Correction of rotational deformity of the tibia in cerebral palsy by percutaneous supramalleolar osteotomy

M. Inan,
F. Ferri-de Baros,
G. Chan,
K. Dabney,
F. Miller

From The Alfred I. DuPont Hospital for Children, Wilmington, USA

A percutaneous supramalleolar osteotomy with multiple drill holes and closed osteoclasis was used to correct rotational deformities of the tibia in patients with cerebral palsy. The technique is described and the results in 247 limbs (160 patients) are reported. The mean age at the time of surgery was 10.7 years (4 to 20). The radiographs were analysed for time to union, loss of correction, and angulation at the site of the osteotomy.

Bone healing was obtained in all patients except one in a mean period of seven weeks (5 to 12). Malunion after loss of reduction at the site of the osteotomy developed in one tibia.

Percutaneous supramalleolar osteotomy of the tibia is a safe and simple surgical procedure.

Rotational deformity of the tibia is a common problem in patients with cerebral palsy and may result in an inefficient pattern of gait.1,2 Derotation osteotomy of the tibia may be used to improve gait3-8 when conservative treatment with splints or shoe modifications is ineffective.9-12 Various surgical techniques have been described. These differ with regard to the level of the osteotomy,10-12 the method of fixation using a cast with or without a Kirschner (K-) wire,5 Steinmann pin,10 a staple,7 plating,8 an intramedullary nail13 or external fixation,14 and whether osteotomy of the fibula is performed.15,16 Successful results have been reported with all of these techniques, but complications such as delayed union, nonunion, malunion, nerve palsy and compartment syndrome have been described.17,18

The ideal technique would be one which provides union with a low rate of complications and minimal surgical trauma. The senior author (FM) therefore began to perform percutaneous supramalleolar osteotomy using multiple percutaneous drill holes. Stabilisation of the site of the osteotomy and maintenance of correction were achieved by a proximal tibial pin incorporated in a short-leg cast. In this study we describe this technique and evaluate the results of 160 patients who underwent this procedure.

Patients and Methods
We performed a retrospective review of patients with cerebral palsy who underwent this procedure between January 1991 and December 2003. A total of 181 sets of notes were reviewed. There were 12 patients with insufficient data, seven with a follow-up of less than 12 months and two in whom fibular osteotomy had been performed intra-operatively because of an external rotation deformity of 60° which were excluded from the study. The remaining 160 (76 females and 84 males) with 247 derotation osteotomies (81 unilateral and 79 bilateral) were included. Inclusion criteria were an internal or external tibial rotation deformity causing functional disability and a distal tibial osteotomy performed without fibular osteotomy. Eight ostotomies in seven patients (six unilateral and one bilateral) had to be repeated and each was evaluated individually. The mean age at the time of operation was 10.7 years (4 to 20). All the patients were able to walk to a variable degree with or without an assistive device. Twenty were hemiplegic, 108 diplegic, and 32 were quadriplegic.

The mean number of additional operations was 2.4 (0 to 6) for each leg including soft-tissue procedures, ostotomies in the foot, derotation ostotomies of the femur, and Dega pelvic ostotomies. Thirty-four limbs had a tibial derotation osteotomy alone, 36 had one additional operation, 56 two, 58 three, 43 four, 15 five, and four six.

Clinical assessment. Rotational deformity was assessed clinically by measuring the thigh-foot angle.19 The measurements were made using a goniometer with the patient prone and the hips...
extended, the knees flexed to 90° and the ankles in the neutral position. Ankle movement was recorded post-operatively and at the last follow-up.

**Radiological assessment.** Radiographs were analysed for time to union, loss of correction, and maximum angulation at the site of the osteotomy in both the sagittal and coronal planes.

**Operative technique.** The patient was placed supine on the operating table under general anaesthesia. After determination of the level of the osteotomy using fluoroscopy, a skin incision 0.5 to 1 cm in length was made on the medial side of the tibia 1 to 2 cm proximal to the distal tibial epiphysis (Fig. 1). The osteotomy was then performed by making multiple drill holes, typically six to ten, using a 3.2 mm drill bit (Fig. 2) and completed by angular bending of the bone in the anteroposterior (AP) direction (Fig. 2a). The osteotomy was then confirmed by fluoroscopy (Fig. 2b). Rotational bending was not performed in order to prevent the formation of an oblique osteotomy. A 1.5 or 2.0 mm K-wire was passed from lateral to medial at the level of the distal part of the tibial tuberosity, parallel to the tibial plateau to control rotation in the cast. Derotation was performed by slowly rotating the foot until a thigh-foot angle of 0° was achieved (Fig. 3). The measurement of the thigh-foot angle intra-operatively was made with the patient in the supine position with the hip and knee in 90° of flexion, and the foot in neutral. To achieve a zero thigh-foot angle, rotational correction was made until the longitudinal axes of the foot and the thigh were identical. It was important to control derotation carefully by holding the heel and not the forefoot in order to obtain accurate rotation through the tibia. A short-leg cast was then applied with the proximal tibial K-wire incorporated in the cast to maintain correction. A radiograph was taken at the end of the operation to check the alignment of the tibia. The time of surgery from incision to closure of the wound was recorded for patients who had an isolated tibial derotation osteotomy.

**Post-operative management.** Post-operative mobilisation mainly depended on the number and nature of the associated procedures performed. With an isolated distal tibial osteotomy the patient was allowed to walk bearing weight as tolerated on the first post-operative day. The K-wire was
Thigh-foot angle of 0˚ is obtained. Diagrams showing a derotation done by slowly rotating the foot until a still 7˚ of varus and 6˚ of recurvatum.

At the time of the latest follow-up at three years there was recurvatum of 16˚. Further surgery was not performed and aged six years, developed a varus angulation of 12˚ and Malunion following loss of reduction at the site of the operatively and was corrected by modification of the cast.

Extended proximally in two tibiae but bone healing was obtained without complications in both. The patients were then allowed to bear weight fully.

Results

The mean follow-up was 4.6 years (1 to 13) and the mean time to union was seven weeks (5 to 12). The mean duration of surgery recorded from 34 isolated procedures was eight minutes (5 to 15). A total of 103 external derotation osteotomies was performed for internal torsion (mean 24˚; 8˚ to 55˚) and 144 internal derotation osteotomies for external torsion (mean 33˚; 10˚ to 45˚). A neutral (0˚) thigh-foot angle was obtained in all tibiae intra-operatively. At the last follow-up, the mean thigh-foot angle was 3˚ (30˚ internal to 28˚ external) in the externally-rotated group and 9˚ (20˚ internal to 45˚ external) in the internally-rotated group.

Intra-operatively, extension of the osteotomy into the ankle joint occurred in one tibia in a patient aged 16 years. A short-leg cast was used to stabilise the fracture and the patient was not allowed to bear weight until fracture callus was seen at the site of the osteotomy. Bony union occurred in ten weeks without further complications. The osteotomy extended proximally in two tibiae but bone healing was obtained without complications in both.

Loss of reduction of > 5˚ was seen in eight tibiae postoperatively and was corrected by modification of the cast. Malunion following loss of reduction at the site of the osteotomy developed in one tibia. This patient, who was aged six years, developed a varus angulation of 12˚ and recurvatum of 16˚. Further surgery was not performed and at the time of the latest follow-up at three years there was still 7˚ of varus and 6˚ of recurvatum.

Delayed union developed in four tibiae (two patients). One patient, aged 14 years, had a higher level of osteotomy, but union was obtained in 12 weeks without any surgical intervention. The second, aged 16 years, also had a higher level of osteotomy and spontaneous union developed with weight-bearing 12 weeks after surgery. In a third patient, aged 14 years, who also had a higher level of osteotomy, no signs of bone healing were noted on radiographs taken at ten weeks after operation. This patient was treated by a reamed intramedullary nail and union was obtained after eight weeks.

During the early period of follow-up, temporary stiffness of the ankle was noted in nine joints. These patients had had a subtalal fusion and lengthening of the lateral column with or without a soft-tissue procedure in addition to the derotational osteotomy. None of the patients showed stiffness at the last follow-up.

Complications. Complications recorded in the charts included pin-track infection, which was graded according to Paley’s classification, wound infection, displacement of the osteotomy, delayed union, nonunion, loss of reduction, malunion of > 5˚, refracture and early arrest of growth.

Grade 3 infection occurred in one pin site and was treated by curettage and debridement, with oral antibiotics. There was no residual infection at follow-up.

None of the patients developed infection at the site of the osteotomy, refracture, or early growth arrest.

Discussion

Rotational deformity of the tibia requiring surgical correction commonly occurs in patients with cerebral palsy. Recently, derotation osteotomy through the distal tibia has become the treatment of choice, but significant rates of complications (4.8% to 10%) have been reported. Our study shows that a closed osteotomy after percutaneous drilling can be used to correct up to 45˚ of either external or internal rotation of the tibia in patients aged between four and 20 years.

Maintenance of correction and stabilisation of the osteotomy are crucial for a successful result. Different methods have been advocated. Casting may result in loss of correction. Ratey and Hyndman found that 17% of patients required repeat manipulation for excessive angulation after distal tibial osteotomy stabilised by a long-leg cast without internal fixation. Banks and Evans developed a simple transverse osteotomy stabilised by a threaded pin incorporated in the cast and reported no cases of malunion. Dodgin et al treated 63 limbs with distal tibial/fibular osteotomies which were stabilised by two crossed K-wires and a long-leg cast. They did not report any loss of reduction but the total time of immobilisation was nine weeks. McNicol et al used a single staple with a long-leg cast for three to four weeks to stabilise the supramalleolar osteotomy. Although they did not report any incidence of malunion, this was an open surgical procedure. Selber et al preferred to use a T-plate and reported nonunion in two of 57 patients and an
early arrest of growth in one. They concluded that their technique allowed early mobilisation and a high rate of bone healing. In our series, nonunion developed in one of 247 osteotomies and patients were allowed to bear weight early in a short-leg cast.

Various levels have been used for derotation osteotomies in the tibia. Proximal osteotomies have been noted to have a higher risk of peroneal nerve injury and compartment syndrome. Diaphyseal osteotomies have the disadvantage of delayed or nonunion and often require the use of plates or intramedullary nails for stabilisation the site of the osteotomy. Recent reports suggest that an osteotomy at the supramalleolar level is the ideal for a derotation osteotomy of the tibia.3,5,8,16

The need for an osteotomy of the fibula remains controversial. Some authors have reported that the intact fibula adds stability and prevents loss of fixation.16,21 In our study, loss of reduction was noted in eight osteotomies (3.2%) after full weight-bearing. However, all the patients were treated successfully by modification of the cast and did not need further surgery. On the other hand, Manouel and Johnson16 stated that leaving the fibula intact may cause recurrence of the rotational deformity. The reason for this is still unclear. It is clearly multifactorial, and may include muscle spasticity and foot deformity.15,17,22

Theoretically, excessive derotation of the distal tibia in the presence of an intact fibula can lead to incongruity of the ankle.23 In our study, stiffness of the ankle occurred after osteotomies of the foot performed at the same time as derotational osteotomy of the tibia. We have not seen any incidence of stiffness and performed correction of up to 45° of external and 55° of internal rotation.

The maximum amount of derotation which can be achieved without a fibular osteotomy has not been clearly described. Lloyd-Roberts, Swann and Catterall24 carried out a derotation on a child with club foot who had an internal rotation deformity of 45° without doing a fibular osteotomy. Asirvatham et al21 performed derotation in 51 patients with poliomyelitis using O’Donoghue’s technique of mid-diaphyseal tibial osteotomy with an intact fibula. Their patients had internal rotation deformities which ranged from 30° to 90° (mean 57°). Full correction was achieved in all patients. Two patients who had external rotation of 60° were excluded from our series. They required fibular osteotomy in addition to the supramalleolar osteotomy in order to achieve full correction. In all other patients who had an external rotation deformity of < 45° or an internal rotation deformity of < 55°, full correction was achieved without an osteotomy of the fibula.

Nonunion in the tibial metaphysis is rare. Delayed union and nonunion after supramalleolar osteotomy have been described infrequently regardless of the technique.8,18 In our series, older age and a higher level of osteotomy appear to be important risk factors for delayed union. All the patients with delayed union were older than 14 years and the level of osteotomy was higher than in other patients.

Open techniques are more invasive and may carry an increased risk of local infection.8,16,18 In our study there was no superficial or deep infection at the site of the osteotomy. Pin-site infection can occur in the proximal tibia, but only one site required surgical treatment and all healed without sequelae.

Arrest of growth after distal derotational osteotomy has been reported rarely.7,15 Early arrest of growth was related to damage to the growth plate during osteotomy or application of the fixation device. There have been no cases in our series at the latest follow-up.

An intra-articular fracture occurred in a 16-year-old girl while performing the supramalleolar osteotomy. After this complication, we used more drill holes in older patients to avoid this complication.

Our results demonstrate that percutaneous supramalleolar osteotomy with multiple drill holes is a safe and simple surgical procedure. Using this technique, external rotation of the tibia of 45° or internal rotation of 55° can be corrected without a fibular osteotomy.

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