CHAPTER 7

THE CLUBFOOT EXPERIENCE OF GUATEMALA

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The authors will present their thoughts and experiences associated with the neglected clubfoot deformity in young children. The information was obtained while on annual voluntary pediatric surgical missions to Guatemala over the past five years.

After participating in a general orthopedic mission to Guatemala in 1992, the senior author was prompted by the Pediatric Liaison of Guatemala to form a foot, ankle, and lower extremity surgical team to deal with the numerous deformities prevalent in the pediatric population. The team was appropriately named "Small Steps" by Dr. Paul Quintavalle, who was instrumental in the support and growth of the team by contributing funds from the West Jersey Health Systems Residency Program.

GUATEMALAN DEMOGRAPHICS

Guatemala is a country struggling to overcome its recent civil war. Like most Central American countries, there is no middle class. The upper class consists of approximately 15% of the country's population, while the remaining 85% are extremely poor. Guatemala is the most populous country in Central America with 7.5 million people. The population continues to grow at a rate of 3.1% annually (compared to 0.9% in the U.S.). The population density is approximately 123 people per square mile as opposed to 58 per square mile in the U.S. Guatemala is slightly smaller than the state of Tennessee.

Approximately 59% of the people are Ladinos, a mix of Spanish, Indian, and westernized Indians. The rest of the population are Indians. Family incomes vary greatly, averaging $325 per month in the city, and $60 per month in the rural areas. Half of the population is employed in agriculture. Annual inflation is over 10% compared to 6% in the U.S., and unemployment ranges from 3% to 25% (compared to 8% in the U.S.).[1]

TEAM PHILOSOPHY

According to the World Health Organization, more than half of the world's population does not have access to adequate health care. "Small Steps" works through the organization *Healing the Children*. The philosophy of the organization is to secure and make available medical and surgical treatment from properly trained personnel to children of impoverished backgrounds. The team consists of anesthesiologists, certified nurse anesthetists, operating room nurses, podiatric surgeons, and residents. This volunteer team travels to countries in need, and provides its services to the children free of charge. The children are located by the country's liaison and are pre-screened by the appropriate orthopedic and pediatric physicians. This is a service-oriented program with emphasis on helping as many children and young adults as cost-effectively as possible.

CLUBFOOT

Definition

Clubfoot, known as Talipes equinovarus, is a term used to describe a combination of three deformities: ankle equinus, rearfoot varus, and forefoot adductus. Abundant literature attributing to the history, evolution, and current treatment concepts have contributed to a better understanding, more refined corrective techniques, and more predictable results. Significant advances have been made over the last twenty years in understanding the pathology and etiology of the deformity.

Clubfoot is classified as congenital or acquired. The sub-categories of congenital clubfoot are idiopathic (intrinsic/rigid and extrinsic/flexible), neurogenic (spinal defects such as myelomeningocele, spina bifida occulta, myelodysplasia), osteogenic, myogenic, cartilaginous, and collagenous. Acquired clubfoot is

divided into sub-categories of neurogenic (polio, cerebral palsy, meningitis) and vascular.[2] There seems to be a genetic preponderance as described by Cowell and Wein.[3]

Incidence

The clubfoot deformity exhibits varying incidence which ultimately depends on ethnic background. Depending on the literary source, the incidence in the United States varies from 1:1000 to 2.29:1000 live births.[4,5] When one child is born with a club-foot deformity, the chances of a sibling being born with the same deformity is 20 times greater.[5] Congenital clubfoot occurs twice as often in males, and is present bilaterally 50% of the time. Unilateral presentation has a predilection for the right foot. Different ethnic backgrounds produce varying incidences. The full-blooded Hawaiian records a 6.81:1000 incidence, the mixed Hawaiian 4.9:1000 incidence, South African black 3.50:1000, and the lowest incidence reported occurs in the Asian population at 0.57:1000.[6,7]

Historical Review

The history of clubfoot is a valuable component to any literary piece, as it exemplifies the evolution of thought processes regarding the cause of clubfoot and its treatment. Table 1 lists the actual historical events which have led to the current methods of treatment.

Table 1

HISTORICAL EVENTS LEADING TO CURRENT METHODS OF TREATMENT

400 B.C.	-	Hippocrates: relates clubfoot to intrauterine pressure, utilizes bandage manipulation.[8,9]
1743	-	Andre': described clubfoot, recommended gentle stretching.[10]
1782	-	Lorenz: performed subcutaneous Achilles tenotomy.[8]
1803	-	Scarpa: described pathologic twisting anatomy of navicular-calcaneal-cuboid joint on talus are caused by soft tissue contractures.[11]
1823	-	Delpech: performed subcutaneous Achilles tenotomy.[12]
1831	-	Stroymeyer: reinforced subcutaneous Achilles tenotomy.[13]
1838	-	Gue'rin: utilized plaster of paris to treat clubfoot.
1857	-	Solly: described cuboid decancellation procedure and called attention to the lateral border of the foot.[14]
1867	-	Lister: Aseptic technique. - Morton: General anesthesia.
1873	-	Esmarch: tourniquet.
1891	-	Phelps: reported plantar soft tissue incision and lengthening of tendon, osteotomy of the talar neck, and lateral wedge resection of calcaneus.[15]
1906	-	Codivilla: utilized soft tissue release and lengthening of all medial tendons, also included anterior tibial tendon.[16]
1920	-	Elmslie: recommended external correction of the clubfoot and included surgical correction by talar neck osteotomy.[17]
1930	-	Kite: repopularized non-operative treatment, gentle manipulation, and soft tissue stretching with casting.[18]
1937	-	Brockman: "congenital atresia of the talo-calcaneo-navicular joint.[19,20]
1947	-	McCauley: emphasized the importance of radiographic evaluation of the results after treatment.[21]
1960	-	Bost and associates: emphasized plantar dissection and posterior release.[22]
1971	-	Turco: one stage postero-medial release with internal fixation, subtalar release leaving the lateral capsule intact to produce hinge effect.[23,24,25]
1982	-	Crawford: transverse Cincinnati incision.[26]
1982	-	Mckay: releasing the lateral subtalar capsule for calcaneal rotation.[27]
1985	-	Simons: re-emphasized complete subtalar release for calcaneal rotation.[28,29]

Etiology

Several theories have evolved to explain the true etiology of congenital idiopathic clubfoot, but each theory remains inadequate to some degree. Irani and Sherman believe the talar head and neck deformity are a result of a primary germ plasm defect.[30] The developmental arrest theory states that embryological arrest occurs during the normal fetal development producing a clubfoot deformity.[31] Wynne-Davis conducted studies which led him to believe that clubfoot was caused by genetic factors and is an autosomal dominant trait.[32] The neurogenic theory states that there is an increase in the number of type I: type II fibers from 1:2 to 7:1 in clubfoot deformity, leading to contraction.[33,34] The myogenic theory speculates there is a defect in muscle and connective tissue,[35] whereas, the vascular theory states that there is hypoplasia or absence of the anterior tibial and dorsalis pedis arteries causing the talar deformity, since the anterior tibial artery supplies the talus.[36,37] Ippolito and Ponseti described a theory of retraction fibrosis of the distal muscles and connective tissue found on the postero-medial aspect of the foot.[38,39] In Carroll's editorial,[40] the Japanese concept that clubfoot is due to neuromuscular dysfunction in which there is an intrauterine partial loss of innervation with reinnervation is as close to the best theory until investigators locate a clubfoot gene.[39,40]

PATHOLOGY

The pathologic anatomy of the idiopathic clubfoot presents with equinus of the ankle, rearfoot varus, forefoot adductus, medial subluxation of the navicular on the talar head, lateral rotation of the talar body within the ankle joint, and posterior deviation of the fibula.[28,41-46] Soft tissue contractures are evident in the posterior, medial, and plantar aspects of the foot and ankle. These anatomic structures include the posterior quadrant: Achilles complex, ankle and subtalar joint capsule, posterior talo-fibular ligament. The medial quadrant contractures consist of the PT, FDL, and FHL tendon, Abductor hallucis, spring ligament, master knot of Henry, talonavicular joint capsule, superficial deltoid ligament, and at times the tibialis anterior tendon. Lateral quadrant deformity is afforded by the calcaneofibular ligament, bifurcate ligament, the long and short plantar ligaments, the peroneal tendons, and the joint capsules of the calcaneocuboid, cuboid-fourth/fifth metatarsals, and cuboid-third cuneiform. Lastly, the plantar structures include the plantar fascia, the long and short plantar ligaments, at times the quadratus plantae and abductor digiti quinti, depending on the presence of cavus deformity.[47] It is important to evaluate the skin and neurovascular bundle when evaluating the severity of clubfoot, as they have shortened due to the overall contraction of the foot. [35,45,48-50]

The primary osseous pathological anatomy lies in the head and neck of the talus. The size is decreased and the talar head/neck are angulated in a plantar-medial direction. The calcaneus pivots on the interosseous talocalcaneal ligament, allowing the anterior aspect to be plantar-medially displaced, while the posterior aspect of the calcaneus assumes a lateral displacement toward the fibula.[51] The navicular is usually abutting the medial malleolus as it is plantar-medially displaced in relation to the talar head.[27]

More recent attention has been directed to the calcaneocuboid joint in regard to correcting the two columns of the foot (medial and lateral). The cuboid is displaced plantar-medially and must be reduced on the long axis of the calcaneus, otherwise, a persistent adductus and supination of the forefoot persists.[40,52]

EVALUATION AND SELECTION IN GUATEMALA

Since 1992, six successful missions have been completed. Generally 100 children are screened upon our arrival for lower extremity deformities, and the 40 most severe are selected based on: the nature of the deformity; future prognosis; health status of the child; ability to rehabilitate and allow for normal ambulatory cycle; and age of the patient (>6 months of age is the surgical criteria). Children presenting with clubfoot who are younger than 6 months are casted for 3 months, and followed by the Guatemalan orthopedic surgeons with whom we exchange knowledge. These patients are dispensed polypropylene nightsplints which are worn during sleep for 9 months following cast removal, and are reappointed to our clinic the ensuing year for evaluation of the deformity, and if necessary, surgical correction.

The most severe rigid clubfoot deformities encountered are usually a result of arthrogryposis

multiplex congenita, failed surgery, or neurogenic factors. Depending on the procedural selection and the rehabilitation needed, the more severe cases will have appropriate arrangements made to be flown back to the United States for a more thorough assessment, hospital surgery, appropriate rehabilitation, and follow-up care up to one year. Some of the most difficult surgeries to date have been the result of failed surgical attempts. The amount of scar contracture and fibrosis increases the overall chance of skin slough, dehiscence, and vascular embarrassment.

The children are first screened by the podiatric surgeons to determine the child's surgical candidacy based upon the previous criteria. If criterion are met, the child is then evaluated by the pediatrician and/or pediatric anesthesiologist for medical clearance. Blood work can be obtained if deemed necessary. Due to the lack of radiological resources, x-rays cannot be utilized in the pre-operative work-up of the deformity. It is critical that intraoperative reduction be obtained with each surgery so that the navicular is reduced on the head of the talus, the talus and calcaneus are properly manipulated into position before pinning, and the cuboid is realigned about the long axis of the calcaneus. Due to the economic constraints, a very limited number of postoperative x-rays can be obtained to confirm the corrected position, and the quality of those obtained are often difficult to interpret.

The authors have found the majority of clubfoot treated were a result of neglect, failed surgical attempts, or neurogenic in nature resulting from myelomeningocele and poliomyelitis. In North America, the initial treatment of choice for infants born with clubfoot is conservative, consisting of manipulation and stretching, followed by plaster casting to maintain position. These casts are changed at weekly intervals during the first three months after birth. However, in many of the Central American countries where hospitals, medical resources, modern equipment, and trained personnel are lacking, this treatment is not possible. This necessitates a more aggressive surgical correction which is proportional to the amount of time the deformity has been neglected.

Postoperative care is handled by our Guatemalan counterparts, which consists of a long-leg cast for six weeks. At six weeks, the cast and K-wires are removed. A short-leg cast is then applied for an additional six weeks. Upper and lower component Wheaton Braces, (Wheaton Brace Co., Carol Stream, Il) are dispensed to the parents before our departure, along with instructions for night splinting for one year from the date of cast removal. Each year, the surgical team returns to the same location, which increases the odds for follow-up with previous cases. Returning to the same location annually has allowed the team the ability to evaluate postoperative results on a continual basis, with expectations of future studies at three, six, and nine years. However, a true critique of postoperative results is difficult in Guatemala. The difficulty stems from the fact that the majority of these patients and families are extremely poor, without means of communication, and lack the necessary transportation to the clinic destination. These factors alone reduce the number of follow-up by approximately 65%. The children who do return are dispensed larger night splints to accommodate growth of the foot for the ensuing year, and generic orthotics donated by a local orthotist.

SURGICAL TREATMENT

The surgical approach used by the authors is that of a four quadrant approach popularized by Goldner and Fitch.[47] The incisional approach is a posteromedial incision described by Turco.[24] A second lateral incision, from the tip of the fibula to the fourth metatarsal base is incorporated to allow access for lateral structures.

The four quadrant theory involves correcting the structures located in the posterior, medial, lateral, and plantar aspects of the foot sequentially, as necessary. The initial posteromedial skin incision is performed via sharp dissection. Blunt dissection is utilized to delineate full-thickness skin flaps which are gently retracted throughout. In the presence of previous scar contracture, scar revision via "W" or multiple "Z" plasties may be required. On occasion, full-thickness skin grafting or deliberate under-correction of the deformity is necessary to ensure soft tissue coverage. The flexor retinaculum is identified and released, and the neurovascular bundle is immediately identified. The neurovascular bundle is carefully dissected and mobilized with a vessel loop. The abductor hallucis muscle is released from its origin and reflected. In severely neglected clubfeet, complete

excision of the entire muscle may be necessary, especially in those feet which remain in an adducted attitude after all four quadrants have been appropriately released.

Following medial release, the posterior quadrant is addressed. The Achilles tendon is Z-plasty lengthened, with the distal release advanced medially to decrease the varus influence. The posterior ankle and subtalar joints are released, along with the posterior talofibular ligament.

The posterior tibial tendon is identified in the medial quadrant and its sheath is incised. The tendon is lengthened in a Z-plasty fashion. The FDL tendon sheath is incised, dissecting the tendon distally to the master knot of Henry, which is also divided. The FHL is immediately identified at the knot of Henry and dissected proximally to the myotendinous junction. The FDL and FHL are then tenodesed proximally, with non-absorbable suture just distal to their myotendinous junctions, and distally at the former knot of Henry, forming a conjoined tendon. A Z-lengthening is performed on the tendons between the sutures. The FDL is released just distal to the proximal tenodesis and the FHL is released proximal to the distal tenodesis, forming one lengthened FDL/FHL tendon. This lengthening technique has proved successful in children over 12 months of age with neglected clubfoot deformities, as it allows increased abduction of the foot, release of plantar digital contractures, and decreases adductus in the rigid foot.

The distal posterior tibial tendon is utilized as an entry point into the talonavicular joint. The talonavicular joint capsule is divided medially, dorsally, plantarly, and laterally. A small skin hook, as described by Blakeslee,[4] is positioned on the medial navicular to "open up" the talonavicular joint, which allows increased visualization of the talar head and lateral talonavicular joint capsule. The spring ligament is divided and the superficial deltoid ligament is identified and released. Recently, authors have encountered overcorrection of the clubfoot when completely dividing the interosseous talocalcaneal ligament.[53] In a rigidly contracted clubfoot, success has been obtained by performing a Z-plasty lengthening and repair of the deltoid ligament, as described by Goldner,[47] versus totally releasing the interosseous talocalcaneal ligament. In the rigid clubfoot, consideration can be given to navicular-cuneiform or first metatarsal-cuneiform arthrotomies. The plantar quadrant is then approached for release of the plantar fascia, long and short plantar ligaments, and the intrinsic musculature.

Attention is directed to the lateral quadrant where the sural nerve is identified and retracted. Through this exposure, the calcaneo-fibular ligament, peroneal tendon sheaths, postero-lateral subtalar joint capsule, lateral talonavicular joint, bifurcate ligament, and third, fourth, and fifth tarsometatarsal joint capsules are identified and divided as necessary to achieve reduction.

Osteochondral impingement is a more frequent occurrence in the neglected clubfoot. Visual inspection of the navicular, upon reduction on the talar head is noted. The navicular can become blocked because of a bony impingement against either the anterior beak of the calcaneus, cuboid, or third cuneiform. The appropriate procedure is performed as needed: resection of the distal aspect of the calcaneus, closing cuboid wedge resection, or excision of a lateral portion of the third cuneiform, to help reduce the talonavicular and calcaneocuboid joints.

Talectomy has been reserved for the severe, rigid, neglected clubfoot after failing to obtain the necessary reduction with a four quadrant soft tissue approach. This procedure is usually a last resort, primarily reserved for older children with a rigid deformity who have been ambulating on the affected foot for years, yet are too young for a pan-talar or triple arthrodesis.

RESULTS AND DISCUSSION

Over the past five years, 69 clubfeet in 46 children have been surgically treated. Twenty of the children had bilateral deformities and the remaining 29 children had a unilateral clubfoot, with 16 right feet and 13 left feet. The average age of the children was 4.5 years. The youngest surgical patient was 6 months of age and the oldest was 16 years old. Only 6 of the 45 children were operated on before the age of ambulation (under 9 months of age). The procedures performed on these 6 infants were consistently soft tissue postero-medial and lateral releases with pinning. Each of these infants has been followed for the past five years, and all have maintained a functional foot with proper dorsiflexion/plantarflexion, void of stiffness. It is still too early to claim long term success, as

they have not yet reached skeletal maturity, and radiographs are not readily accessible. The remaining 39 children received the four quadrant release plus additional bone procedures when indicated, such as cuboid decancellation, resection of the anterior calcaneal beak, lateral excision of the third cuneiform, calcaneal-cuboid fusion (in children over 4 years of age), talectomy, triple arthrodesis, and pan-talar arthrodesis. There has been sporadic follow-up of these 39 children based on the socio-economic factors previously described. Four talectomies were performed on four patients aged 9, 6, 3, and 2.5 years. Talectomy was utilized as a salvage procedure following inadequate reduction of the talo-calcaneo-navicular joint and a non-reducible, rigid varus deformity after first performing a four quadrant release. All were previous failed surgical attempts by local physicians.

Due to the economics of families, and the lack of transportation and communication, long-term follow-up on a majority of patients is non-existent. Each child does receive appropriate follow-up for six months by the Guatemalan orthopedic community, who in return communicate with the authors on their condition via fax. Normally, 5 to 8 children from the previous year will return for re-evaluation. These numbers have progressively increased as the team has emphasized the importance of this evaluation to members of the child's family.

These follow-up appointments will allow the team to closely scrutinize the results based on the procedural selection and decisions made intra-operatively. Even though the follow-up is limited to approximately 34% of the children operated on annually, the authors have found favorable correction in the neglected, rigid clubfoot from an aggressive four quadrant approach. The task ahead lies in the increased return of post-operative children on an annual basis from the date of operation until skeletal maturity so the authors can report at 3, 6, and 9 year intervals.

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