial plateau. This angle is subtended by the mechanical axis of the tibia and a line from the lateral tip of the lateral tibial plateau to the top of the intercondylar eminence (Fig. 1). In a subgroup of normal limbs, this angle was found to have a normal range of between 75° and 85°. The mean pre-operative tibial varus angle in our patients was 102° (90° to 135°).

The distal lateral femoral angle was used to assess concomitant femoral deformity.¹³ Twelve knees had a normal angle of 87°. Seven had mild valgus, with a mean of 84° (80° to 86°), and 15 had mild varus with a mean of 90° (88° to

94°). No knee had femoral deformity (> 10°) sufficient to require a femoral osteotomy.

Operative technique

We prepare the iliac crest for the harvesting of a tricortical graft before inflating the limb tourniquet in order to save tourniquet time.

Osteotomies. Through a separate lateral incision a mid-fibular osteotomy is performed, excising 1 cm subperiosteally. An anteromedial curved incision is made to enable both tibial osteotomies to be performed through one incision.

The elevating osteotomy of the medial tibial plateau is performed from below the metaphyseal beak to the intercondylar area under image-intensifier control. An appropriately-sized wedge of iliac crest and the excised fibula are used as a strut. The tricortical wedge is held with a transverse 1.6 mm Kirschner wire and cut flush with bone. We then perform a barrel-vault osteotomy just below the tibial apophysis to correct the remaining tibial varus to within 0°

Fig. 3a

Fig. 3b

Anteroposterior radiographs of the right knee taken a) pre-operatively to show stage VI disease² with a mechanical axis varus of 30°, an angle of depression of the medial tibial plateau of 40°, a tibial varus angle of 100° and a normal distal lateral femoral angle of 87°, and b) follow-up at two years showing the mechanical axis, the angle of depression of the medial tibial plateau and the tibial varus angle to be unchanged.

Fig. 4a

Fig. 4b

Anteroposterior radiographs of the left knee of a 12-year-old boy taken a) pre-operatively to show stage V infantile Blount's disease with an angle of depression of the medial tibial plateau of 50° and a tibial varus angle of 95°, and b) ten months post-operatively with a recurrent mechanical varus of 5°, the angle of depression of the medial tibial plateau maintained at 25° but the tibial varus angle increased to 90° because of fusion of the medial tibial physis, with an open lateral physis.

to 5° of valgus, and the tibial torsion to 15° of external rotation. Anterior bowing, if present, is also addressed. The osteotomy is held by two crossed 2.4 mm Steinmann pins and cut flush with bone.

Epiphysiodesis

Delayed. Eleven children (15 knees) were treated between 1994 and 1997 and had percutaneous epiphysiodesis three to 12 months after osteotomy. In the initial eight knees (six patients), epiphysiodesis was performed when we became aware of recurrent tibial varus because of medial physeal closure at a mean follow-up of 10.8 months (6 to 12). Sub-

sequently, earlier epiphysiodesis at three to five months was performed on the remaining seven knees (five patients), until we changed to our current policy of concomitant epiphysiodesis.

Concomitant. In the subsequent 13 children (19 knees) treated between 1998 and 2000, a concomitant lateral proximal tibial and fibular epiphysiodesis was performed percutaneously (Fig. 2).

In unilateral cases a percutaneous epiphysiodesis of the contralateral proximal tibia and fibula was also performed. Bilateral cases were operated upon with an interval of two

weeks. An above-knee plaster was used post-operatively for six weeks.

Results

There were three complications. Two patients had wound sepsis, one resulting in wound breakdown requiring a split-skin graft. One tibia required an extension osteotomy for failure to correct anterior tibial bowing fully, 15 months after the first operation. Three Kirschner wires and four Steinmann pins migrated after union, becoming prominent subcutaneously, and were removed under local anaesthesia.

The mean follow-up was 2.9 years (2 to 6) and the mean age at follow-up was 12.3 years (10 to 17). Five patients (seven knees) were skeletally mature.

Clinical findings. Of the 34 knees, 21 were in neutral or slight valgus at follow-up. Thirteen were in slight varus but the patients were happy with the cosmetic result. All were stable and had a full range of movement. There was no lateral thrust on walking and the Siffert-Katz sign was negative. The foot-thigh angle ranged from 10° to 25° of external rotation. No patient had a leg-length discrepancy greater than 1 cm.

Radiological findings. The radiological parameters pre-operatively, post-operatively at union, and at follow-up are shown in Table I (all 34 knees), Table II (15 knees with delayed epiphysiodesis) and Table III (19 knees with concomitant epiphysiodesis).

The mean pre-operative mechanical varus of 30.6° was corrected to 0° to 5° of valgus in 29 of the 34 knees post-operatively. Five knees were undercorrected and had residual varus of 2° to 5°. At follow-up it was found that in 21 knees the valgus correction was maintained. All of these had concomitant or early (≤ 5 months) lateral epiphysiodesis. Thirteen knees were in varus (2° to 10°). Of these, five were originally undercorrected (2° to 5°), and no change in varus occurred. The remaining eight (5° to 10°) had a delay of more than five months before lateral epiphysiodesis (mean 10.8 months, 6 to 12).

The mean angle of depression of the medial tibial plateau of 49° was corrected to a mean of 26° (20° to 30°). This was maintained in all cases at follow-up.

The mean pre-operative tibial varus angle of 102° (90° to 135°) was corrected to normal (mean 77.4° (75° to 85°)) post-operatively in the 29 knees with a valgus mechanical axis of 0° to 5°. At follow-up the 21 knees with early (≤ 5 months) or concomitant lateral epiphysiodesis maintained this correction (mean 80° (75° to 85°)) (Fig. 3). In the eight knees with a delay (> 5 months) to epiphysiodesis (mean 10.8 months, (6 to 12)) the tibial varus angle increased to a mean of 92° (90° to 97°) (Fig. 4).

Of the eight knees with a delay of more than five months to epiphysiodesis, six were stage IV or V2 and at six months after operation fusion of the medial growth plate had occurred. At the final follow-up the medial physis was fused in all patients. Five patients (seven knees) were skeletally mature. The lateral physis fused successfully in all knees after percutaneous epiphysiodesis.

Discussion

Patients with late-presenting (after four years of age) infantile Blount's disease have severe and resistant deformities. Before double-elevating osteotomy was popularised by Gregosiewicz et al¹¹ in 1989 and Schoenecker et al⁷ in 1992, many of our patients required multiple tibial valgus osteotomies.

The term double-elevating osteotomy coined by Gregosiewicz et al¹¹ is a misnomer. Only the medial tibial plateau is elevated. In the tibial shaft a valgus osteotomy is performed by removing a laterally-based wedge of bone, which is then used to support the elevated tibial plateau. We found it difficult to correlate the size of the wedge needed to support the plateau with the amount of tibial valgus required. We therefore abandoned this technique after the first three cases, but still use the term double-elevating osteotomy.

Once the medial tibial plateau has been elevated and supported by the tricortical iliac wedge, the knee becomes stable. A horizontal 1.6 mm Kirschner wire is adequate to hold the wedge. We do not think that the plates and screws as described by Schoenecker et al⁷ are necessary. The stable knee now allows a valgus derotation osteotomy of the tibia to be performed, and fixed by the two crossed 2.4 mm Steinmann pins.

Stanitski, Stanitski and Trumble¹⁴ have questioned the existence of the depression of the medial tibial plateau. They performed MRI on all their 13 knees pre-operatively and an arthrogram in 11 knees at surgery. No depression of the medial plateau was demonstrated on MRI and the apparent empty space on plain radiography was occupied by articular cartilage or the meniscus. The arthrogram demonstrated a smooth contour and paralleled the distal femoral condyle. This has not been our experience. In our earlier cases the medial joint was opened, and our findings were similar to those described by Siffert and Katz,¹² i.e. postero-medial joint depression and a hypertrophic medial meniscus. The patients in our study had more severe disease. Six of the 13 knees in the study of Stanitski et al¹⁴ were in Langenskiöld stage III, which by definition has no depression of the medial plateau, and all the patients were aged eight years or younger. Also in severe Blount's disease the tibia subluxes laterally so that the intercondylar area of the tibia pivots at a point of contact on the medial aspect of the lateral femoral condyle. The meniscus shifts to allow the femur to sag into the tibial depression and the articular surfaces of the medial compartment become parallel.^{6,8,12} This is probably why the lateral and not the medial compartment develops degenerative changes in untreated infantile Blount's disease followed up into early adult life.^{4,5}

Schoenecker et al⁷ were the first to address the problem of femoral deformity in infantile Blount's disease. Four of the seven knees in their study had sufficient valgus (> 10°) to warrant a femoral osteotomy, undertaken either before the tibial procedure or simultaneously. None of our patients showed a deviation of more than 7° from the normal distal

lateral femoral angle, and therefore femoral osteotomy was not thought to be necessary. This differs from the experience in adolescent (late-onset) Blount's disease. Kline, Bostrum and Griffin¹⁵ reported a mean of 10° of femoral varus contributing 56% to the total varus in six patients with adolescent Blount's disease and van Huyssteen et al¹⁶ reported a mean of 11° of femoral varus contributing 55% of the total varus in nine of 14 knees. Wenger, Mickelson and Maynard¹⁷ postulated that the ossified proximal medial tibial epiphysis in adolescent Blount's disease was less vulnerable to deformity than the poorly ossified epiphysis in the infantile form. In adolescent Blount's disease the pressure from the varus deformity is shared between the medial proximal tibial and distal femoral physis, while in infantile Blount's disease most of the pressure is exerted on the unossified tibial physis, with less effect on the femoral growth plate. The lateral subluxation of the tibia also decreases the forces on the medial femoral growth plate.

Eighteen of the 34 knees in our study had stage VI disease with fusion of the medial tibial physis. The five patients (seven knees) who were skeletally mature at follow-up had stage VI disease. There are three possible reasons why the ten knees in stage IV and the six in stage V fused medially. The so-called anteroposterior radiograph of the knee may have been an oblique view of the proximal tibia, resulting in an understaging of the damage to the medial joint. The inhibition of growth of the medial tibial physis may have become irreversible in spite of the corrective osteotomy, because of repetitive chondrocyte injury, with resultant loss of normal endochondral ossification.^{2,8} This has been confirmed histopathologically (disorganisation and malalignment of physal zones) by Golding and McNeil-Smith⁶ in infantile and by Wenger et al¹⁷ and Carter et al¹⁸ in adolescent Blount's disease. The elevating osteotomy of the medial plateau may have resulted in increased pressure on the already inhibited growth plate and accelerated physal closure although the purpose of the operation was to correct the varus alignment to neutral.

Recently, external fixation has become popular, as first reported by Price, Scott and Greenberg.¹⁹ The main advantages of external fixation seem to be that it can be used for leg lengthening and is less cumbersome than plaster in obese, adolescent patients.

Leg-length discrepancy should not be a problem in bilateral cases (ten of 24 patients in our study) and in unilateral cases can be avoided by performing a simultaneous epiphysiodesis of the contralateral proximal tibia and fibula. None of our patients had a discrepancy of more than 1 cm. Moseley²⁰ suggested that the maximum acceptable shortening of a limb at maturity was 5 to 6 cm. Therefore, using the growth chart of Anderson, Green and Messner,²¹ the minimum skeletal age for surgery should be seven years for girls and eight years for boys.

The disadvantages of external fixation are the long period of treatment (6 to 8 months) and the relatively high rate of complications.^{22,23} In the study by Jones et al²² three

of the seven patients had premature consolidation of the gradually elevated medial plateau and, although the leg lengthening was started after a second procedure, the tibial varus was not corrected.

With our technique all the deformities were corrected in one operation. The medial plateau was elevated, the tibial varus and internal rotation corrected and recurrence was prevented by performing a concomitant lateral epiphysiodesis. In unilateral cases leg-length discrepancy was avoided by a simultaneous epiphysiodesis of the contralateral leg.

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References

1. Blount WP. Tibia vara: osteochondrosis deformans tibiae. *J Bone Joint Surg* 1937; 19:1-29.
2. Langenskiöld A, Riska EB. Tibia vara (osteochondrosis deformans tibiae): a survey of seventy-one cases. *J Bone Joint Surg [Am]* 1964;46-A:1405-20.
3. Loder RT, Johnston CE 2nd. Infantile tibia vara. *J Pediatr Orthop* 1987;7:639-46.
4. Hofmann A, Jones RE, Herring JA. Blount's disease after skeletal maturity. *J Bone Joint Surg [Am]* 1982;64-A:1004-9.
5. Doyle BS, Volk AG, Smith CF. Infantile Blount disease: long-term follow-up of surgically treated patients at skeletal maturity. *J Pediatr Orthop* 1996;16:469-76.
6. Golding JSR, McNeil-Smith JDG. Observations on the etiology of tibia vara. *J Bone Joint Surg [Br]* 1963;45-B:320-5.
7. Schoenecker PL, Johnston R, Rich MM, Capelli AM. Elevation of the medial plateau of the tibia in the treatment of Blount disease. *J Bone Joint Surg [Am]* 1992; 74-A:351-8.
8. Siffert RS. Intraepiphyseal osteotomy for progressive tibia vara: case report and rationale of management. *J Pediatr Orthop* 1982;2:81-5.
9. Støren H. Operative elevation of the medial tibial joint surface in Blount's disease. *Acta Orthop Scand* 1970;40:788-96.
10. Sasaki T, Yagi T, Monji J, Yasuda K, Kanno Y. Transepiphyseal plate osteotomy for severe tibia vara in children: follow-up study of four cases. *J Pediatr Orthop* 1986; 6:61-5.
11. Gregosiewicz A, Wosko I, Kandzierski G, Drabik Z. Double-elevating osteotomy of tibiae in the treatment of severe cases of Blount's disease. *J Pediatr Orthop* 1989; 9:178-81.
12. Siffert RS, Katz JF. The intra-articular deformity in osteochondrosis deformans tibiae. *J Bone Joint Surg [Am]* 1970;52-A:800-4.
13. Paley D, Tetsworth K. Mechanical axis deviation of the lower limbs: preoperative planning of uniapical angular deformities of the tibia or femur. *Clin Orthop* 1992; 280:48-64.
14. Stanitski DF, Stanitski CL, Trumble S. Depression of the medial tibial plateau in early-onset Blount disease: myth or reality? *J Pediatr Orthop* 1999;19:265-9.
15. Kline SC, Bostrum M, Griffin PP. Femoral varus: an important component in late-onset Blount's disease. *J Pediatr Orthop* 1992;12:197-206.
16. van Huyssteen AL, Davies JQ, Hastings CJ, Hoffman EB, Roche SJL. Late-onset Blount's disease: an epidemiological, radiological and histological study. *J Bone Joint Surg [Br]* 2001;83-B (Supp 1):4.
17. Wenger DR, Mickelson M, Maynard JA. The evolution and histopathology of adolescent tibia vara. *J Pediatr Orthop* 1984;4:78-88.
18. Carter JR, Leeson MC, Thompson GH, et al. Late-onset tibia vara: a histopathologic analysis: a comparative evaluation with infantile tibia vara and slipped capital femoral epiphysis. *J Pediatr Orthop* 1988;8:187-95.
19. Price CT, Scott DS, Greenberg DA. Dynamic axial external fixation in the surgical treatment of tibia vara. *J Pediatr Orthop* 1995;15:236-43.
20. Moseley CF. Leg length discrepancy. In: Morrissey RT, Weinstein SL, eds. *Lovell and Winter's paediatric orthopaedics*. Vol. 2. Philadelphia: Lippincott, Williams & Wilkins, 2001:1105-150.
21. Anderson M, Green WT, Messner MB. Growth and predictions of growth in the lower extremities. *Am J Orthop* 1963;45-A:1-14.
22. Jones S, Hosalkar HS, Hill RA, Hartley J. Relapsed infantile Blount's disease treated by hemiplateau elevation using the Ilizarov frame. *J Bone Joint Surg [Br]* 2003;85-B:565-71.
23. Accadbled F, Laville JM, Harper L. One-step treatment for evolved Blount's disease: four cases and review of the literature. *J Pediatr Orthop* 2003;23:747-52.