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Hemiepiphysiodesis Using a Transphyseal Screw at the Medial Malleolus for the Treatment of Ankle Valgus Deformity

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Abstract

Background: The purpose of this study is to report outcomes of transphyseal screw hemi-epiphysiodesis at the medial malleolus for the treatment of valgus ankle deformity.

Methods: An institutional review board–approved retrospective review was done of 24 patient charts. Lateral distal tibial angle (LDTA) was measured preoperatively and at final follow-up.

Results: The average change in LDTA was 8.3 degrees (SD 4.9 degrees; range 0-19 degrees). The average rate of correction was 0.4 degrees per month (SD 0.3; range 0-1.4).

Conclusion: Medial malleolar transphyseal screw hemiepiphysiodesis is a simple, effective, and safe treatment for valgus ankle deformity in skeletally immature children.

Level of Evidence: Level IV, case series.

Keywords: hemiepiphysiodesis, transphyseal screw, ankle valgus

Introduction

Ankle valgus is a coronal plane deformity most commonly seen in pediatric patients with a congenital or acquired pathology of the lower limb. A wide variety of pathologies have been linked in the literature to ankle valgus deformity.[3,5-7,9,15,16,18,20,21] These can be categorized by type including neurogenic, genetic, other congenital, and traumatic.[16]

Ankle valgus can occur independently or in combination with hindfoot valgus. This must be carefully distinguished using weightbearing radiographs to determine appropriate treatment.[14]

There are 3 radiographic indicators for ankle valgus described in the literature: a persistent high fibular station (described by the Malholtra classification), a persistent wedging of the secondary ossification center of the distal tibial epiphysis, and a persistent valgus tibiotalar axis.[3,5,9,14,15]

Initial conservative treatment can start with bracing and/or orthoses, commonly used by patients with neuromuscular disorders.[20] However, ankle valgus will sometimes progress with growth, eventually leading to shoe and brace wear, pain, difficulty ambulating, and osteoarthritis.[10,20]

Surgery is an option for patients with severe persistent/progressive deformity. The purpose of this study is to report outcomes of transphyseal screw hemiepiphysiodesis at the medial malleolus for the treatment of valgus ankle deformity.

Materials and Methods

The current study was approved by the medical school IRB. Patients were identified from a single pediatric hospital by searching the hospital's billing database. A total of 30 patients were identified over an 8-year period that had undergone an ankle transphyseal screw hemiepiphysiodesis

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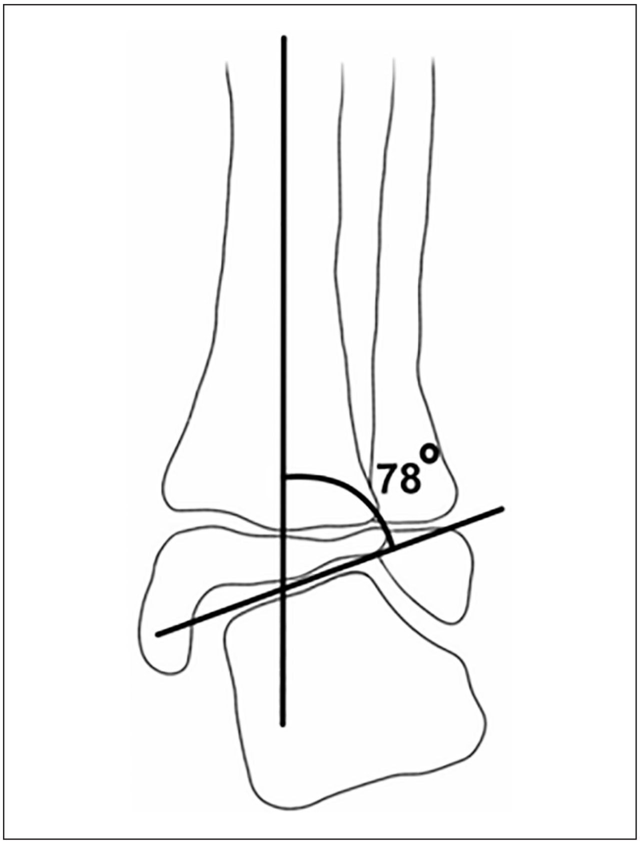

Figure 1. The lateral distal tibial angle is measured in a weightbearing view at the angle of the lateral and tibial quadrant of 2 intersecting lines, one drawn down the axis of the tibia and one drawn across the plafond.

procedure. A retrospective review of those 30 patients was done. Inclusion criteria for patients who underwent transphyseal screw hemiepiphysiodesis at the medial malleolus included patients with valgus ankle deformity, patients aged 6-13 years who were skeletally immature at time of surgery, and patients with at least 2 years of follow-up. Normal ankle alignment was defined as an ankle with a lateral distal tibial angle (LDTA) of 89 ± 3 degrees. Ankle valgus deformity was therefore defined as an ankle with an LDTA of less than 86 degrees. Exclusion criteria included patients aged >13 years, inadequate records, follow-up <2 years, and patients undergoing additional surgery that would have the potential to affect growth at the distal tibial physis (Figure 1).

Eight patients were excluded from the study results owing to not meeting the inclusion criteria. Of the 22 remaining patients, the following information was obtained: underlying diagnosis, age at surgery, gender, LDTA preoperatively, LDTA angle at 1-year follow-up, LDTA at skeletal maturity or final follow-up, fibular station preoperatively based on the Malholtra classification (Figure 2), fibular station at skeletal maturity or final follow-up, type of screw used, complications, and length of follow-up. All 22 patients were able to ambulate. Average rate of correction was calculated over a 1-year period following surgery using the change in LDTA from the preoperative radiograph to the radiograph at 1 year of follow-up.

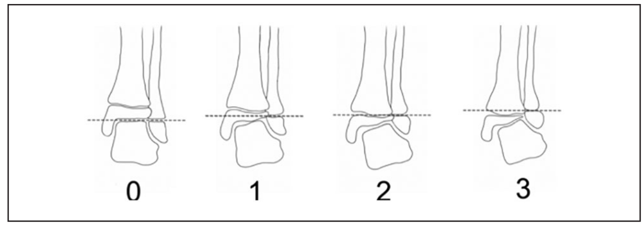

Figure 2. The Malholtra Classifications: 0 = the fibular physis is at the level of the plafond; 1 = the fibular physis is between the plafond and the tibial physis; 2 = the fibular physis is at the level of the tibial physis; 3 = the fibular physis is proximal to the tibial physis.

Radiographs in the weightbearing position were used to follow correction of ankle valgus deformity. Correction of up to 5 degrees of varus (LDTA of 94 degrees) was tolerated in patients to account for potential rebound deformity after screw removal or coexisting subtalar valgus. Appropriate correction was defined as an LDTA of 86-94 degrees. Undercorrection was defined as an LDTA of <86 degrees. Overcorrection was defined as >94 degrees.

Statistics

Descriptive statistics were used to characterize the demographic data and rate of correction.

Surgical Technique

An approximately 1-cm incision is made over the distal tip of the medial malleolus. The tibialis posterior tendon sheath was identified before insertion of the screw. Under fluoroscopy, a guidewire is inserted through the medial malleolus across the epiphysis and into the metaphysis of the tibia in a technique described by Davids et al.[5] In the anteroposterior view, the wire was placed perpendicular and in the medial quarter of the physis. In the sagittal plane, the guidewire was placed so it crosses through the middle third of the physis.[15] A cannulated drill set is then used to insert a partially threaded 4-mm cancellous screw over the guidewire to obtain physeal compression. A partially threaded screw is used to increase compression of the physis. Then the guidewire is removed. Fluoroscopy is used to confirm appropriate screw placement on both anteroposterior and lateral views. The wound is irrigated with sterile saline and closed with two 4-0 PDS simple sutures.

Table 1. Study Data and Results.

Patient Number/ Laterality	Age at Surgery	Gender	Underlying Pathology	Pre-LDTA	Post-LDTA	Pre-FS	Post-FS
1L	9.8	Male	Clubfoot	85	89	I	I
2L	11.8	Male	Spina bifida	80	87	I	I
2R	11.8	Male	Spina bifida	75	91	II	I
3R	8.4	Male	Spina bifida	80	85	0	0
4L	11.9	Male	Clubfoot	80	91	0	0
4R	11.9	Male	Clubfoot	83	85	0	0
5L	7.8	Female	Spina bifida	82	93	I	I
5R	7.8	Female	Spina bifida	83	93	I	I
6L	11.7	Male	Multiple hereditary exostoses	65	79	II	I
6R	11.7	Male	Multiple hereditary exostoses	71	87	II	II
7L	12.7	Male	Spina bifida	78	87	I	II
8R	12.9	Male	Multiple hereditary exostoses	80	83	I	I
9L	9.5	Male	Spina bifida	78	83	I	I
9R	9.5	Male	Spina bifida	76	80	I	I
10L	12.6	Female	Tibial fracture with tibiofibular synostosis	84	89	I	I
11L	11.9	Female	Multiple epiphyseal dysplasia	74	87	0	0
11R	11.9	Female	Multiple epiphyseal dysplasia	77	85	0	0
12R	11.2	Female	Multiple hereditary exostoses	84	89	II	II
13L	9.6	Male	Spina bifida	80	88	I	0
13R	9.6	Male	Spina bifida	75	80	I	I
14L	6.3	Female	Spina bifida	70	74	I	I
14R	6.3	Female	Spina bifida	77	86	II	II
15L	9.8	Male	Clubfoot	76	82	0	0
15R	9.8	Male	Clubfoot	80	87	0	0
16L	9.2	Female	Multiple hereditary exostoses	76	86	I	I
17L	9.2	Female	Spina bifida	85	97	I	I
17R	9.2	Female	Spina bifida	83	92	I	I
18R	8.3	Female	Congenital peroneal nerve palsy	84	93	III	III
19R	10.9	Female	Ewing sarcoma	80	95	III	II
20L	9.4	Female	Clubfoot	84	101	0	0
20R	9.4	Female	Clubfoot	85	105	0	0
21L	10.6	Male	Spina bifida	75	90	I	0
21R	10.6	Male	Spina bifida	81	88	I	I
22L	11.4	Female	Multiple hereditary exostoses	84	89	II	II
Mean	10.2			79.1	88.1		

Abbreviation: LDTA, Lateral Distal Tibial Angle.

Results

A total of 22 patients and 34 ankles were included in the current study. Eleven were male and 11 were female. Underlying diagnoses included 9 with spina bifida, 5 with multiple hereditary exostoses (MHE), 4 with clubfoot, 1 with a prior tibial fracture with tibiofibular synostosis, 1 with multiple epiphyseal dysplasia, 1 with a congenital peroneal nerve palsy, and 1 with Ewing sarcoma (Table 1). The average length of follow-up in this study was 7.2 years with a range of 2-13 years.

The average age at surgery was 10.3 years (range 6.3-12.9). Preoperative planning included the child's age and growth potential of the distal tibial physis for the amount of desired correction.[1] The average preoperative LDTA was 79.2 degrees (SD 4.6, range 65-86). The average final LDTA was 88.1 degrees (SD 6.1, range 74-105). The average change in LDTA was 8.9 degrees (SD 4.9, range 0-19) (Figure 3). The average rate of correction was 0.4 degrees per month (SD 0.3, range 0-1.4). Fibular station was noted to improve (to a Malholtra classification of lesser value) in 4 ankles in 4 different patients (Figure 4). Some degree of correction was observed in all 34 ankles. In 20 ankles, the surgery corrected the joint to neutral. Ten ankles were undercorrected, and 4 ankles were overcorrected. The

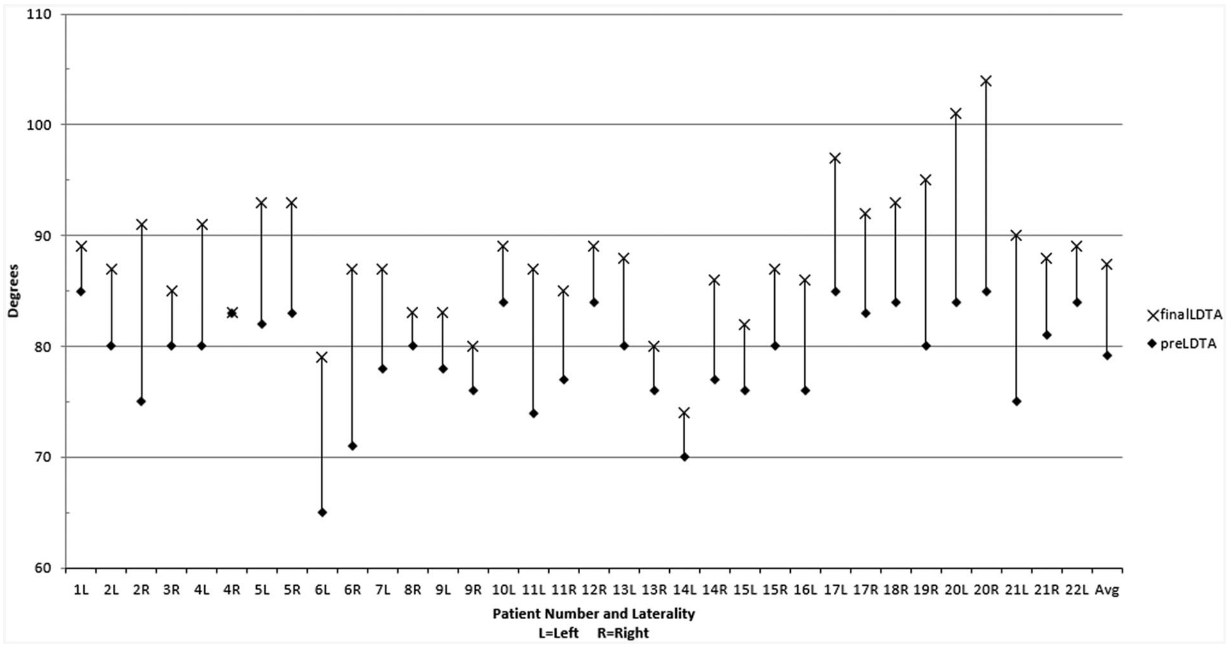

Figure 3. Change in lateral distal tibial angle (LDTA).

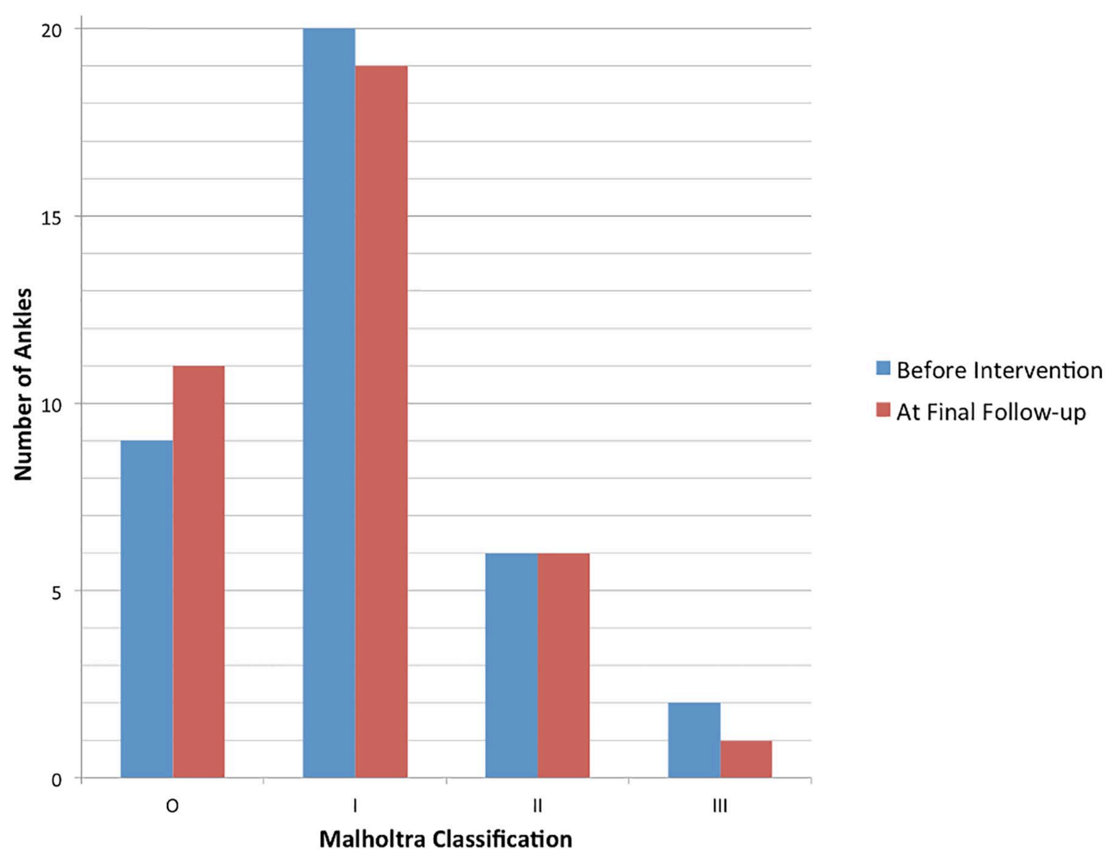

Figure 4. Change in fibular station.

Figure 5. Patient 15R. Progressive improvement of ankle valgus deformity.

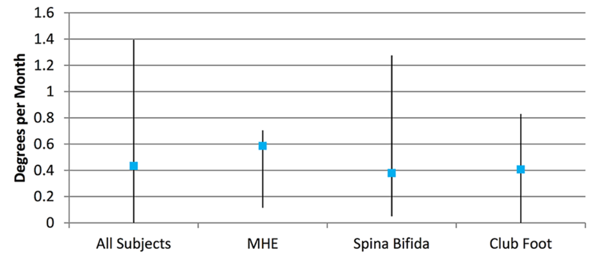

Figure 6. Rate of correction by pathology. The blue squares indicate the average rate of correction, and the corresponding vertical lines indicate the range.

average age of the 10 undercorrected ankles was 11.5 years and the average age of the 4 overcorrected was 9.8 years. All the 4 overcorrected ankles had an LDTA of about 100 degrees. The underlying diagnoses of these 4 ankles were clubfoot, Ewing sarcoma, and spina bifida. Two ankles in 1 patient were lost to follow-up for 2 years and presented with overcorrection.

The transphyseal screws were removed in 19 ankles of 12 patients. The average time to screw removal was 81 weeks, with a range of 30-214 weeks. Of the 19 screws removed, 2 screws were removed because of a reason other than the LDTA reaching a neutral position. One screw was removed owing to irritation related to the hardware, and another was removed owing to loosening of the screw. The other 17 screws were removed in patients who reached a neutral position (94 degrees LDTA) with growth remaining. During operative removal of the screws, 5 were documented to have bony overgrowth over the head of the screw. All 5 were successfully removed. Four screws were bent on attempted removal. Three were successfully removed. One screw broke, and part of the screw was left deep in the bone.

After screw removal, 10 ankles resumed growth at the medial tibial physis. Rebound toward valgus was seen in each of those 10 ankles of 5 degrees. The diagnosis of these 10 rebound ankles were as follows: 2 clubfoot, 4 spina bifida, 2 MHE, and 2 MED. Five ankles had a rebound less than 5 degrees, and 5 ankles had a rebound greater than 5 degrees, with the greatest being 15 degrees. This patient with 15 degrees was offered an osteotomy, but the patient declined. There were no instances of permanent growth arrest at the distal tibial physis secondary to the transphyseal screw. Four ankles in 3 patients had been overcorrected by about 6 degrees. No corrective osteotomies were performed.

There was 1 complication of an operative site infection in a patient who had also undergone a tendon transfer. The infection was located at the separate incision site of the transfer and resolved uneventfully with antibiotics. There were no other complications such as hardware infection, neurovascular injury, compartment syndrome, or joint injury.

Discussion

Phemister pioneered hemiepiphysiodesis in 1933 with a permanent technique using a bone graft across the physis.[13] Haas discovered reversible growth restriction by accident in 1945 while using tensioned loop wires across growth plates in animals, and he subsequently performed the first successful reversible growth restriction surgery in humans.[8,13] Blount and Clarke used staples across the physis for growth restriction in 1949 and later developed the "Blount staple" in 1953.[13] In 1997, Stevens and Belle[16] reported the use of transphyseal screws and in 2007 Stevens et al[19] reported the use of tension band plates.

Historically, in neuromuscular patients, fibular Achilles tenodesis has been used successfully to treat ankle valgus deformity. However, this surgery is more complex and is done in younger patients because of slower deformity correction.[17] If ankle valgus is left untreated, it can lead to difficulty with ambulation because of loss of range of motion, changes in gait, and arthritis. Most recently, a transphyseal screw has been used across the medial malleolus for temporary hemiepiphysiodesis.[5,11,16] This is our technique of choice because it is quick, simple, and has low risk of complications. However, the downside is that when one applies a rigid restraint across a physis, the implant can bend, break, or migrate, making it difficult to remove the hardware (Figure 5).[20,22] Westberry et al[22] showed that complications for screw removal increased when screws had been placed for longer lengths of time and if patients were younger. These complications led to increased exposure, longer operations, and need for additional equipment.[22] This may result in a need for corrective osteotomy in patients who fail to return for a timely follow-up.

Our data support that a transphyseal medial malleolar screw can be an effective method of temporary hemiepiphysiodesis for the treatment of valgus ankle deformity (Figure 5). In 20 of 34 cases (60%), a neutral ankle was achieved. In the remaining 14 cases, partial correction near neutral was achieved. The rate of overall correction was higher in the 5 MHE patients and was also noted to peak around 10-11 years of age (Figures 6 and 7). The slowest

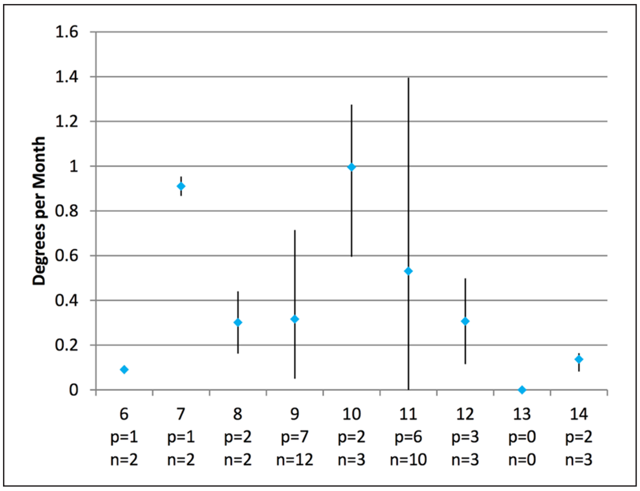

Figure 7. Rate of correction by age. The blue diamonds indicate the average rate of correction, and the corresponding vertical line indicates the range.

rate of correction was in the spina bifida patients (Figure 6). Rupprecht et al in a study with 79 patients (125 ankles) showed that LDTA normalized to 89 degrees (range 73-97) after screw placement with an average rate of correction of 0.65 degrees.[12] They also reported the highest rate of correction in patients with clubfoot and lowest in meningomyelocele. Chang et al[4] reported that patients with cerebral palsy had the fastest correction rate, and spina bifida was the slowest rate of correction with MHE in between. In our study, the average correction for patients with spina bifida was 8.3 degrees compared with 13.4 as seen by Bayhan et al.[2] Fibular station was not significantly affected using this method.

The advantages of the transphyseal screw technique include less metal prominence at the medial malleolus, decreased risk of skin irritation, and faster time to deformity correction.[5,6] This method can be advantageous in patients wearing braces. Only 1 patient in the current study had screw removal due to irritation from the screw head.

Limitations of the study include a small sample size, the retrospective nature of the study, lack of randomization, lack of bone age use, and lack of a comparison group.

Conclusions

Medial malleolar transphyseal screw hemiepiphysiodesis is a simple, effective, and safe treatment for valgus ankle deformity in skeletally immature children.

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Ethical Approval

This study was reviewed and approved by the Penn State Hershey IRB (003811).

Declaration of Conflicting Interests

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