Surgical Repair and Rehabilitation of Moderate Flat Foot Deformity of a 16-year-old Gymkhana Competitor: A Case Report

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- Abstract-

Introduction: Adult Acquired Flat Foot Deformity is characterized by pes planus and results from foot hyper-pronation and eversion of the subtalar joint. Pain can occur in weight bearing and is treated with a range of procedures including physical therapy and surgical correction.

Case Description: The patient is a 16-year-old girl with pain, decreased strength and range of motion status post two surgical procedures on the right foot.

Intervention: Physical therapy was 2-3 times a week for 8 weeks, it included home exercise programs, pain control, range of motion and strengthening exercises and gait/balance training.

Discussion: Discharge was established by the orthopedic surgeon after 4 weeks secondary to patient being pain free and having re established joint motion, strength and an appropriate gait pattern.

Conclusion: This case provides information regarding the success of and future studies on the use of surgical treatment and physical therapy to correct flat foot deformity.

Introduction:

In today's society, 20% of adults present with Adult Aquired Flat Foot Deformity (FFD), many times secondary to various pathologies. One particular pathology is Posterior Tibialis Tendon Insufficiency, which is characterized by flexible or rigid pes planus and can result from hyper-pronation of the foot, or increased eversion of the subtalar joint. This forces the calcaneous to move in a valgus direction and become externally rotated relative to the talus, causing dorsal subluxation of the navicular bone on the talus. This results in a midfoot sag, as well as biomechanical issues such as talonavicular subluxation during the stance phase of gait. As a consequence to these, many patients diagnosed with FFD experience lateral column shortening in relations to the medial column.[1] The lateral column consisting of the calcaneous, the cuboid, the fourth and fifth metatarsals, the calcaneocuboid, cuboid-metatarsal and the corresponding fourth and fifth intermetatarsal joints[2], is also known as the lateral boarder of the foot. Most often it is seen with these patients that the mid and forefoot are overly abducted which results in abnormal biomechanics of the foot[3], along with malalignment of the lateral aspect of the talonavicular joint, which therefore causes the lateral column to appear shorter than the medial[4]. Some patients can have FFD for years without any adverse effects or painful weightbearing, while others may find it unbearable and seek medical help from a variety of professionals.[1,2,3,4]

There are a variety of treatments, both conservative and controversial for FFD. Conservative treatment includes physical therapy for heel cord stretching and "locking of the midfoot" which results by stretching the heel cord while the patient's foot is supinated[5]. Along with physical therapy, corrective shoes and inserts are molded and made for individual patients that can correct the misalignment of the foot. In some cases, when conservative

treatment fails to help the patient function pain free or at optimal level, more controversial procedures are assessed, such as surgical correction of FFD through a variety of procedures. Physical therapy follows the surgical correction, to strengthen, increase active and passive range of motion and rehabilitate the patient to previous functional activities and/or when a single heel raise can be completed painfree.[1]

In the literature today, there is not a lot of information on the long term outcomes of these surgical procedures on young adults with no other underlying pathologies.[6] A number of studies have been conducted for short term results, with little literature regarding long term results, leaving the success rate somewhat inconclusive.[1] Even more so, the use of surgical procedures on adolescents is even more controversial and limited, with most literature involving patients with other pathologies including cerebral palsy and myelomeningecele.[4] This case will be looking at the short term results of a surgical correction and physical rehabilitation of FFD, including strengthening, stretching, gait training and neuromuscular re-education, in order to regain fully functional strength, range of motion, functional activity and appropriate biomechanics of the affected foot. This study will look into the case of a 16 year old female diagnosed with FFD in order to provide more information to the literature on the results and effects achieved when younger patients undergo corrective surgery for FFD combined with post-operative physical therapy rehabilitation. This case report was approved by the Institutional Review Board at The Sage Colleges in Troy, New York.

Case Description:

The patient in this case report is a 16-year-old female who is an only child and resides with her parents. She is currently a sophomore in high school, who is active in a variety of

equestrian activities including Gymkhanas, which according to the patient requires riders to complete obstacle courses, races and relays during competitions, as well as leisure and trail riding. She was diagnosed with flexible FFD, with complaints of painful weight-bearing in the right foot approximately 2 years ago. The patient underwent conservative treatment for the bio-mechanical dysfunction, consisting of the use of orthotics to correct the FFD and physical therapy at an outpatient orthopedic clinic to strengthen and stretch the tendons, muscles and ligaments of her foot. The patient has a history of reoccurring grade II ankle sprains and the fracture of 2 bones in her foot over the past 3-4 year. She has previously undergone a surgical procedure to lengthen the Achilles tendon in March of 2007. She presently is being treated in physical therapy status post a second surgery on May 4, 2009 involving a partial calcaneus excision, a calcaneal-cuboid joint arthrotomy and rerouting of the posterior tibial tendon.

Upon examination by the head physical therapist of the outpatient rehabilitation clinic, she is 6 weeks post op the previously mentioned surgery and is weight bearing as tolerated with bilateral axillary crutches and cast boot. She reports pain of 5-6 out of 10 on the VAS[7], describing it as a "bruise" type pain in the lateral malleolus region, which increases when she walks. Observation of her right foot shows incisions of previous surgery on her medial malleolus and Achilles tendon. She has two new incisions which are healing well with steri-strips intact. She has moderate edema and no redness around the incision area. Active range of motion (ROM) of the right foot show 5° of dorsiflexion, 25° of plantar flexion, 15° of inversion and 0° eversion. Passively she has 10°, 35°, 25° and 9° respectively.[8] Manual muscle tests show 3+/5 strength in both dorsiflexion and plantar flexion, 2/5 strength in inversion and 2-/5 strength in eversion of the right ankle.[9] She is also

showing limited flexion and extension of all five digits on her right foot. No special tests were conducted secondary to the patient being status post surgery. Patient reports being unable to climb stairs at home and at school, complete horse chores and household activities of daily living, such as standing in the shower, standing at the sink to do dishes, single leg stance on right lower extremity in order to don pants. She presents with antalgic gait with decreased stance time on right lower extremity and decreased swing phase on left lower extremity secondary to pain in right lower extremity. She also presents with diminished heel strike/push off and circumduction of the right lower extremity during gait.

Evaluation:

The patient is a good candidate for physical therapy to rehabilitate her right foot for range of motion, strength and motor function. Table 1 lists details regarding examination findings both subjectively and objectively.

Diagnosis:

The Preferred Practice Pattern this patient falls in is Musculoskeletal Pattern I: Impaired joint mobility, motor function, muscle performance and range of motion associated with bony/soft tissue surgery.[10]

Plan of Care:

Short term goals and long term goals were the following:

Short Term Goals:

1. Patient will increase active range of motion of the right ankle by 10° throughout in 1 week.
2. Patient will increase strength of right ankle by ½ a grade throughout in 2 weeks.
3. Patient will be independent with Home Exercise Program (HEP) in 1 week.

Long Term Goals:

1. Patient will increase active range of motion of right ankle to within normal limits (WNL) to safely ascend and descend stairs in school in 8 weeks.

2. Patient will increase strength of right ankle to at least 4+/5 to resume horseback riding activities in 8 weeks.

3. Patient will ambulate independently without an assistive device demonstrating a normal heelstrike/push off more for more than 1000 feet in 8 weeks.

4. Patient will report pain decreased to 0-1/10 with all Activities of Daily Living (ADL's) in 8 weeks.

The patient's plan of care (POC) consisted of physical therapy 2-3 times a week for 8 weeks. While in therapy, she conducted her HEP each day as prescribed. Whirlpool, hotpacks, cryotherapy, and electrical stimulation were utilized for pain control, decreased inflammation and tissue repair. Passive range of motion (PROM), active range of motion (AROM) and stretching were conducted each session for increased range of motion of the right ankle. Isometric and Isotonic exerciese were utilized to increase right ankle strength including the use of theraband and exercise machines such as the stationary bike, the Nu-Step machine, the Shuttle (gravity eliminated) leg press, and the Universal Gym lower extremity press. Gait and balance training were also conducted for the re-establishment of appropriate gait patterns.

Interventions:

General activities completed at each treatment session can be found in Table 2. Details of each treatment session are as follows:

During session 1 the initial evaluation was completed. The patient's right foot was placed in a whirl pool of 102°F with a chlorazene additive to help prevent infection at the

incision site. The patient conducted active range of motion exercises of ankle circles for fifteen minutes. The patient was instructed of home exercise program and asked to demonstrate it for the therapist. The home exercise program consisted of towel toe curls, toe-grab exercises (3 sets of 10 each) and ankle pumps (3 sets of 25) for the right foot.

At session 2 the patient's right foot was again placed in a whirl pool, at 104°F with a chlorazene additive to prevent infection. The same active range of motion exercises were conducted as in treatment 1, with the addition of alphabet writing added in, for fifteen minutes. The therapist applied passive range of motion to the right ankle in dorsiflexion, plantarflexion, inversion and eversion 10 times each with a 10 second hold. The patient was then asked to utilize active range of motion of the right ankle with yellow theraband in dorsiflexion, plantarflexion, inversion and eversion 10 times each. The patient completed seated right lower extremity wobble board exercises in plantar flexion, dorsiflexion, inversion and eversion circles 15 times each. An inversion/eversion towel slide was completed 3 times in each direction as well as towel toe curls for 3 sets of 15 on the right foot. The session ended with the patient utilizing the lower extremities only on the NuStep machine at level 3 for 10 minutes.

During session 3 the patient's right foot was placed in a whirl pool, at 104°F with a chlorazene additive to prevent infection. The same active range of motion exercises were conducted as in treatment 2. The therapist applied passive range of motion to the right ankle in dorsiflexion, plantarflexion, inversion and eversion 5 times each with a 10 second hold. The patient conducted right ankle active range of motion with theraband of dorsiflexion, plantarflexion, inversion and eversion for 3 sets of 10 each, with resistance being increased to a green Theraband. The patient was then instructed in proper gait at the wall rail. The patient

practiced appropriate gait in both forward and backward motion, as well as practicing sidestepping a 50 foot length, twice in the session. Treatment was concluded with the patient utilizing the recumbant bike at level 3 for 10 minutes. The patient left with no complaints of pain.

During session 4 the same whirlpool and active range of motion exercises were conducted as in session 3. The therapist then remeasrued the patient's active range of motion and manual muscle strength tests with the following results: *Dorsiflexion 15° and 4-/ 5; Plantarflexion 25° and 4-/5; Inversion 32° and 3-/5; Eversion 9° and 3-/5.* Gait training was again done at the handrail with the same directions and distance as the previous session 3. The patient was then instructed to practice dorsiflexion-plantarflexion and lateral weight shifts while standing on a wobble board, 15 times each. To work on balance, the patient utilized the Plyometric rebounder (a small trampoline placed at a 30° angle). The patient was instructed to throw a 4lb medicine ball at the rebounder and catch it while standing in a variety of stances: normal stance, feet together, bilateral tandem, bilateral rising step, and bilateral single leg stance 15 times in each. The patient then utilized the Shuttle machine to strengthen the lower extremities using 4 bands of resistance for 3 sets of 10 double leg presses. The treatment was concluded with the patient utilizing the hybrid bike at level 3 for 10 minutes. The patient left without any complaints of discomfort.

Session 5 was initiated with a whirlpool treatment and active range of motion the same as the two previous sessions. The therapist applied passive range of motion to the right ankle of dorsiflexion, plantar flexion, inversion and eversion 5 times each with a 10 second hold. The patient was instructed on how to perform a gastroc-soleus self stretch against a wall for 15 seconds, 5 times each leg. The patient utilized the treadmill for increased

endurance using appropriate gait patterns at 2 mph with a 0% incline for 5 minutes. Strengthening was done on the Shuttle with a double leg press with 5 bands resistance for 3 sets of 10. The session concluded with the patient utilizing the NUSTEP with only lower extremities at level 6 for 10 minutes.

Session 6 was initiated in the whirlpool the same as the previous few sessions with the same active range of motion exercises being conducted by the patient. The therapist applied passive range of motion to the right ankle in dorsiflexion, plantarflexion, inversion and eversion with a 10 second hold 10 times each. The patient was instructed how to utilize the Prostretch to apply a stretch to the gastro-soleus for 15 seconds 4 times each. Strengthing was again done on the Shuttle conducting a double leg press when standing on a balance board for increased instability. Six bands of resistance were applied during the 3 sets of 15. The patient then was instructed on how to do a single leg press on the right with the balance board on the shuttle, utilizing 4 bands resistance for 3 sets of 10. The patient then practiced full weight bearing on the wobble board with dorsiflexion-plantarflexion and lateral weight shifts for 2 sets of 15 each. The plyometric rebounder was utilized using the same stances as in session 4 using a 5lb medicine ball 10 times on each side. The session concluded with endurance training with appropriate gait patterns on the treadmill at 2mph with a 0% incline for 8 minutes.

Session 7 began with a warm up on the NUSTEP using lower extremities only at level 5 for 10 minutes. Double leg presses with the balance board with 6 bands resistance were conducted on the Shuttle for 3 sets of 15. Right single leg presses with the balance board with 5 bands resistance were also completed for 3 sets of 15. The patient was instructed to maintain right single leg stance while on the wobble board and practicing dorsi

and plantar flexion for 3 sets of 15. Double leg dorsiflexion-plantarflexion and lateral weight shifts were also done for 3 sets of 15 on the wobble board. Calf raises were conducted on the Universal gym with no added weight for 3 sets of 10. Balance training was applied through 2 sets of 10 lunges on a blue unstable mat surface. Right sided single leg squats were also on the mat done while reaching for cones for 2 sets of 15. Stability training was conducted on the Biodex for 2 sessions for a total of 3 minutes. The patient reported some soreness after treatment and so a cryopack was applied to the right ankle for pain control for 15 minutes at the conclusion of the session.

Session 8 began with the patient riding a recumbent bike at level 4 for 12 minutes. Double leg presses with the balance board were conducted on the Shuttle using 7 bands resistance, and right single leg presses with the balance board using 6 bands resistance for 3 sets of 15 each. The patient was instructed on how to perform double leg squats on a pilates disc for balance and strength training for a set of 25. Bilateral step ups were conducted for gait and stair training on a 6” step for 25 reps on each side. The plyometric rebounder was done with a 6lb medicine ball in all stances as previously done 15 times each. Right single leg stance squats were done for balance training on the blue mat reaching for cones for 2 sets of 15. Calf raises were done without added weight for ankle stability and lower extremity strengthening for 3 sets of 15. The session was concluded with the patient utilizing the NUSTEP using only lower extremities at level 6 for 10 minutes.

Session 9 began using the NUSTEP for lower extremities only at level 7 for 10 minutes. Double leg presses with the balance board on the Shuttle using 8 bands of resistance, and right sided single leg press with balance board using 7 bands resistance were done for 3 sets of 15 each. Pilates disc double leg squats were done 25 times without any loss

of balance by the patient. The patient practiced stair climbing using a 6"step for bilateral step ups, 25 times each side. The plyometric rebounder with an 11lb medicine ball was done in all of the same stances as previously done 15 times each. A double leg stance on a pilates disc using a 6lb medicine ball and the rebounder was done 15 times and right sided single leg stance with a 4lb ball and the rebounder was done on a level surface 15 times. The patient completed the Biodex stability training programs using both double and single leg stance for a total of 6 minutes. Universal gym calf raises were done with no added weight for 3 sets of 15. The session concluded with the patient on the hybrid bike for 12 minutes at level 4 and had no complaints of pain, only fatigue at the end of the session.

Outcomes:

Patient was discharged after 9 treatment sessions as per physician's request, considering patient was back to functional baseline and pain free, with all goals having been met at this time. Active range of motion was measured as follows: dorsiflexion 16°, plantarflexion 36°, eversion 12°, inversion 35°. Strength was grossly measured as 4/5 throughout right lower extremity. Patient reports being pain free consistently throughout daily activities and had returned to completing activities of daily living, horse chores independently and has returned to horseback riding 2 days prior to discharge. Normal gait was achieved when ambulating >1000ft at this time.

Discussion:

When treating FFD, the optimum treatment is non-surgical treatment. These vary between aggressive physical therapy for strengthening, range of motion and stabilization of the foot and ankle. Many times personal orthotics are fitted to help correct the flexible flat foot. Rarely are surgical procedures conducted to realign the foot and correct dysfunctions so

that the foot is utilizing the most correct mechanical function as possible. Even more so, surgery is very rarely seen as an option when working with children. In regards to this case, the 16 year old patient had been issued a variety of orthotics prior to attempting any surgical correction of her flexible FFD. According to Lee mechanical devices, along with physical therapy treatment, are generally utilized before surgical treatment is considered.[11] This article goes on to describe the general surgical procedures considered when these less invasive procedures do not restore pain free function for the patient. These procedures include but are not limited to synovectomy, tendon transfers, Achilles tendon lengthening, calcaneal osteotomies including Evans calcaneal osteotomy, realignment arthrodesis.[11]Though surgical treatment is generally left for last, when it is needed the major consenus among professionals is that a combination of a tendon transfer to reconstruct the posterior tibial tendon (PTT) with a corrective osteotomy, usually to the cuboid and/or calcaneous. This combination provides the patient with the correct boney structure alignment so that optimal biomechanical function can be utilized of the corrected posterior tibial tendon.[12,13,14]

In this case study, the patient received all the above procedures, in a number of corrective surgeries before finding relief from pain, edema and inflammation of her PPT and correction of the FFD. It is rare that surgical procedures are conducted on patients so young, mostly because of the effect of osteotomies, arthrodesis and reconstruction to tendons can have on the long term biomechanics of the lower extremity as the patient continues to grow and mature into adulthood. This needs to be considered in a variety of foot deformities besides FFD including club foot.[15, 16] Considering that this patient has no other diagnoses such as cerebral palsy or myelomeningecele[4], she is one of a limited number of adolescent patients to have surgical procedures conduced to correct her flexible FFD.[15, 16] Even more so,

that she reported abolishment of pain when returning to her previous activities secondary to surgical procedures and the above described rehabilitation treatment adds to the limited amount of literature out there that these procedures can have positive short to mid-term outcomes.

In her particular case, the patient was able to fully return to horseback riding and competed in her first Gymkhana 2 months post discharge from physical therapy. Her particular physical therapy program focused on increasing strength and range of motion, then progressing to neuromuscular re-education of the right ankle attributed to the success of this patient and her return to functional activities of daily living. However treatment would have been optimal if it had been continued 2-3 weeks longer than it was. With the physician being satisfied with outcomes just 9 treatments into therapy, rehabilitation was discontinued. Had treatment continued, the patient would have continued to increase strength and range of motion as she had been and may have been able to return to horseback riding sooner than 2 months post therapy.

Conclusion:

The patient initially had complaints of pain, decreased range of motion, decreased strength, antalgic gait and significant restriction in activities of daily living secondary to flat foot deformity and a surgical procedure to revise it. The goals for this patient included increasing active range of motion and strength to be able to ascend/descend stairs safely and return to horseback riding activities, as well as other daily activities pain free. The patient had difficulty ambulating long distances due to fatigue and pain, characterized by a limp as well as lack of normal heelstrike and pushoff during gait. By the discontinuation of therapy, the patient was reporting no pain on a daily basis, was able to demonstrate a gross muscle

strength of 4 out of 5, an increase in range of motion to a normal and functional level. She was able to demonstrate a normal gait pattern as well as functionally being able to ascend and descend stairs safely, all of which allowed her to return to normal activities of daily living, including her horseback riding activities and Gymkhana competitions.

This case report provides significant information regarding the success rate of utilizing surgical treatment and physical therapy to treat adult acquired flat foot deformity in young adults. The majority of the few research articles out there discussing surgical treatment of adult acquired flat foot deformity, have been inconclusive with both long term and short term success rates. The information regarding this patient provides positive short term outcomes of a mostly controversial procedure, especially in a patient so young. More importantly, it provides the potential for future research when looking into the long term effects of the surgical procedure with this particular patient. Ideally being able to study the long term affects this patient experiences with the surgery and therapy would provide an important outlook into the success of these procedures. Positive short term outcomes, such as the ones this patient experienced offer reassurance that this treatment protocol is indeed successful and can be utilized with patients in the future.

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Table 1: Subjective and Objective Findings

Body Function and Structure	Activities capacity and performance with participation capacity and performance
Pain with movement Decreased Active and Passive Range of Motion of Right Ankle and toes Decreased overall strength of Right ankle	Antalgic Gait Unable to climb stairs Unable to horseback ride Unable to complete horse chores/household ADL's

Table 2: Treatments per session

Treatments	Sessions								
	1	2	3	4	5	6	7	8	9
Whirlpool	X	X	X	X	X	X			
PROM		X	X		↑	↑			
WP AROM	X	↑	X	X	X	X			
Land AROM		X							
Theraband		X	↑						
Wobble board				X		↑	↑		
Shuttle				X	↑	↑	↑	↑	↑
Univ Calf Raise							X	X	X
NUSTEP		X			↑		↓	↑	↑
Bike			X	X				↑	X
Treadmill					X	↑			
Plyometric Rebounders				X		↑		↑	↑
Pilates disc squats								X	X
Lunges, SL squat							X	↓	
Biodex							X		↑
Gait Training			X	X				↑	
ROM/MMT	X			X					X

Key: ↑ = increase in intensity ↓ = decrease in intensity
WP= Whirlpool SL= Single leg
ROM= range of motion MMT= manual muscle test