Progressive Valgus Angulation of the Ankle Secondary to Loss of Fibular Congruity Treated With Medial Tibial Hemiepiphysiodesis and Fibular Reconstruction

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Abstract

The fibula is an important stabilizer of the lateral ankle. Discontinuity of the fibular shaft can lead to progressive pain and shortening of the fibula, ultimately causing loss of lateral support to the ankle.

Two children, who sustained segmental bone loss of the shaft of the fibula, developed progressive symptomatic valgus of the ankle with widening of the mortice and lateral subluxation of the talus. Both patients were treated with fibular plating and grafting with tricalcium sulfate with acute reconstitution of fibular length. Distal medial tibial hemiepiphysiodesis was simultaneously performed. One patient required revision plating and grafting 14 months after the index surgery because of plate failure. The valgus angulation and the widened medial mortice were corrected in the ankles of both patients, who returned to full activities. The patients were followed to maturity; the correction has been maintained, and they remain asymptomatic.

The technique used in these cases can correct valgus angulation secondary to loss of fibular congruity rather than only halting progression of the deformity.

The fibula is an important stabilizer of the lateral ankle. Much of the length of the fibula comes from the proximal physis. Discontinuity of the fibular shaft can lead to progressive shortening of the fibula, causing loss of lateral support to the ankle. Traditional treatment at the time of free vascularized fibular graft harvesting includes stabilizing the distal fibula to the tibia with screw fixation to prevent this shortening. In younger children, this may not be necessary if a nonvascularized graft is obtained percutaneously and the periosteum is preserved, because the fibula typically fully reconstitutes. In traumatic segmented bone loss or when the periosteum is taken with the graft, as in the second case, reconstitution may not occur. These cases present an alternative treatment when significant angular deformity and fibular shortening have occurred secondary to loss of fibular continuity. Reconstruction of fibula integrity allows for restoration of the fibular length and growth from proximal to distal, and augmenting the distal medial tibia with a hemiepiphysiodesis corrects the angular deformity and widening of the mortice.

The parents of each child provided written informed consent for print and electronic publication of these case reports.

Case One

The patient sustained a lawn mower injury to both legs at age 3 years. Completion of amputation of the right fifth toe, left medial cuneiform, first metatarsal, and great toe was required. In addition to multiple lacerations, bilateral open tibial shaft fractures were treated with external fixation. The patient also sustained a left midshaft fibular fracture with segmental bone loss; this progressed to a fibular diaphyseal nonunion. Six months after the injury, progressive asymptomatic hindfoot valgus with significant pronation of the foot was identified. Ten months postoperatively, valgus angulation of 16° and 10° was recognized in the left tibia shaft and ankle, respectively. This was well controlled with orthotic treatment until 5 years postinjury, when proximal migration of the left lateral malleolus was seen radiographically.

The patient wore ankle-foot orthotics (AFOs) and remained asymptomatic with his foot and ankle in valgus angulation until he developed significant medial ankle pain at age 10 years (**Figure 1A**). He was treated successfully with AFOs until age 14 years when he underwent a distal medial tibial hemiepiphysiodesis with an 8-plate procedure performed in association with immediate fibular lengthening with plating, and grafting with a tricalcium phosphate bone substitute (Vitoss, Orthovita, Inc., Malvern, Pennsylvania; **Figure 1B**). The 8-plate required removal secondary to screw protrusion and overlying skin necrosis at 10 days postoperatively but was not infected. The patient's ankle pain resolved, but the valgus angulation of his

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Figure 1. Case 1—(A) Preoperative radiograph at age 10 years shows persistent fibular nonunion and mild valgus ankle angulation. The distal fibular physis is level with the distal tibial physis. (B) Immediate preoperative radiograph at age 14 years with thinning of lateral tibial epiphysis, nonunion of fibula and proximal migration of fibular physis, which is 4 mm proximal to the tibial physis. (C) Seven-month postoperative radiograph after insertion of medial hemiepiphysiodesis screw at age 15 years. (D) Thirty-month follow-up radiograph shows improvement of valgus angulation and reconstitution of the fibular diaphysis. The fibular physial scar is at the level of the tibial plafond.

ankle persisted until he underwent percutaneous screw medial hemiepiphysiodesis at age 15 years (**Figure 1C**).

Follow-up 30 months postoperatively at skeletal maturity at age 17 years showed significant improvement in valgus angulation, no associated pain, and an asymptomatic 0.5-inch leg length discrepancy with the right leg longer than the left (**Figure 1D**). The ankle alignment was improved, and persistent valgus of the hindfoot secondary to loss of the first metatarsal has responded well to orthotic treatment. This patient may require stabilization of his hindfoot, which will also improve his leg length. However, he is unlikely to require tibial osteotomy because of the correction of his ankle valgus.

Case Two

The patient was diagnosed with fibro-osseous dysplasia of his left tibia at age 4 years. At age 8 years, he underwent intercalary tibial resection with contralateral subperiosteal fibular grafting. Two years postoperatively, he developed 1-cm fibular shortening on the previously normal donor right side, and 3 years postoperatively, he developed medial ankle pain. His radiographs showed fibular discontinuity, a prominent right medial malleolus with fragmentation, ankle valgus of 12°, and lateral talar subluxation with medial mortice widening at age 10 years. The medial malleolus was markedly abnormal (**Figure 2A**). Subsequently, a medial hemiepiphysiodesis of the right distal tibia and acute fibular lengthening with plating and grafting with a tricalcium sulfate bone substitute (Vitoss) was performed to correct the defect (**Figure 2B**). Eleven months postoperatively, fibular length was maintained, although the fibular plate was noted to be disrupted; however, he was asymptomatic (**Figure 2C**).

Fourteen months after the index surgery, the hemiepiphysiodesis staple was removed because the ankle had corrected

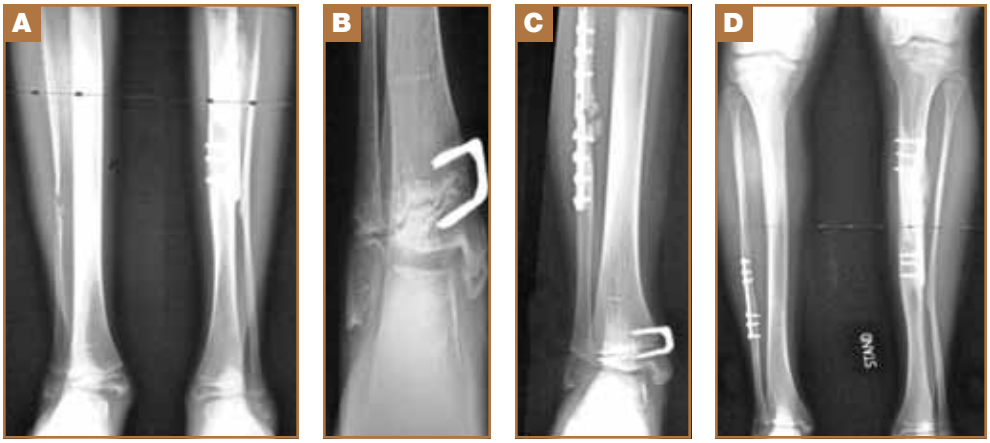

Figure 2. Case 2—(A) Preoperative radiograph shows right-ankle valgus angulation, fibular nonunion, lateral tibial epiphyseal narrowing, and a widened medial mortice. The fibular physis is clearly proximal to the tibial physis on the right. (B) Six-month postoperative radiograph of ankle mortice shows regrowth of the distal medial malleolus. The fibular physis is at the level of the tibial physis. (C) Eleven-month postoperative radiograph shows fibular plate fatigue failure but no proximal migration of the fibula. (D) Five-year follow-up radiograph at skeletal maturity after resolution of symptoms does not appear to show ankle valgus.

to a neutral position, and it was bothersome to the patient. In addition, the fibula was replated and regrafted with Grafton Demineralized Bone Matrix (Medtronic, Minneapolis, Minnesota). A clinical leg-length discrepancy of 4 mm (left greater than right), despite relative overgrowth of the left tibia as shown in **Figure 2D**, and occasional mild fibular graft-site tenderness are the only residual complaints. The patient's right-ankle alignment is normal at maturity; he has remained asymptomatic, and has returned to full activity at 5-year follow-up. The morphology of the medial malleolus has markedly improved also.

Results

Preventing valgus angulation of the ankle is the objective for any patient with loss of fibular congruity. However, both patients in this study presented with excessive ankle valgus secondary to fibular discontinuity and shortening.

The technique used in these cases is an alternative method to correct valgus angulation secondary to loss of fibular congruity. The procedure can fully correct valgus angulation rather than only halting its progression; furthermore, it can also lead to prevention of degenerative changes long-term: both patients have resumed full activity at skeletal maturity, are symptom-free, and have more normal joint alignment. However, it should be noted that each patient had a significant complication requiring a second surgical procedure, and follow-up is limited.

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Discussion

Fibular development is important for normal ankle biomechanics, and a loss of fibular congruity, whether from trauma or from surgical resection, can lead to progressive valgus angulation of the ankle. Makin[1] states "At birth the tibia is 20% of its total length. Until 50% of its length has been reached, the lower epiphysis is the dominant one. The upper tibial epiphysis then assumes the major role. The fibula at birth is 20% of its total length, but its lower epiphysis is dominant only for 30% of its growth, after which the upper epiphysis predominates. This reversal of role is peculiar to the tibia and fibula and does not occur in other long bones." Other studies have shown that the proximal fibular epiphysis contributes 60% to 61% of total longitudinal growth of the fibula.[2,3] The greater contribution of the proximal epiphysis propels the lateral malleolus distally via the intact diaphysis of the fibula;[4,5] this subsequently provides lateral support to the talus.[4] The fibula can also be responsible for up to 16% of the weight-bearing load.[6]

Fibular discontinuity disrupts normal fibular growth and development. The distal segment of the fibula will no longer have the driving force of the proximal epiphyseal growth to migrate distally and will result in a relative shortening of the distal fibula, causing proximal migration of the lateral malleolus.[5,7,8] Partial fibular resection can also decrease the weight-bearing–load transmission of the fibula from its normal 15% to 1%.[4] These malformations can lead to a loss of lateral talus support and cause progressive ankle valgus.[5,7-9] The reduction in weight-bearing function of the fibula causes a relative increase in lateral tibial weight bearing; this coupled with lateral angulation of the ankle joint will compress the lateral tibial epiphysis, causing the medial epiphysis to relatively overgrow and resulting in further valgus deformation of the ankle.[4,5,9]

Surgical correction has been the mainstay of therapy for various causes of ankle valgus. Specific approaches include supramalleolar tibial osteotomy, fibular-Achilles tenodesis, distal tibiofibular synostosis, hemiepiphysiodesis (open and transcutaneous approaches), osteosynthesis with intercalary grafting, and bone grafting.[5,10,11] Distal tibiofibular synostosis was first described by Langenskiöld[12] in 1967 for ankle valgus due to pseudarthrosis of the fibula. The fusion of the distal fibular segment to the tibia prevented the progression of valgus angulation.[12] Since then, it has been the accepted treatment modality for ankle valgus with associated fibular deformity.[11-13] However, more recent articles have showed variable results from this procedure.[4,9,13] Progressive valgus angulation with or without failure of the synostosis was seen when pseudarthrosis of the fibula was the underlying condition.[4,9,13] This may be secondary to the altered mechanics between the tibia and the fibula after a synostosis and can lead to valgus angulation and postoperative ankle pain.[11] Kanaya and colleagues[13] described this procedure for children who developed ankle valgus after fibular grafts and noted that tibiofibular synostosis can impede the development of ankle valgus; however, it cannot completely prevent its development.

Bone grafting was recommended by Wiltse[8] in 1972 and described by Hsu and colleagues[5] in 1974 as another approach to correct ankle valgus. The graft would correct the proximal fibular migration and restore lateral talus support, allowing the lateral tibial epiphysis to resume normal growth and correcting valgus angulation.[5] Because of the rarity of these types of injuries, little data is available about correction of valgus angulation secondary to fibular discontinuity; therefore, it is difficult to compare long-term outcomes of a bone-grafting procedure versus tibiofibular synostosis. However, investigators have disagreed about the most effective procedure to correct valgus angulation of the ankle that results from congenital pseudarthrosis of the fibula (CPF). Martus and Johnston[11] described restoration of the mechanical properties of the ankle with fibular osteosynthesis and bone grafting with a medial tibial hemiepiphysiodesis. Lampasi and colleagues[14] recommended

only the osteosynthesis procedure for neutral or slightly valgus ankle secondary to CPF. Not only is it difficult to accept 1 procedure to correct CPF, the lack of consensus further complicates the decision-making process to correct valgus angulation of the ankle secondary to fibular discontinuity.

While most recommendations are for surgical correction of a preexisting deformity, 1 group assessed prevention of deformity after a fibular graft harvesting. Xin and colleagues[15] described a periosteum-preserving technique for fibular harvesting that incorporates bone grafting at the donor site with the initial harvesting. Postoperative pain and donor site deformity were not complications of this approach.[15] This approach can prevent valgus angulation of the ankle secondary to loss of fibular continuity.

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Am J Orthop. 2014;43(6):280-283.

References

1. Makin M. Tibio-fibular relationship in paralysed limbs. *J Bone Joint Surg Br.* 1965;47:500-506.
2. Beals RK, Skyhar M. Growth and development of the tibia, fibula, and ankle joint. *Clin Orthop.* 1984;(182):289-292.
3. Pritchett JW. Growth and growth prediction of the fibula. *Clin Orthop.* 1997;(334):251-256.
4. Gonzalez-Herranz P, del Rio A, Burgos J, López-Mondejar JA, Rapariz JM. Valgus deformity after fibular resection in children. *J Pediatr Orthop.* 2003;23(1):55-59.
5. Hsu LC, O'Brien JP, Yau AC, Hodgson AR. Valgus deformity of the ankle in children with fibular pseudarthrosis. Results of treatment by bone-grafting of the fibula. *J Bone Joint Surg Am.* 1974;56(3):503-510.
6. Lambert KL. The weight-bearing function of the fibula. A strain gauge study. *J Bone Joint Surg Am.* 1971;53(3):507-513.
7. Dias LS. Valgus deformity of the ankle joint: pathogenesis of fibular shortening. *J Pediatr Orthop.* 1985;5(2):176-180.
8. Wiltse LL. Valgus deformity of the ankle: A sequel to acquired or congenital abnormalities of the fibula. *J Bone Joint Surg Am.* 1972;54(3):595-606.
9. Frick SL, Shoemaker S, Mubarak SJ. Altered fibular growth patterns after tibiofibular synostosis in children. *J Bone Joint Surg Am.* 2001;83(2):247-254.
10. Davids JR, Valadie AL, Ferguson RL, Bray EW, Allen BL Jr. Surgical management of ankle valgus in children: use of a transphyseal medial malleolar screw. *J Pediatr Orthop.* 1997;17(1):3-8.
11. Martus JE, Johnston CE 2nd. Isolated congenital pseudoarthrosis of the fibula: a comparison of fibular osteosynthesis with distal tibiofibular synostosis. *J Pediatr Orthop.* 2008;28(8):825-830.
12. Langenskiöld A. Pseudarthrosis of the fibula and progressive valgus deformity of the ankle in children: treatment by fusion of the distal tibial and fibular metaphyses. Review of three cases. *J Bone Joint Surg Am.* 1967;49(3):463-470.
13. Kanaya K, Wada T, Kura H, Yamashita T, Usui M, Ishii S. Valgus deformity of the ankle following harvesting of a vascularized fibular graft in children. *J Reconstr Microsurg.* 2002;18(2):91-96.
14. Lampasi M, Antonioli D, Di Gennaro GL, Magnani M, Donzelli O. Congenital pseudarthrosis of the fibula and valgus deformity of the ankle in young children. *J Pediatr Orthop B.* 2008;17(6):315-321.
15. Xin ZF, Kim KH, Jung ST. Regeneration of the fibula using a periosteum-preserving technique in children. *Orthopedics.* 2009;32(11):820.

This paper will be judged for the Resident Writer's Award.