Outcomes of Tibial Derotational Osteotomies Performed in Patients With Myelodysplasia

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Background: Rotational deformities of the tibia are common in patients with myelodysplasia. The current recommended treatment is tibial derotational osteotomy to improve gait biomechanics. Previously reported complication rates are widely variable. The purpose of this study is to review the outcomes of derotational osteotomies as a function of complication and revision surgery rates as compared with previous studies.

Methods: A retrospective chart review was performed on all tibial derotational osteotomies performed in patients with myelodysplasia from 1985 to 2010 in patients older than 5 years with > 2 years of follow-up. Charts were reviewed for demographics, amount of derotation at index surgery, incidence of complications, and the need for repeat derotational surgery. Descriptive statistics were used to determine the incidence of complications as well as need for reoperation. Further analysis was performed using Fisher Exact Test and the Student *t* test to identify independent risk factors for complication and rerotation.

Results: Eighty-two patients (129 limbs) had sufficient data for inclusion. The average follow-up was 7.15 years. Surgery was indicated for symptomatic torsion measuring > 20 degrees. The average amount of derotation was 28 ± 12 degrees. The incidence of complications was 10.85%, with a 3.10% incidence of major complications including fracture, deep infection, and hardware failure. The repeat derotation rate was 16.28%, all in patients initially treated for external tibial torsion. Age at initial surgery had no effect on complication rate or need for reoperation. Level of spinal involvement was not associated with complication risk; however, lumbar-level involvement was an independent risk factor for rerotation.

Conclusions: With meticulous operative technique, derotational osteotomy of the tibia in patients with myelomeningocele remains a safe and effective method to treat tibial torsion, with an acceptable overall complication rate of 10.85% and a major complication rate of 3.10%. The data presented will aid providers in appropriate counseling of patients considering tibial derotational osteotomy.

Level of Evidence: Level II–prognostic study, retrospective review.

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Unlike idiopathic tibial torsion, torsion in children with myelodysplasia—both internal and external—does not characteristically resolve without surgical intervention. Internal tibial torsion in the general population is commonly caused by intrauterine positioning[1,2] and predictably improves with age. Idiopathic external tibial torsion is often progressive, more frequently requiring surgical correction, even in the nonmyelodysplastic population.[1] In contrast, internal tibial torsion in children with myelodysplasia is typically a fixed deformity often associated with clubfoot that does not spontaneously resolve if left untreated. The etiology of external tibial torsion in this population is unknown, but dynamic muscle imbalance is likely a contributing factor. It will similarly not improve without surgical correction.[3]

Children with low lumbar or sacral level myelodysplasia are generally ambulatory, and rotational malalignment in this population can significantly alter gait biomechanics and velocity. In this population, internal tibial torsion may result in frequent falls as a result of difficulties with foot clearance. External tibial torsion can lead to hindfoot valgus, pes planus, excessive shoe wear, trophic ulcerations, and poor orthotic control.[3,4]

Surgical consideration should be given to an otherwise-healthy child 9 years of age or older with a thigh foot angle > 15 degrees internal or 30 degrees external,[2] measured per the description of Staheli et al.[5] In the myelodysplastic population, surgery should be considered for all tibial torsion affecting gait biomechanics (typically > 20 degrees in either direction), with a goal of minimizing brace requirement and achieving a gait pattern as close to normal as possible.[6] And while myelodysplastic patients do benefit from surgical correction of tibial torsion with derotational osteotomy,[7] previously reported complication rates between 5% and 33%[4,8–14] have tempered enthusiasm for surgical intervention. However, there is a paucity of outcomes data on tibial derotational osteotomies performed specifically in patients with myelodysplasia. The majority of reported outcomes are in mixed populations of children with myelodysplasia, cerebral palsy, and other less common neuromuscular conditions. However, the etiology and natural history of rotational deformities in these populations are not equivalent, and their response to surgical intervention may also be dissimilar. As such, the goal of the present study was to review the results of derotational osteotomies as a function of complication and need for revision surgery in an ambulatory population of children with myelodysplasia.

METHODS

A retrospective chart review was performed to identify patients with myelodysaplasia who underwent tibial derotational osteotomies for tibial torsion affecting brace wear, gait biomechanics, and/or gait velocity between 1985 and 2010. All children included in the analysis had lumbar or sacral level myelodysplasia, were 5 years of age or older, and had at least 20 degrees of measured tibial torsion that interfered with gait, with at least 2 years of follow-up. Subjects were excluded from the analysis for insufficient data, age less than 5 years at time of surgery and for less than 2 years of follow-up.

Rotation was calculated by the 2 senior authors using thigh foot angle[5] preoperatively, intraoperatively, and postoperatively. Unfortunately, as this was a retrospective chart review, we do not have enough data to determine accuracy or interobserver error. However, this has been previously described in similar studies.[2] All surgeries were performed by the 2 senior authors at Children's Memorial Hospital in Chicago, IL. After identification of subjects, charts were reviewed for demographic information, correction achieved (in degrees) at index surgery, incidence of complications, type of complication, as well as the need for reoperation. Complications included in analysis were cellulitis, deep infection, nonunion/delayed union, fracture, and hardware failure. Descriptive statistics were used to determine the incidence of complications as well as need for reoperation. Further statistical analysis was performed using Fisher Exact Test and Student *t* test to determine independent risk factors for complication and rerotation.

Surgical Technique

All surgeries were performed in the same manner by one of the 2 senior authors. The patient is positioned supine with a mid-thigh pneumatic tourniquet. Before tibial osteotomy, a direct lateral longitudinal incision is made overlying the fibula at the same level as the planned tibial osteotomy, and a transverse osteotomy is completed using an oscillating saw. The tibial osteotomy is performed through a separate longitudinal incision, placed along the anterolateral aspect of the distal tibia, to allow at least 2 screw holes of a 4- to 6-hole 3.5 or 4.5 mm limited contact direct compression plate distal to the proposed osteotomy site and proximal to the distal tibial physis.

Prophylactic anterior compartment fasciotomy is performed on all patients to prevent compartment syndrome in this patient population without complete protective sensation. The osteotomy is created with multiple drill holes placed in parallel, and it is completed using a straight AO osteotome to limit osteonecrosis. The derotation is then performed manually, using smooth K-wires placed proximal and distal to the osteotomy site before osteotomy as a guide for correction, with a goal of correction to between neutral and 5 degrees of external rotation. The osteotomy is then fixed using the limited contact direct compression plate, placed on the anterolateral face of the tibia, in compression mode (Fig. 1). The incisions are closed with interrupted nylon sutures over a drain that remains in place for 24 hours. Intravenous antibiotics are given for 24 hours postoperatively. All patients are placed in a short-leg cast and made non–weight-bearing for an average of 3 weeks with an additional 3 weeks spent in a walking cast. Routine removal of hardware was not performed.

FIGURE 1. Postoperative radiographs. Anteroposterior and lateral views of the tibia following distal tibia and fibula derotational osteotomies fixed with 6-hole limited contact direct compression plate.

RESULTS

A total of 82 patients—47 of which had simultaneous bilateral osteotomies—met criteria for inclusion, for a total of 129 limbs. In total, 35 female and 47 male patients were included in the analysis, 67 of which had a primary diagnosis of myelomoneningocele, 13 carried a diagnosis of lipomeningocele and 2 had diastomatomyelia. The average age at index surgery was 9.85 years with an average follow-up of 7.15 years. Of the total 129, 37 (28.68%) had surgical correction of internal tibial torsion, and the remaining 92 (71.32%) had external tibial torsion (Table 1). The average

TABLE 1. Patient Characteristics

Patient Demographics	n (%)
Total patients	82
Total limbs	129
Internal tibial torsion	37 (28.68)
External tibial torsion	92 (71.32)
Male	35 (42.68)
Female	47 (57.32)
Diagnosis	
Myelomeningocele	67 (81.71)
Lipomeningoele	13 (15.85)
Diastomeylia	2 (2.44)

TABLE 2. Predictors for Need for Second Surgery for Rerotation

Rerotation Characteristics	n (%)	*P*
Total number of rederotations	21 (16.28)	
External torsion	21 (16.28)	0.002
Internal torsion	0 (0)	0.002
Lumbar level	14 (10.85)	0.03
Sacral level	7 (5.43)	0.03
Age (y)	11.4	0.13

derotation achieved was 27.5 degrees (± 12.3 degrees) and was maintained at 24.5 degrees (± 13 degrees) at final follow-up. Concomitant surgeries included lower extremity tendon/muscular lengthening, lower extremity tenotomy, and/or femoral osteotomies.

All patients went on to union despite 3 tibiae (2.33%) that required prolonged casting (> 10.5 wk) for delayed union. The average time spent in a cast was 7.64 weeks (± 2.86 wk). A total of 14 (10.85%) limbs had associated complications, including 3 (2.33%) superficial infections within 90 days postoperatively, 1 (0.78%) deep infection within 90 days postoperatively, 1 (0.78%) fracture approximately 4 months postoperatively, 1 (0.78%) wound dehiscence within 30 days postoperatively, 2 (1.55%) hardware failures within 90 days postoperatively, and 3 (2.33%) hardware removals for symptomatic hardware between 1 and 6 years postoperatively. All superficial infections were treated successfully with oral antibiotics. The 1 deep infection required surgical debridement without removal of hardware. The fracture at the level of the osteotomy occurred 4 months postoperatively and went on to union with casting. Age at initial surgical intervention had no effect on complication rate ($P = 0.37$), nor did level of spinal involvement ($P = 0.46$).

A total of 21 limbs (16.28%) required rederotation, all of which originally had been treated for external tibial torsion. Repeat surgery occurred on average 5.0 ± 2.5 years following index surgery. Indication for reoperation was the same as for index surgery—tibial torsion affecting gait biomechanics, velocity, and/or orthotic wear. Age at initial surgical intervention had no effect on retorsion rate ($P = 0.13$), nor did degree of initial correction achieved (25.29 vs. 27.39 degrees, $P = 0.45$). However, patients with lumbar-level spinal involvement had a significantly higher rate of retorsion requiring repeat surgical intervention (10.85%) compared with those with sacral level disease (5.43%) ($P = 0.03$) (Table 2).

DISCUSSION

Using meticulous surgical technique, there is an acceptable complication rate of 10.85%—the majority of which is minor—following distal tibial derotational osteotomy in the myelodysplastic population. Our complication rate is consistent with previously reported complication rates (4.8% to 13%) in mixed idiopathic/neuromuscular populations[2,9–13,15] and significantly lower than the reported complication rate (28% to 33%) in smaller populations of patients with myelodysplasia.[3,4,14] Further, our reoperation rate is significantly lower than previously reported outcomes in a similar population (16.28% vs. 31%).[14] Previous reports have described both proximal and distal osteotomies, with and without concomitant fibular osteotomies, secured with K-wire and with plate fixation. This variance in surgical technique may be, in part, responsible for the disparity in reported outcomes.

Krengel and Staheli,[12] previously reported that the complication rate with distal osteotomy was significantly lower than that for proximal. A recent review of distal osteotomies had a major complication rate of 5.3%, including nonunion, fracture, and distal tibia physeal growth arrest.[10] In contrast, our major complication rate including deep infection, fracture, and hardware failure was 3.10%. We attribute our low complication rate and relatively low reoperative rate to a metaphyseal level osteotomy, the use of drill holes and osteotome to reduce osteonecrosis with osteotomy, rigid fixation with compression at the osteotomy site, along with the use of nonabsorbable, interrupted sutures for closure over a drain.

And while Ryan and colleagues reported lower complication rates following K-wire fixation (6/66, 9%) as compared with plate fixation (2/6, 33%) for distal tibial derotational osteotomy, their series was an exclusive cerebral palsy population and not applicable to a myelodysplastic population known to traditionally have a higher complication rate. K-wire fixation does not provide compression or rigid fixation, both of which, we suspect, are necessary for reliable healing in this population and to which we attribute our low complication rate compared with other series of myelodysplastic patients (10.85% vs. 28% to 33%[3,4,14]). Furthermore, the complication rate with plate fixation in this series is quite reasonable with a smaller associated delayed union rate than published in previous studies (2.3% vs. 4%).[13]

In addition, previous reports note a higher trend toward posterior and coronal angulation at the osteotomy site in patients with concurrent fibular and tibial osteotomies.[16,17] However, these complications were seen following tibial osteotomy fixed with K-wires. Given that plate fixation was used in this series and that adequate derotation cannot always be achieved with tibial osteotomy alone, fibular osteotomies were performed in all patients to allow for consistent operative technique without resultant coronal or sagittal malalignment.

Recurrence of tibial torsion was found to be significantly greater for patients with external as opposed to internal tibial torsion in this cohort. This is likely a reflection of their unique etiologies. Internal tibial torsion is typically a fixed, congenital deformity that is unlikely to progress after correction and fixation. However, external tibial torsion tends to be a more progressive deformity, possibly related to dynamic competing muscular forces. As for the elevated risk of recurrence in patients with lumbar level disease, this may be a result of increasing abnormal muscular forces and muscular imbalance as compared with sacral level involvement. However, further investigation is necessary to explain this observed correlation between level of involvement and risk for recurrence.

Given the natural history of the deformity, the majority of ambulatory myelodysplastic patients with tibial torsion will ultimately require surgery to maintain a functional gait pattern. Without surgery, internal tibial torsion leads to frequent falls resulting from difficulty with clearing 1 foot in front of the other. Even in the idiopathic population, untreated internal tibial torsion is associated with falls, foot/ankle pain, and knee pain, all of which significantly improve with derotational osteotomy.[15] Further, internal tibial torsion, if left untreated, has been related to increased varus loads during the stance phase of gait, which may be associated with a propensity toward arthritic changes.[18]

Excessive external tibial torsion leads to valgus overload at the knee joint[6] as well as lever arm disease.[19] An externally rotated foot decreases the extension moment at the knee during mid-stance, leading to premature knee flexion and crouch gait. This mechanical disadvantage cannot be overcome with ankle-foot orthoses alone when the malrotation is >20 degrees.[20] The combined coronal and sagittal malalignment may predispose affected patients to early knee arthrosis. In fact, up to 24% of adults with myelodysplasia report knee pain associated with arthritic changes,[21] in part because of rotational malalignment.

Correction of tibial rotational deformities may, in part, prevent late degenerative changes in the knees of affected patients. Specifically, following internal derotational osteotomy for external tibial torsion, there is a reported improvement in knee extension during stance phase.[20] Moreover, patients who required knee-ankle-foot orthoses to maintain independent gait preoperatively are able to walk with ankle-foot orthotics alone following surgery. Perhaps most importantly, sagittal and coronal kinematics at the knee[20] and ankle[7] trended toward normal variants following derotational osteotomy.

Although this is the largest reported cohort of myelodysplastic patients following tibial derotational osteotomy, it was limited primarily by its retrospective nature. Concomitant surgeries were not taken into consideration nor controlled for. Given that many children with myelodysplasia and tibial torsion require multiple surgeries for lower limb deformity and gait disturbance and that many of these surgeries are performed simultaneously, it was clinically irrelevant to control for the possibility of concurrent soft-tissue procedure or lower extremity osteotomy. Further, we do not have functional or subjective outcome data. However, previous reports, including that of the senior author (L.D.) have previously demonstrated improvements in gait following derotational osteotomy for tibial torsion.[7,20]

Given the relatively favorable complication profile as well as the short and presumed long-term benefits of tibial derotational osteotomy for tibial torsion in patients with myelodysplasia, it should be strongly considered for patients with appropriate indications. With meticulous attention to surgical technique, tibial derotational osteotomy remains a safe and effective surgical option for children with nonidiopathic tibial torsion.

REFERENCES

1. Lincoln TL, Suen PW. Common rotational variations in children. *J Am Acad Orthop Surg*. 2003;11:312–320.
2. Staheli LT. Torsion—treatment indications. *Clin Orthop Relat Res*. 1989;247:61–66.
3. Dias LS, Jasty MJ, Collins P. Rotational deformities of the lower limb in myelomeningocele. Evaluation and treatment. *J Bone Joint Surg Am*. 1984;66:215–223.
4. Fraser RK, Menelaus MB. The management of tibial torsion in patients with spina bifida. *J Bone Joint Surg Br*. 1993;75:495–497.
5. Staheli LT, Corbett M, Wyss C, et al. Lower-extremity rotational problems in children. Normal values to guide management. *J Bone Joint Surg Am*. 1985;67:39–47.
6. Lim R, Dias L, Vankoski S, et al. Valgus knee stress in lumbosacral myelomeningocele: a gait-analysis evaluation. *J Pediatr Orthop*. 1998;18:428–433.
7. Stefko RM, de Swart RJ, Dodgin DA, et al. Kinematic and kinetic analysis of distal derotational osteotomy of the leg in children with cerebral palsy. *J Pediatr Orthop*. 1998;18:81–87.
8. Walton DM, Liu RW, Farrow LD, et al. Proximal tibial derotation osteotomy for torsion of the tibia: a review of 43 cases. *J Child Orthop*. 2012;6:81–85.
9. Dodgin DA, De Swart RJ, Stefko RM, et al. Distal tibial/fibular derotation osteotomy for correction of tibial torsion: review of technique and results in 63 cases. *J Pediatr Orthop*. 1998;18:95–101.
10. Selber P, Filho ER, Dallalana R, et al. Supramalleolar derotation osteotomy of the tibia, with T plate fixation. Technique and results in patients with neuromuscular disease. *J Bone Joint Surg Br*. 2004;86:1170–1175.
11. McNicol D, Leong JC, Hsu LC. Supramalleolar derotation osteotomy for lateral tibial torsion and associated equinovarus deformity of the foot. *J Bone Joint Surg Br*. 1983;65:166–170.
12. Krengel WF III, Staheli LT. Tibial rotational osteotomy for idiopathic torsion. A comparison of the proximal and distal osteotomy levels. *Clin Orthop Relat Res*. 1992;283:285–289.
13. Ryan DD, Rethlefsen SA, Skaggs DL, et al. Results of tibial rotational osteotomy without concomitant fibular osteotomy in children with cerebral palsy. *J Pediatr Orthop*. 2005;25:84–88.
14. Martin SL, Samartzis D, Gerson A, et al. Tibial Rotational Osteotomies in Patients with Myelodysplasia: Outcomes and Risk Factors. E-poster presented at 2009 POSNA Annual Meeting April 2009, 2009; Boston, MA.
15. Davids JR, Davis RB, Jameson LC, et al. Surgical management of persistent intoeing gait due to increased internal tibial torsion in children. *J Pediatr Orthop*. 2014;34:467–473.
16. Manouel M, Johnson LO. The role of fibular osteotomy in rotational osteotomy of the distal tibia. *J Pediatr Orthop*. 1994;14:611–614.
17. Rattey T, Hyndman J. Rotational osteotomies of the leg: tibia alone versus both tibia and fibula. *J Pediatr Orthop*. 1994;14:615–618.
18. Krackow KA, Mandeville DS, Rachala SR, et al. Torsion deformity and joint loading for medial knee osteoarthritis. *Gait Posture*. 2011;33:625–629.
19. Gage JR. *Gait Analysis in Cerebral Palsy*. London, New York: Mac Keith Press; Distributor Cambridge University Press; 1991.
20. Dunteman RC, Vankoski SJ, Dias LS. Internal derotation osteotomy of the tibia: pre- and postoperative gait analysis in persons with high sacral myelomeningocele. *J Pediatr Orthop*. 2000;20:623–628.
21. Williams JJ, Graham GP, Dunne KB, et al. Late knee problems in myelomeningocele. *J Pediatr Orthop*. 1993;13:701–703.