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Supramalleolar wedge osteotomy: a method of correcting fixed equinus and associated deformities in children☆

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Abstract

Patients with fixed equinus and associated angular and rotational deformities, who have had multiple previous surgeries, present a significant challenge to the orthopaedic surgeon. We chose to correct these deformities with supramalleolar extension wedge osteotomies in 21 feet in 13 patients between 1991 and 2002. The median age at presentation was 11 years (range: 2–17 years). An average correction of 20° of extension (range: 10–33°) was required to achieve a plantigrade foot. Fourteen of 20 feet (70%) remained plantigrade at a mean follow-up of 6 years. Unlike traditional procedures such as triple arthrodesis and talectomy, this technique preserves preoperative mobility, avoids shortening of the foot, and restores a plantigrade and functional attitude.

Keywords: Supramalleolar osteotomy; Resistant clubfoot; Arthrogryposis

1. Introduction

Management of residual fixed equinus deformity presents a formidable problem. These feet are frequently stiff, deformed, and scarred by previous failed soft tissue surgeries. Orthoses and casts are ineffective and may be associated with pressure sores, ulcers, and even osteomyelitis [1]. Further soft tissue releases usually fail and may worsen stiffness. Traditional salvage procedures for this deformity include triple arthrodesis and talectomy. Arthrodesis increases foot stiffness and shortening, and imposes abnormal stresses on the midfoot and ankle joints that can lead to early degenerative disease, and ultimate failure. Talectomy does not guarantee a plantigrade attitude, shortens the foot, does not correct all deformities and is prone to relapse [2]. Painful degeneration frequently occurs at the tibiocalcaneal joint. The Ilizarov distractor has also been utilized to correct equinus deformity, but has been associated with pin tract infections, increased stiffness, and occasional distal tibial growth plate disturbance [3]. Supramallaleolar osteotomy avoids these shortcomings by correcting deformity above the ankle joint, thus maintaining foot length and mobility.

2. Methods

We reviewed 20 feet in 12 patients with fixed equinus and equinovarus deformities who had undergone supramalleolar wedge osteotomy from 1991 to 2002. Five patients were arthrogrypotic (9 feet), four had classic resistant clubfeet (6 feet), one had spastic diplegia (2 feet), one had thrombocytopenia-absent radius (TAR) syndrome (2 feet), and one had diastrophic dysplasia (1 foot). There were five boys and seven girls in this series. The median age at the time of surgery was 10 years (range: 2–17 years). The mean range of ankle motion preoperatively was 10° (range: 0–20°). There was associated rigid varus in 14 feet and internal rotation in 9 feet. Residual forefoot adduction was present in nine feet. Eight feet were associated with ipsilateral knee contractures greater that 20°.

All feet had undergone an average of two procedures prior to presentation (range: 1–5 procedures). Although the exact nature of these procedures was unclear because many were performed at outside institutions, most procedures in-

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volved soft tissue releases. Bilateral talectomies had been previously performed in the girl with diastrophic dysplasia. One arthrogrypotic patient underwent previous bilateral extension supramalleolar osteotomies at the age of 3 years. Her equinus deformity relapsed in both feet at 10 years, when she presented for repeat supramalleolar osteotomies.

After informed consent was obtained, a midthigh tourniquet was applied and surgery was performed under general anesthesia. The distal tibia was osteotomized just superior to the growth plate through an anteromedial approach. An oblique fibular osteotomy was performed separately at a slightly higher level to allow adequate motion at the tibial osteotomy but provide some stability. Rotation was corrected first. Equinus was then addressed by an anterior tibial wedge resection (Fig. 1). When necessary, the wedge was angled anterolaterally to correct varus alignment. The osteotomy was fixed with two smooth crossed percutaneous Steinmann pins. The pins were bent and cut outside the skin and a long leg cast was applied (Fig. 2a and b). External fixation was used in one patient with diastrophic dysplasia, where calf bulk and a short foot precluded casting (Fig. 3).

Supramalleolar osteotomy can produce a plantigrade foot attitude, but does not address metatarsus adductus, cavus, or toe flexor contractures. For this reason, basal metatarsal osteotomies were performed in nine feet to correct residual forefoot adduction and rotational deformities. Additional limited soft tissue procedures were performed in six feet. These corrections included distal toe flexor tenotomies in 3 feet (2 patients), plantar fascia releases in 2 feet (1 patient), and abductor hallucis recessions in 2 feet (1 patient) (Table 1).

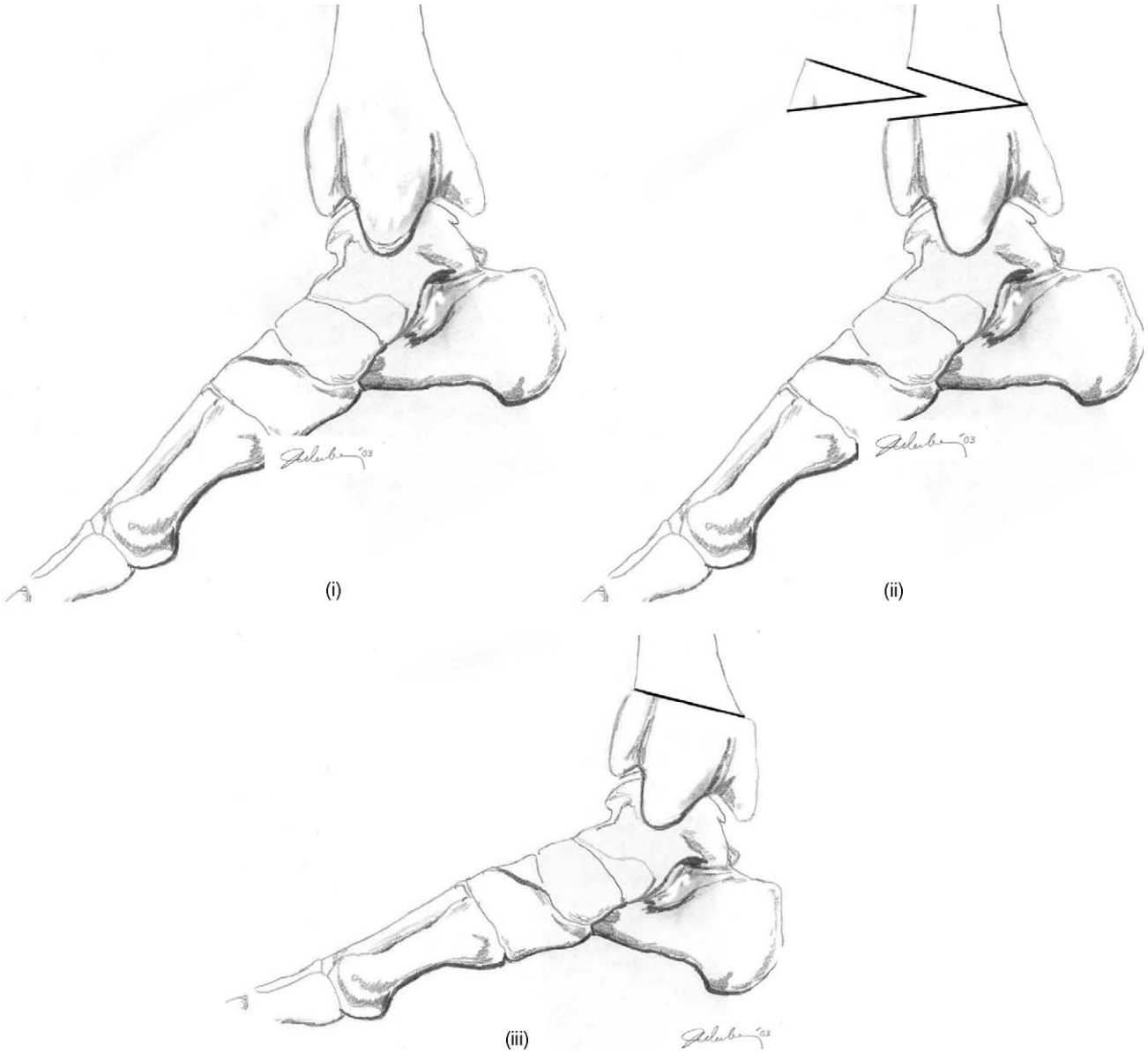

Fig. 1. (i, ii, iii) Supramalleolar wedge osteotomy to correct equinus deformity is demonstrated.

Fig. 2. (a) Radiographs demonstrate the tibial osteotomy held with crossed Steinmann pins and a long leg cast in a 14-year-old girl with spastic diplegia. (b) Repeat radiographs are performed 1 year later, demonstrating a healed osteotomy.

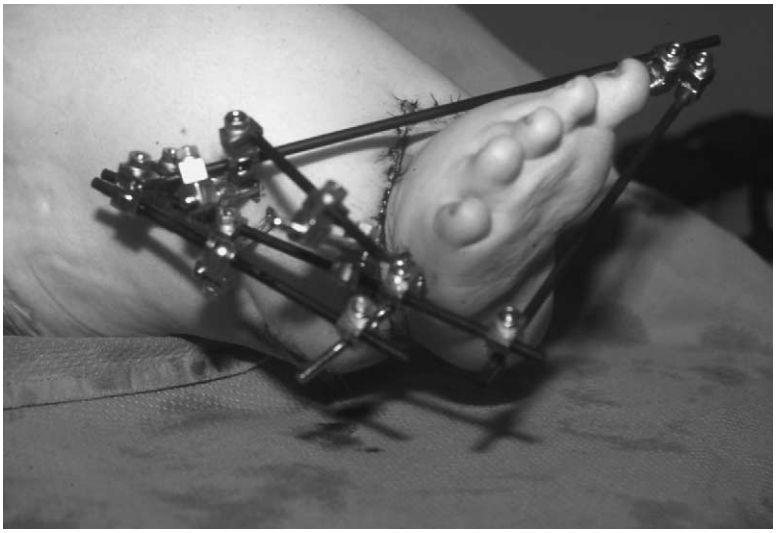

Fig. 3. External fixation is used to maintain the supramalleolar wedge osteotomy in a patient with diastrophic dysplasia.

In this series, eight knee contractures in four patients were treated concurrently at the time of supramalleolar extension osteotomy. Correction was achieved by four extension distal femoral osteotomies (2 patients), two proximal hamstring releases (1 patient), and two manipulations with extension casting and subsequent wedging (1 patient). These procedures helped achieve sagittal balance.

Some angular deformity of the distal tibia was accepted to achieve a plantigrade foot. Patients and their parents accepted this as a prerequisite for obtaining a functional and plantigrade foot.

All patients were initially kept non-weight bearing until early callus appeared radiographically, generally at 4 weeks. The long leg cast and pins were then removed, and patients were placed in a short leg walking fiberglass cast. This cast was maintained until the osteotomy was healed radiographically and clinically. Following removal of the cast, the plantigrade attitude was maintained by a dynamic dorsiflexing night ankle-foot orthosis during the growth years (Fig. 4). This orthosis is cut out posteriorly to permit dorsal hinging, and dorsiflexion is held by medial and lateral adjustable straps from the metatarsal heads to the top of the orthosis.

Table 1
Summary of corrections in addition to distal tibia extension

Case	Diagnosis	Age (years)	Side	Valgus	External rotation	Metatarsal osteotomies	Soft tissue procedures
1	Arthrogryposis	10	R	Yes	Yes	Yes	No
2	Arthrogryposis	2	R	No	No	No	No
			L	No	No	No	No
3	Arthrogryposis	10	R	Yes	No	Yes	No
			L	Yes	No	Yes	No
4	Arthrogryposis	14	R	Yes	No	No	No
			L	Yes	No	No	No
5	Arthrogryposis	10	R	No	Yes	No	No
			L	No	Yes	No	No
6	Idiopathic clubfoot	6	R	Yes	Yes	Yes	No
7	Idiopathic clubfoot	5	R	No	Yes	Yes	Yes[a,b]
			L	No	Yes	Yes	Yes[a,b]
8	Idiopathic clubfoot	15	L	No	No	Yes	Yes[c]
9	Idiopathic clubfoot	14	R	Yes	No	No	No
			L	Yes	No	No	No
10	Diastrophic dysplasia	10	R	Yes	Yes	No	No
11	TAR	17	R	Yes	Yes	No	No
			L	Yes	Yes	No	No
12	CP-diplegic	14	R	Yes	No	Yes	Yes[c]
			L	Yes	No	Yes	Yes[c]

[a] Plantar fascia release.
[b] Abductor hallucis recession.
[c] Distal toe flexor tendon tenotomies.

Fig. 4. Dynamic dorsiflexing night ankle-foot orthotic used in the post-operative protocol.

All patients were followed clinically to assess possible recurrence of deformity. Patients and parents were also asked to complete a subjective questionnaire. They scored their mobility, before and after surgery, on the following scale: 0 for wheelchair bound, 1 for standing only, 2 for household ambulation, 3 for community ambulation with pain, 4 for unlimited community ambulation, 5 for unlimited high impact activity. The questionnaire addressed satisfaction and cosmesis on a 0 to 10 score. Patients were also asked whether they would repeat the procedure.

Fig. 5. (i, ii, iii) A 17-year-old girl with TAR syndrome presented with bilateral fixed equinus deformities, and associated internal tibial torsion and heel varus. Feet are plantigrade at 3 years follow-up.

Fig. 6. Range of motion is maintained in a 10-year-old arthrogrypotic girl after supramalleolar extension osteotomy.

3. Results

A plantigrade and aligned foot was achieved in all feet at the time of surgery. The mean correction was 20° of extension (range: 10–33°). All osteotomies healed uneventfully. The average period of immobilization was 10 weeks (range: 8–12 weeks).

There were no major complications with either the cast and Steinmann pins or the external fixator. These techniques were well tolerated by all the children and none of the parents requested premature cast removal. The only minor complication in this series was a single Steinmann pin tract infection that was treated effectively with oral antibiotics and early pin removal through a cast window.

At a mean of 6 years follow-up (range: 3–12 years), 14 of 20 feet were plantigrade (Fig. 5). Both feet in two children with arthrogryposis, ages 2 and 10 at surgery, had equinus recurrence. The two feet of a 5-year-old boy with idiopathic clubfoot also relapsed. Radiographically, bony remodeling at the distal tibia occurred in these patients.

The mean ankle range of motion was 10° (range: 0–20°) at follow-up, unchanged from preoperative assessment (Fig. 6). Furthermore, previous skin callosities had all resolved. No patient complained of pain in the ankle or foot.

Ten of 12 patients responded to the questionnaire on 17 feet. Nine of 10 patients reported improvement of at least one level of mobility. Three of 10 patients no longer require the use of orthoses for ambulation. Two patients are currently able to participate in high impact athletic activities. The average satisfaction score was 8.8 and the average cosmesis score was 8.2. Nine of 10 patients surveyed would repeat the procedure.

4. Discussion

Triple arthrodesis has been utilized to correct residual equinus deformity in children who have had previous unsuccessful soft tissue releases. This procedure, however, does not correct the equinus heel attitude. Furthermore, significant complications have been reported. Nonunion and malunion was seen in 12% to 16% of feet, requiring subsequent revision surgery. The foot was shortened 0.75 to 0.81 in. [2,4]. In one series, avascular necrosis of the talus was seen in two arthrogrypotic feet, both of which required extensive talar resection [2]. Stress on adjacent non-fused joints may lead to early arthritis, pain and a poor result [5].

Talectomy has also been associated with complications. Legaspi and colleagues followed clubfeet corrected by talectomy after 20 years. Deformity recurred in 67% of feet. Further complications were tibiocalcaneal arthritis in 33%, and spontaneous fusion of tibia to calcaneus in 29%. One quarter of these patients experienced some pain at follow-up [6]. Ankle fusion may be necessary to salvage severe calcaneovalgus and calcaneovarus deformities, and significant tibiocalcaneal subluxation [2].

The Ilizarov method has been used to correct rigid equinovarus deformity through gradual distraction. Additional osteotomies may be required in older children. This method avoids tibial malalignment. However, in Paley's series, correction by this technique required an average of 6.4 months and was associated with 20 complications in 18 feet [7]. Pin tract infections and stiff feet with possible intertarsal fusion were commonly seen with this application of the distractor. Less common complications include anterior subluxation of the talus and partial separation of the distal tibial physis [8–10].

Correction by supramalleolar wedge resection osteotomy accepts the deformity in the foot and achieves correction above the ankle joint. This technique avoids many of the complications inherent in other methods. Morbidity is low and the osteotomy is easily performed. Cancellous bony union is reliable and rapid in the supramalleolar region [11]. This series confirms consistent bony union.

Supramalleolar osteotomies have been successfully performed for rotational and varus-valgus deformities [11–14]. External rotation osteotomy in the supramalleolar region has been used to treat equinovarus deformities [15]. Isolated ro-

tational correction of this type may worsen function and does not correct deformity [16]. In our series, associated equinus is specifically addressed by dorsiflexing wedge resection.

We report relapse in two arthrogrypotic children and one 5-year-old child with idiopathic clubfoot. The younger of the arthrogrypotics was 2 years of age. He was lost to follow-up for 1 year, and during that period, he had no physical therapy and no night splinting. Given the patient's age and ability to remodel bone, we were not surprised by this relapse. The uncontrolled muscle imbalance of arthrogryposis may produce relapse, even in a child as old as 10 years. We believe that proper night splinting may prevent relapse, even in arthrogryposis. Napiontek and Nazar believe that this osteotomy works best in the older child [17]. In this series, however, we have demonstrated that with aggressive post-operative care, this procedure was effective in a 6-year-old child with clubfoot.

The timing of supramalleolar osteotomy is a matter of surgical judgment. Because remodeling may produce relapse, performing the osteotomy close to the end of growth is theoretically ideal. This does not help the young patient who is significantly handicapped by a fixed deformity that precludes ambulation. An early osteotomy that provides function is worthwhile even if repeat surgery is necessary later. The success of this strategy is clearly demonstrated by one of our arthrogrypotic patients, who maintain plantigrade feet 4 years after bilateral revision osteotomies.

We did not specifically examine the limits of tibial angulation that is acceptable to correct equinus, rotation, and angular deformities. Patients with very severe deformities may not be candidates for correction by this method. We appreciate that the tibiotalar angle may be adversely altered by this procedure. However, most of the children in our series demonstrated stiff ankles that are unlikely to deteriorate with altered biomechanics. Degenerative changes in the ankle joints with symptoms are well documented in both talectomy and triple arthrodesis [5,6]. No patient in this series complained of ankle pain. In our experience, the knee and hip are able to compensate for any alteration in the sagittal mechanical axis.

Achieving plantigrade feet in this patient population requires salvage procedures that may create further deformities. We believe that tibial angulation is preferable to increased foot stiffness and shortening. There is no easy treatment for relapse after triple arthrodesis or talectomy. Should, however, tibial remodeling after supramalleolar osteotomy recreate an equinus deformity, a second osteotomy can be performed and has shown to be successful in this series. Supramalleolar osteotomy is presented as the most benign and potentially effective of this group of salvage operations.

Supramalleolar wedge osteotomy is an effective method for correcting recurrent equinus with associated rotational and angular deformities. This technique maintains mobility and restores a plantigrade functional foot. Based on improved mobility scores, supramalleolar osteotomy is a useful means of improving ambulation, even with severe deformity. Some tibial deformity is accepted to achieve a plantigrade foot. Metatarsal osteotomies may be required to correct associated metatarsus adductus and rotational forefoot deformities. The procedure is simple and is well tolerated. Compliance with dynamic night dorsiflexion ankle foot orthotics may prevent relapse of equinus deformity in the growth years.

This patient population suffered from significant equinus, varus, and rotational foot deformities. The advantage of achieving plantigrade and aligned feet far outweighed the potential malalignment of tibia and fibula and ankle joint tilt that may have been created. The post-operative course was short with few complications. Clinical success and quality of life improvement has been gratifying.

References

[1] Mirzayan R, Early SD, Matthys GA, Thordarson DB. Single-stage talectomy and tibiocalcaneal arthrodesis as a salvage of severe, rigid equinovarus deformity. Foot Ankle Int 2001;22:209–13.
[2] Galindo MJ, Siff SJ, Butler JE, Cain TE. Triple arthrodesis in young children: a salvage procedure after failed releases in severely affected feet. Foot Ankle Int 1987;7:320–5.
[3] Grill F, Franke J. The Ilizarov distractor for the correction of relapsed or neglected clubfoot. J Bone Joint Surg (Br) 1987;69B:593–7.
[4] Hill NA, Wilson HJ, Chevres F, Seterlitsch PR. Triple arthrodesis in the young child. Clin Orthop 1970;70:187–90.
[5] Mosca VS. The Foot. In: Morrisey RT, Weinstein SL, editors. Lovell and Winter's Pediatric Orthopaedics. 5th ed. New York: Lippincot Williams & Wilkins; 2001. p. 1153.
[6] Legaspi J, Li YH, Chow W, Leong JC. Talectomy in patients with recurrent deformity in club foot. J Bone Joint Surg (Br) 2001;83B:384–7.
[7] Paley D. Correction of complex foot deformities using Ilizarov's distraction ostetomies. Clin Orthop 1993;293:97–111.
[8] Bradish CF, Noor S. The Ilizarov method in the management of relapsed clubfeet. J Bone Joint Surg (Br) 2000;82B:387–91.
[9] Choi IH, Yang MS, Chung CY, Cho TJ, Sohn YJ. The treatment of recurrent arthrogrypotic clubfoot in children by the Ilizarov method. J Bone Joint Surg (Br) 2001;83B:731–7.
[10] Wallander H, Hansson G, Tjernstrom B. Correction of persistent clubfoot deformities with the Ilizarov external fixators. Acta Orthop Scand 1996;67:283–7.
[11] McNicol D, Leong JCY, Hsu LCS. Supramalleolar derotation osteotomy for lateral tibial torsion and associated equinovarus deformity of the foot. J Bone Joint Surg (Br) 1983;65B:166–70.
[12] Malhotra D, Puri R, Own R. Valgus deformity of the ankle in children with spina bifida aperta. J Bone Joint Surg (Br) 1984;66B:381–5.
[13] Mangone PG. Distal tibial osteotomies for the treatment of foot and ankle disorders. Foot Ankle Clin 2001;6:583–97.
[14] Sharrard WJ, Webb J. Supramalleolar wedge osteotomy of the tibia in children with myelomeningocele. J Bone Joint Surg (Br) 1974;56B:458–61.
[15] Lloyd-Roberts GC, Swann M, Catterall A. Medial rotational osteotomy for severe residual deformity in clubfoot. J Bone Joint Surg (Br) 1974;56B:37–43.
[16] Lichtblau SL. External rotation tibial osteotomy in clubfoot. Adverse late effects. Clin Orthop 1978;136:225–9.
[17] Napiontek M, Nazar J. Tibial osteotomy as a salvage procedure in the treatment of congenital talipes equinovarus. J Pediatr Orthop 1994;14:763–7.