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Talar and Calcaneal Y-Osteotomy with Distraction Osteogenesis for the Correction of Rigid Equinus

by Sutpal Singh, DPM, FACFAS[1], Albert Kim, DPM[2], Timothy Dailey, DPM[3], Long Truong, DPM[4], Maria Mejia, DPM[5]

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Types of equinus, surgical management for equinus involving the Y- talocalcaneal osteotomy supplementing an external fixation device is presented. A case report is introduced involving surgical correction of a 53 year-old male who had a severe equinus flat top talus with mild varus secondary to clubfoot surgery. Treatment included surgical correction utilizing Steindler stripping, Achilles tendon lengthening, and a rather rare Y- osteotomy of the calcaneus and talus with the use of a multiplaner external fixator in an unconstrained system to correct the equinus and varus deformity. Slow distraction was performed in order to decrease the risks of having neurovascular injury, soft tissue injury, and shortening of the foot. After months of follow-up, there was good healing of the osteotomy sites and the patient had a plantigrade foot.

Key words: Clubfoot, Rigid Equinus, Flat top talus, Y-Osteotomy, External fixation, Distraction Osteogenesis, Ilizarov method.

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Ankle joint equinus can be divided into a three types; soft tissue, osseous and a combination of the two.[1] Soft tissue equinus alone can be easily repaired, but when multiple deformities occur such as clubfoot, it can complicate the treatment.

Address correspondence to: Sutpal Singh, DPM, FACFAS, Chief Ilizarov Surgical Instructor at Doctors Hospital West Covina, Fellow of the American College of Foot and Ankle Surgeons, Private practice in Southern California.

1 Chief Ilizarov Surgical Instructor at Doctors Hospital West Covina.CA. Fellow American College of Foot and Ankle Surgeons. Private practice in Southern California
2 PM&S 36, R3 (Foot and Ankle Medicine and Surgery) Doctors Hospital of West Covina.
3 PM&S, R2 (Foot and Ankle Medicine and Surgery) Doctors Hospital of West Covina.
4 PM&S, R1 (Foot and Ankle Medicine and Surgery) Doctors Hospital of West Covina.
5 PM&S, R1 (Foot and Ankle Medicine and Surgery) Doctors Hospital of West Covina.

The etiology of ankle equinus can include trauma, diabetes mellitus, poliomyelitis, osteomyelitis, contracture from burns, neglected or relapsed clubfeet, prolonged immobilization in plantarflexion, as well as neuromuscular disease.[1,3,7]

Traditionally, correction has been managed through arthrodesis and extensive soft tissue release. Treatments for soft tissue ankle equinus include procedures such as splinting, tendo-Achilles lengthening, gastrocnemius recession, and rare deformities such as accessory soleus release.[10,13] Neurovascular, soft tissue problems and shortening of the foot may occur with traditional techniques. Also, prior surgeries may make the surgical management of the foot deformities more difficult later in life.

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An Ilizarov external fixator can be used to correct equinus and it can be applied in two ways; constrained and unconstrained. The constrained technique places the axis of rotation at a planned anatomical axis of the joint.[9] The constrained technique can correct deformities within the joint unlike the unconstrained that keeps the natural axis of rotation. The unconstrained technique places the axis of rotation around the natural axes of the joint.[9] The unconstrained technique requires distraction of the ankle joint before an attempted correction.

The Ilizarov external fixator can be used to correct equinus without an osteotomy, only when the equinus is soft tissue in nature. Only correcting the soft tissue deformity with an Ilizarov frame has a high recurrence rate.[3] When dealing with an osseous equinus an osteotomy must be performed and Ilizarov used the process called distraction osteogenesis to correct the deformity.[18] "*Gradual distraction of the soft tissues and bones enables reshaping of the foot.*"[8] The Ilizarov technique can fix these deformities with minimal incisions. The downside to this is the patient has an external fixator for several months. During this time the patient may bear weight on the area which has an advantage over internal fixation. Another advantage is during osseous correction it can also correct for soft tissue deformities at the same time.

There are three main types of Ilizarov rearfoot osteotomies including the U, V and Y osteotomies.[9] The Y- osteotomy is the least published of the three. The Y is an osteotomy through the neck of the talus and an osteotomy of the posterior calcaneus below and parallel to the subtalar joint making an apex in the anterior calcaneus and then an osteotomy plantarly thus creating the shape of a "Y".[9] The Y- osteotomy has the same implications as the V- osteotomy except it doesn't elongate the foot as much.[9] The Y-osteotomy with external fixation allows small changes each day to allow the new bone to form and correct the deformity. This osteotomy allows correction of complicated equinus cases. Which osteotomy is chosen depends greatly on the surgeons' experience.

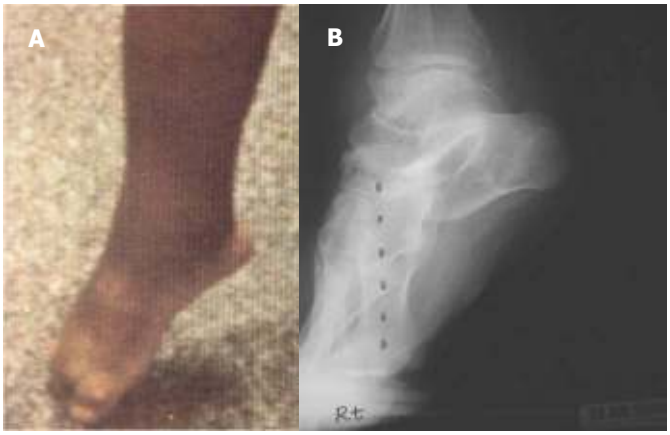

Figure 1A and 1B Preoperative photo (A) and radiograph (B) showing ankle equinus deformity.

Case Report

A 53 year-old male was seen in the office due to severe pain around the sub right 4th and 5th metatarsals. The patient had an equinus deformity of the right lower extremity with varus deformity. (Figs. 1A and 1B) His past surgical history was significant for club foot surgery when he was 4 years-old, which still left him ambulating on the ball of his right foot. The rest of the history was unremarkable.

Physical exam showed that he had scar tissue around the medial, lateral, and posterior heel on the right foot. The positioning of his right lower extremity included a tight contracted Achilles tendon that correlated with a rigid equinus deformity, varus of the foot with subtalar joint stiffness with no range of motion at the mid foot, rear foot and ankle. Also, there were contractures of all the digits. There was no leg length discrepancy noted and the length of the foot was within normal limits. The patient had difficulty wearing shoes and could only wear sandals. There was increased pain under the right 4th and 5th metatarsophalangeal joints due to the excessive pressure while ambulating secondary to the rigid equinus and inversion of the foot. This, in effect, was placing too much pressure on his 4th and 5th metatarsal heads.

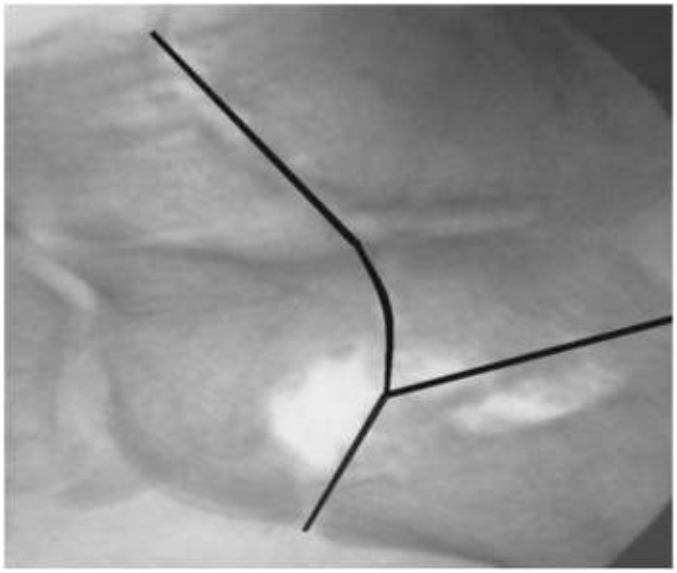

Figure 2 Intra-operative radiograph of the Y-osteotomy. The left side of the Y is the Talar neck osteotomy, the right side of the Y is the calcaneal osteotomy below the subtalar joint and the stem of the Y osteotomy is located at the distal calcaneus.

The procedure that was performed included a Steindler stripping, an Achilles tendon lengthening, talar and calcaneal Y-osteotomies, plantar tenotomy of all five digits, and the application of an Ilizarov external fixator.

The patient was prepped and draped in the usual standard manner. No tourniquet was applied. A # 15 blade was used to perform a percutaneous tendon lengthening of the Achilles Tendon. The foot was only able to dorsiflex several degrees due to the severity of the deformity from negative 45 to negative 40 degrees. Along the plantar medial calcaneus a Steindler stripping was then performed. This helped release all the fascial and muscular contractions on the plantar foot from the calcaneus. A prophylactic tarsal tunnel release was also performed by transecting the laciniate ligament. Two tibial rings were then applied to the lower leg. One half-ring was applied to the calcaneus and one half-ring was applied to the distal foot. All wires were then tensioned appropriately. The calcaneal half-ring was attached to the posterior tibial ring. The distal foot half-ring was then connected to the anterior tibial ring.

Figure 3 Initial frame placement at the time of the surgery.

The calcaneal ring was then connected to the distal foot half ring. All connections had distraction capability to correct the foot in three dimensions. Prior to any distraction, using flouroscan [fluoroscan] a small incision was made at the medial aspect of the talar neck. The incision was deepened to the subcutaneous tissue and then to the periosteum of the talus. A small osteotome was then used to perform a complete osteotomy of the talar neck. Along the lateral aspect of the calcaneus a small incision was made parallel and inferior to the subtalar joint. The incision was deepened to the subcutaneous level and then to the periosteum of the calcaneus. A small osteotome was used to perform a complete osteotomy of the calcaneus 1 cm posterior and inferior to the subtalar joint. Along the anterior aspect of the calcaneus a small incision was made 1 cm proximal to the calcaneal cuboid joint. The incision was deepened to the subcutaneous level and then down to the periosteum of the calcaneus. A small osteotome was inserted down to bone and rotated being careful not to transect the peroneal tendons or sural nerve. A complete osteotomy was then performed at the distal calcaneus. (Fig. 2)

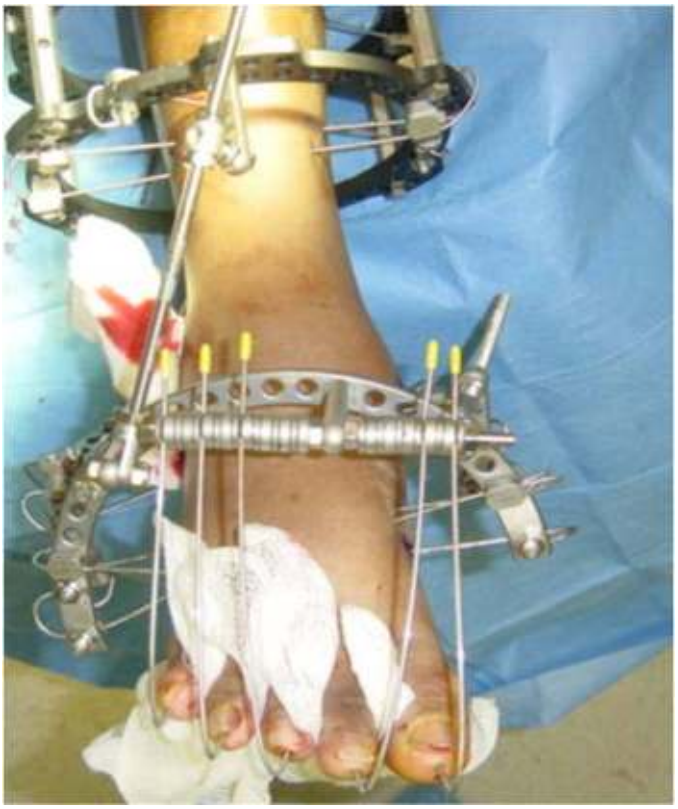

Figure 4 Note the rod rotating the distal ring out of varus and dorsiflexing it.

Note that a void was created while removing the osteotome at the stem of the osteotomy. This eventually healed well due to the vascular nature of the calcaneus. All surgical sites were irrigated with normal saline and bacitracin and sutured with 3-0 Prolene. Attention was then directed to all the plantar toes and plantar flexor tenotomies were then performed and smooth wires were then inserted and attached to the distal half ring. The surgical site was then dressed with Adaptic, gauze and Kerlex. (Figures 3, 4, 5A, 5B, and 6)

At one week, the following manipulations to the bones in the external fixator were initiated: 1) distraction of the calcaneus towards eversion and inferior displacement, 2) rotation of the distal foot towards eversion and dorsiflexion, 3) distraction of the forefoot from the rearfoot.

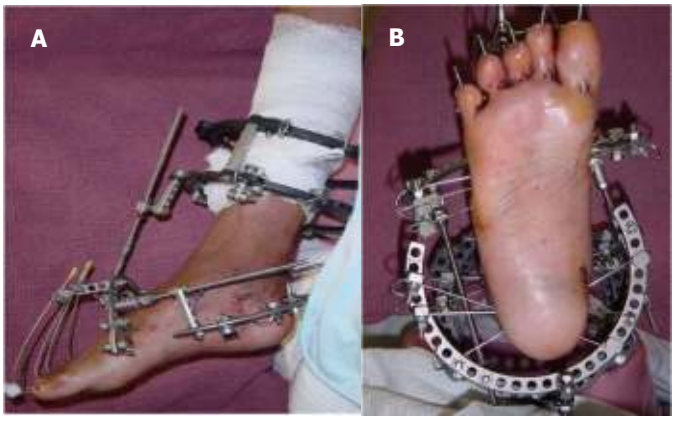

Figure 5A and 5B Note that the forefoot and rearfoot can be manipulated independent of each other. Note the wires from the toes being attached to the forefoot half ring. (A) The plantar view showing the percutaneous plantar tenotomies of all the toes with wires going into the metatarsals and attached to the foot half ring. (B)

Figure 6 The post-operative radiograph.

Figure 7 More rods were applied for more distraction at 3 weeks after surgery.

The patient was instructed to increase the movements by a total of 1 mm per day achieved by a ¼ turn of the distraction mechanism 4 times per day. The patient was taken back to the OR at week 3 (Fig. 7) and at week 8 (Fig. 8) for the addition of extra rods and bars for greater manipulation and a better line of pull. At week 12, there was good alignment of the foot in a plantigrade position and at week 20, the external fixator was removed. (Fig. 9) At 6 months, the patient was ambulating in a custom made AFO. (Fig. 10)

Figure 8 At 8 weeks , the patient had more bars and rods added with frame manipulation.

Overall, the patient was able to ambulate with the heel on the ground with minimal pain; however, did not have much range of motion at the ankle or foot. All the pain under the lateral forefoot resolved. The patient was satisfied with his plantigrade foot and able to ambulate with a custom AFO.

Discussion

There are multiple surgical procedures available for correction of acquired ankle equinus, soft tissue as well as bone procedures.[1,2,4] When this deformity becomes fixed it poses a challenge to many foot and ankle surgeons due to soft tissue contraction and bony adaption and requires a combination of soft tissue and bone procedures.[1,2,4] Flexible deformities can be treated with manipulation methods thus preventing surgery.

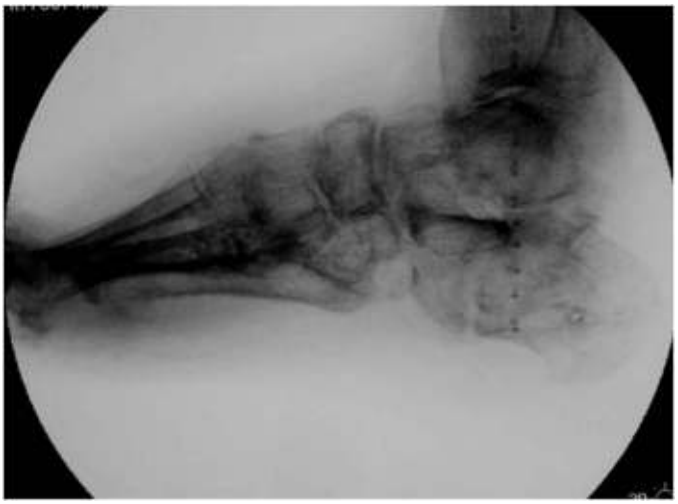

Figure 9 At 5 months the frame was removed and the patient was placed in a below the knee cast.

When manipulation methods don't work then surgery is required. Surgical correction consisting of extensive soft tissue releases with and without arthrodesis for equinus deformity has been well described.[15] Different osteotomies with and without an external fixator have been described in literature for correction of complex foot deformities.[9,11,14,16,17,20]

Correcting deformities such as clubfoot become a challenge especially after failed surgeries due to stiffness of the soft tissues and residual deformities such as equinus.[16,17] There are several osteotomies and a few of the commonly discussed ones are the U (Scythe-shaped), V, and less commonly discussed Y-osteotomy.[16,17]

The scythe-shaped (U) osteotomy is a curved osteotomy that divides the foot into two sections. It starts posterior to the lateral malleolus and runs from 1-1.5 cm below the posterior subtalar joint, then penetrates the floor of the sinus tarsi and emerges at the talar neck.[9,11] This type of osteotomy allows for correction of equinus with a rigid tibio-talar joint.[9]

Figure 10 At 6 months, the patient had his foot plantigrade and was full weight bearing in a custom made AFO.

The V - osteotomy is a combination of oblique cuts that are angled at 60-70 degrees.[9] The osteotomy is performed along the posterior calcaneus and the anterior calcaneal-talar. This type of procedure is indicated for treatment of complex deformity of the hindfoot and the midfoot.[9,11,19,20] The V- osteotomy offers versatility when combined with an external fixator because it has the ability to preserve foot length and perform simultaneous tibial corrections.[20]

The Y - osteotomy is similar to the V - osteotomy in a sense that it allows one to apply differentiated correction between the hindfoot and the forefoot. The osteotomy results in a three ray star that is all 120 degrees apart. The osteotomy is first performed at the oblique posterior aspect of the calcaneus, then a vertical osteotomy of the calcaneus, and finally the calcaneal-talar ostetomy.[9] This type of procedure allows for the same correction as the V - osteotomy but with fewer complications.[9]

The hinges are positioned on the medial and lateral threaded rods of the calcaneal half ring. The equinus is corrected by lowering the calcaneus and raising the forefoot in relationship to the talar body.[9] Correction is achieved through the movement of the fragments of the osteotomy with the majority of correction of the calcaneal and talar equinus.[9,14] The Y - osteotomy does not cause any skeletal lengthening as with the scythe-shaped osteotomy, therefore it offers three advantages.[9] The advantages include faster consolidation because of less bone regeneration, skin alteration is easily contained, and prevention of calcaneocuboid diastasis is unnecessary.[9]

The Ilizarov method with external fixation was chosen for the correction after performing the osteotomy because it enables correction in all three orthogonal planes.[4,9,11,14,17] Using an external fixator is not only minimally invasive, but it also allows the surgeon to stage the treatment appropriately to manipulate the rate and direction of the correction. It can be used as either a constrained or unconstrained hinge system. In the constrained foot frame, forces applied to the foot are directed around the axis.[14] This technique is usually reserved for large joints. In the unconstrained system, joints of the ankle and the foot are used as the fulcrum points for correction and it is usually used with smaller joints or deformities with multiple joint axes.[14]

The Steindler stripping procedure is recommended for patient with significant contractures of the plantar aponeurosis and plantar musculature.[1] The abductor hallucis, flexor digitorum brevis, and abductor digiti quinti are released from the periosteum of the calcaneus. However, this procedure is limited in that it does not correct fixed deformities and only corrects in the sagittal plane.[1]

The complications associated with the use of an external fixator and any type of osteotomy includes tarsal tunnel syndrome, neurovascular symptoms, pin tract infection, flexor contractures, valgus drift, incomplete osteotomy, residual deformity, and recurrence of problem.[4,9,11,14,16,17,19,20]

Due to such complications, it has been recommended that a prophylactic tarsal tunnel release be performed to decrease the likelihood of nerve entrapment secondary to the correction and to minimize the risk of vascular injury.[16] There is a high incidence of nerve injury as a result of acute angular deformity correction.[20] If compressive symptoms of the tibial nerve are experienced during the correction, it can be addressed either by performing a secondary surgical decompression or by decreasing the rate of correction.[11,14] Pin tract infection and flexor contractures are usually secondary to prolonged fixator utilization.[19,20] Pin tract problem are related to skin motion and controlled with local pin site care. Pin tract infections are minor complications that occurs with any type of external fixator but respond very well to oral antibiotics and rarely lead to osteomyelitis requiring pin removal.[17,20] Premature consolidation of the osteotomy before full correction is reached is also not an uncommon complication. To avoid this problem, it is recommended to start distraction routinely on the third postoperative day.[16]

Despite such complications, the Ilizarov technique remains an effective and safe tool for complex lower limb reconstruction surgery. It allows corrections in all planes at a rate that can be tailored to the deformity without the constraints of traditional methods.

When looking back at the literature regarding the Y-osteotomy there is not much to be found. Our case presentation is unique that to our knowledge there are no other journal articles on which a y calcaneal osteotomy is used in conjunction with an Ilizarov distractor. Furthermore there is close to no literature regarding the Y- osteotomy. In the literature the main focus has been on correcting the structural equinus foot by using the V.[16,17] Also there has not been another study in which the y osteotomy is used in conjunction with the Ilizarov distractor. In our case study we found that the Y- osteotomy allows for correction of a severe deformity while minimizing neurovascular and soft tissue complications as well as avoiding excessive shortening of the foot as is many times encountered with traditional techniques.

Traditional methods although successful with certain patients they involve much more cut in the bone which can lead to excessive shortening and soft tissue complications. Our case report helps to illustrate a successful way in which a rigid equinus can be corrected by the use of an under researched osteotomy with gradual distraction of the structures in the foot. In our case the patient was satisfied with his plantigrade foot even though he did not have much range of motion at the ankle or foot. This view is supported by other studies in which patient satisfaction is achieved with improvement in appearance of the foot.[6,16,21]

Conclusion

In this case study, we presented a rigid equinus foot that was corrected with the use of a Y - osteotomy along with the use of Ilizarov methodology. There is limited literature based on the usage of the Y - osteotomy even though it has three main advantages which are: faster consolidation, skin alterations are easier to contain, and there is less chance of calcaneal-cuboid diastasis.[1] Furthermore, the Y - osteotomy avoids excessive lengthening of the foot. Correction of severe foot deformities with the Ilizarov method is technically difficult but when used with the Y - osteotomy, differentiated correction between the hindfoot and forefoot can be applied. In the case study it was successfully shown that the Y - osteotomy allows for correction of a severe deformity while minimizing neurovascular and soft tissue complications as well as avoiding excessive shortening of the foot as is many times encountered with traditional techniques. The final result was a plantigrade foot. Thus, the Y - osteotomy through the talus and calcaneus with distraction osteogenesis using the Ilizarov methodology is an effective surgical procedure in correcting rigid equino-varus foot deformities.

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