Increasing Ankle Strength and ROM Following Tarsal Coalition and Achilles Lengthening: A Case Report

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Abstract:

Background and Purpose: Tarsal coalition (TC) is an abnormality that results in the fusion of two or more of the hind bones of the foot. The purpose of this case report is to describe how physical therapy protocol for Achilies lengthening rehabilitation including: gait training, balance exercises, PROM and AROM exercises, manual therapy techniques, Maitland mobilizations, strength and flexibility exercises and modalities affected a patient after removal of a tarsal coalition and Achilies tendon lengthening. **Case Description:** The patient was a 19 year-old long distance runner with symptoms of increased pain, decreased strength, ROM, balance and dysfunctional gait. On initial assessment the patient had 8/10 pain at the worst, decreased dorsiflexion (DF) at 15º, plantarflexion (PF) at 15º, inversion (IV) and eversion (EV) both at 15º with end range pain. Manual muscle test showed functional deficit with inversion 3+/5. The patient had tenderness to palpation of the (L) ankle 2+, with hypomobility of the subtalar joint. The patient also had atrophy of the (L) gastroc complex. **Intervention:** The patient was seen 2 times a week for 8 weeks with therapy consisting of gait training, balance exercises, PROM and AROM exercises, manual therapy techniques, Maitland mobilizations, strength and flexibility exercises and modalities**.** **Outcomes:** The patient showed net gains in ankle ROM ranging from 15º to 18º DF, 15º to 30º PF and 15 to 35 IV without pain at the end of 8 weeks. Improvements were also seen in gait, balance and strength. **Discussion:** Ankle interventions including Maitland mobilizations may be effective in treating patients who are post-op for tarsal coalition and Achilies tendon lengthening.

Introduction

Tarsal coalition is a condition in which there is an anatomical bridge that causes restricted motion in any two of the seven bones that comprise the mid and hind foot. These bones can include the talus, calcaneus, cuboid, navicular and the three cuneiforms. Coalitions between these bones can produce a series of symptoms that may ultimately be labeled as rigid peroneal spastic flatfoot.[1,2] Limitation of motion may occur by full coalition or by a premature abutment of one tarsal bone to another by an accessory ossicle.[3] A full understanding of tarsal coalition and the associated complex of symptoms, needs to be understood clinically for the physical therapist as this knowledge will initiate the correct treatment for the patient.

The incidence of tarsal coalition or peroneal spastic flatfoot varies greatly in frequency detection depending on the techniques used.[4] The coalition syndrome is not common, occurring in less than 1% of the population.[5] Overall there are two common types; calcaneonavicular was found to be the most common type at 53% and talocalcaneal at 37% comprising about 90% of all reported coalitions.[5] Other tarsal coalitions that comprise the last 10% are far less frequent but have been reported.[1]

In order to gain understanding of the pathology associated with this syndrome the anatomy of the structures in question must be investigated. For this condition anatomy of the foot will be discussed. There are three articulating facets that are located between the talus and the calcaneus. The anterior and middle facets are not always separate from each other but the two are separated from the posterior by the talocalcaneal ligaments.[6] The classification of the coalition therefore is based on the bones or facets affected and are named accordingly.

There are two schools of thought in the etiology of tarsal coalition. One school believes that the addition of an accessory intertarsal ossicle results in bridging of the joint when the ossicle fuses to the adjacent tarsal bones.[7] The theory believes that the os calcaneus, a small irregular bone that is located between the calcaneus, talus, cuboid and navicular, commonly fuses to the anterior aspect of the calcaneus that forms a process that can commonly be fractured. It is also theorized that this bone may fuse to the navicular resulting in the formation of the calcaneonavicular bar.[7] The other bone implicated in this theory is the os trigonum. This ossicle is located at the posterior lateral aspect of the talus. This bone may form a bony union with the talus or attach to the talus via a cartilaginous or fibrous union.[7] The ossicle may also form a bridge to the calcaneus as well. An attachment to both the talus and calcaneus can result in a posterior talocalcaneal coalition causing impairment of motion at the subtalar joint.[7, 8]

The second school of thought is from the anatomists that believe in the idea that tarsal coalition is a congenital issue. This group believes that coalition formation results from failure of differentiation and segmentation of primitive bones that results in decreased joint formation.[7] This congenital coalition is more frequently identified and reported although the mechanism of the coalition is not conclusively known.[1] This theory attributes congenital coalitions to an inheritable defect or to an insult during the first trimester of pregnancy. The former being supported by numerous studies saying that there is a gene mutation for a coalition formation which is then passed on as autosomal dominant gene. In a large study done by Leonard[9], the conclusion was that the tarsal coalition was a unifactorial disorder with autosomal dominant inheritance.[7, 9] Today, the underlying agreement is that this congenital anomaly is caused by a genetic mutation that results in the failure of differentiation and segmentation off the primitive medenchyme.[7, 9]

There is a final school of thought that hypothesizes that tarsal coalition may also be acquired. This can result form arthritis, infection, trauma, neoplasm's or other causes.[10] The acquired coalition typically starts as a diminished range of motion within the involved joints with a varying degree all the way to fusion of the involved struvtures.[1, 11] With this type of coalition, disability and pain are minimal.

When referring to spectrum of the coalition from a fibrous bridge to complete fusion, there are three manifestations that can occur. The first is syndesmosis where fibrous bridging is occurring, which generally starts from birth in congenital coalitions. The second is synchodrosis where the fibrous bridge has progressed to cartilaginous bridging. The third is synostosis, where there is an osseous or bone bridge present and more often has complete fusion.[7, 12] The deformity may be unilateral or bilateral and usually fall into one the following presenting types, with the first two the most common making up about 90% of the coalitions reported.[5] The list includes calcaneonavicular, anterior middle or posterior facet talocalcaneal, talonavicular, calcaneocuboid, cubonavicular, naviculocuneiform, multiple combinations of these and massive where all of the tarsal bones are fused into one solid piece.[7]

Once classified, the completeness of the coalition must be determined and is then categorized into one of three subsets. The first being rudimentary, where an associated abnormality similar to talar beaking takes place. An osseous projection from one of the talar bones inhibts proper joint motion.[12] Next is incomplete, where projections of each of the involved bones are not actually united but are separated by a fibrous and/or cartilaginous tissue. The third is therefore complete, where fusion of the tarsal bones occurs and completely limits motion of that joint.[12] It follows that to name a coalition as in a report completeness of the coalition is named first, followed by the bones involved and then the tissue type. An example, as it would appear in literature, would be a complete Talocalcaneal Synostosis.

Development can progress from fibrous at birth to cartilaginous with age and exacerbation from activity to an osseous bridge if not treated. Synostosis is not likely to limit the patients ROM.[12] Ossification, if left untreated will typically occur within the second decade of life[12], as was the case with patient in this case report. Once ossification has occurred the patient will develop osteoarthritic compensations secondary to the now severely restricted ROM. Cowell[13], suggested that talonavicular coalitions ossifies from the ages of 3-5, calcaneonavicular from 8-12 years and talocalcaneal from 12-16 years.

Tarsal coalition may be completely without symptoms and be an incidental finding on routine radiographs in relation to the age of the patient and the overall activity of him or her. Three clinical findings pain, limitation of motion and muscle spasm should make the clinician suspicious of tarsal coalition. The other clinical finding usually associated with coalition is peroneal spastic flat foot.[3]

Pain is a common finding in patients with coalition and is relieved by rest. The pain felt is usually a deep ache frequently in the area of the coalition.[4, 7] Along with this the patient can localize tenderness over the coalition. This is a more common sign in coalitions that are incomplete or cartilaginous.[4] In symptomatic coalitions, painful limitation of inversion is usually associated with point tenderness laterally, in the anterolateral part of the ankle or on the dorsum surface of the midfoot.[4, 7]

The onset of pain is usually insidious, developing from excessive walking hiking, running or supination injuries like ankle sprains or recurrent sprains.[3, 7, 12]It is theorized that the decreased rear foot motion associated with coalition may cause an increase in laxity of the ankle ligaments resulting in more frequent sprains.[14] Pain and other associated symptoms will usually manifest themselves in the second decade of life when increased strain on the tarsus occurs due to the increase in body weight and level of activity that the child will participate in.

According to E. Dalton McGlamry D.P.M.,[7] the most frequent clinical finding is a decrease in ROM of the subtalar joint. Normal ROM at the subtalar joint is usually 35º of inversion and 15º of eversion. The decrease in motion usually results in symptoms like pain and tenderness to touch. These symptoms of different coalitions manifest at different ages because the ossification of the coalitions occur at different ages.[3, 12] With talocalcaneal coalitions ROM at the subtalar joint is usually completely absent and movement at the midtarsal joint is greatly resticted.[3, 12]

Due to the this decrease in the rearfoot ROM associated with the tarsal coalition, it is hypothesized that the problem can cause an increase in laxity of the ankle ligaments.[14] The end result being a patient that will frequently seek medical attention for repeated ankle sprains, especially medially with a secondary trait of flat foot. Limitation of the subtalar and midtarsal joint motion is typically the most obvious clinical finding, with inversion limited at the subtalar joint. This limitation becomes more evident if peroneal muscle spasm is present.[14]

With a tarsal coalition the muscle spasm that is most frequent is tonic and usually involves the peroneus brevis. It is theorized that as the subtalar motion becomes painful the brevis muscle attempts to guard and limit motion to protect the joint.[1, 3] Spasms may be intermittent or continuous, and as symptoms progress will likely become more intense in nature. Upon examination the taut tendon of the peroneus brevis can be felt laterally and the person will rest the foot in a position of rearfoot valgus.[1, 3] McGlamry and Downey, find that the rearfoot valgus resting position will lead to a decrease in the medial longitudinal arch and abduction of the forefoot, both visible upon evaluation. With time and if left untreated, this deformity will become more rigid in nature and the patient could develop a position of maximum capsular capacity (eversion).[1, 3]

It should be mentioned that this spastic flat foot is not always present in cases of coalition. There is a chance that other muscles may be spastic including the anterior and posterior tibialis and peroneus longus muscles.[15] These muscle spasms, like pain, are aggravated with activity and relieved by rest.

Physical therapy for patients with tarsal coalitions and excisions of the bridges aims at increasing ROM, increasing strength to the surrounding muscles to help support the ankle joint from recurring sprains second to the laxity of the ligaments, decreasing pain and improving/retraining gait patterns. Treatment of a tarsal coalition usually follows protocol for treatment of peroneal spastic flatfoot (PSFF). This is due to the fact that coalitions are the underlying pathology related to the flatoot.[16] In the article by Kelo and Riddle, treatment involved increasing ROM through the use of ultrasound, mobilization and orthotics to increase subtalar supination. The authors also used active and passive supination exercises to help with this positioning. The article allowed for only 5 visits of the patient. The purpose of this paper is to analyze through literature, the rehabilitation process of a patient s/p excision of a coalition and determine whether standard treatment of PSFF will work to improve deficits and analyze other types of treatment that were not used but could have been added to achieve desired outcomes. This case report was approved by the Sage College's Institutional Review Board.

Patient Description:

The patient chosen for this case report was a female, 19 years old, s/p left ankle tarsal coalition and achilies lengthening. The patient at the time lived at home with her parents and had been complaining of ankle pain since the seventh grade about 11 years old. Prior to the surgery the patient had been a long distance track runner and found that she was able to perform all activities despite pain. The patient also suffered multiple ankle sprains over the course of the eight years while running.

The patient was referred to physical therapy for evaluation and treatment for congenital tarsal coalition and achilies lengthening following surgery. The patient had surgery at the beginning of the year and was splinted and casted for eight weeks following the surgical procedure. The patient was subsequently progressed to a walking boot and crutches with a steady progression to full weight bearing. Prior to arrival at physical therapy the patient had been seen by the orthopaedic surgeon and a school physical therapist who had given her an active range of motion home exercise program (HEP). The HEP was instituted once the splint and the cast were removed.

The patient came to this physical therapy center approximately five months after the surgery with complaints of increased pain/symptoms with extended periods of walking and standing, as well as limited ability to descend stairs and obtain a squatting position. The patient stated that she was also unable to run at that time. At the time the patient was not taking any medications for pain and no over the counter medications for pain and/or swelling.

Examination:

The patient was initially examined in an out patient physical therapy clinic by the treating physical therapist and the author, a physical therapy student. Subsequent examination and evaluations were performed by the author of this paper with supervision of a licensed physical therapist as to eliminate any discrepancies in the treatment from other therapists.

The patient reported pain in the left ankle, more specifically the anterolateral aspect of the ankle joint. The pain was reported on a visual analog scale as being 8/10 at the worst and 5/10 at rest. The 10 point pain scale was chosen because in study done by Boeckstyns and Backer, they found that a 10 point pain scale was more reliable than a pain questionnaire when canvassing information on pain among patients with a total knee replacement.[17] The pain was termed “sore and achy”, and would be intermittent. The patient also reported occasional soreness to the along the achilies region of insertion and up the tendon of the muscle, just proximal to the insertion.

Initial inspection of the patient showed that she had mild decrease in push off with her left lower extremity at terminal stance and decreased hip flexion of the left LE with swing phase. The patient when standing had bilateral pes planus or flat feet, a condition where the arch or instep of the foot falls and comes in contact with the ground. Although not assessed with any special tests, such as the Feis Line, the determination was made through observation of the structures. The patient had atrophy of the left gastroc muscle complex when compared to the uninvolved side. The left ankle had three scars one each on the posterior, lateral and medial surfaces all healed with no signs of adhesion for any of the scars. There was slight inflammation noted around the left ankle. Measurement taken around the malleoli revealed .5 cm difference L>R.

Hands on inspection showed tenderness to palpation on the posterior tibialis tendon, achilies tendon, lateral malleoli and peroneal tendons. The achilies tendon tenderness was rated at 2+, with all other points rated at 1. Joint mobility was assessed and revealed hypomobility at the talocrural and subtalar joints when compared to the right. The left gastrocnemius had mild restriction upon inspection and the right had full excursion with no deficit noted. Muscle length and flexibility are terms used to describe the ability of a particular muscle to be lengthened to the end range of motion.[18]

Manual muscle testing was performed according to the guidelines established by Hilsop and Montgomery.[19] Some studies have shown that grades taken in the named protocol were identical 90% of the time. Iddings et al,[20] reported intertester and intra tester scores to be in agreement 48% of the tests and within a plus or minus in 91% of the tests. Therefore, reliability and validity of the tests acceptable for clinical use and can have limited subjectivity if performed by the dame therapist. The scale used for measuring strength is the one used in Hilsop and Montgomery.[19] Left DF was 4+/5, PF 4/5, EV 4+/5, IV 3+/5. Comparison to the non-involved side revealed ® DF and PF 5/5, EV and IV 4+/5. Special tests performed were the functional squat showing that the patient could only achieve 50-75% of full squat before her heel came off the ground. This finding is indicative of the soleus being restricted. According to Kendall et al,[21] when assessing muscles that pass over one or two joints, the normal range of motion of the muscle length will be less than range of motion of the one or two joints it passes over. Therefore, when assessing the muscle length of the gastrocnemius and soleus it is important to keep the knee in a flexed position, because it slackens the muscle behind the knee. The functional squat was used not only to provide visual evidence of dysfunction but to test the closed chain plantar and dorsiflexion of the muscles. This functional technique was used by Cyriax to develop a system of relating pain and dysfunction of movement.[22] The functional squat is a method for determining strength and flexibility of the LE, but is not a reliable test for determining dysfunction, because patients can function with little strength and minimal flexibility.

Patients' right heel was able to maintain contact with the ground through the range. Single leg balance testing revealed the ® rated as good and the (L) as poor-fair. With increased trauma to the ankle, especially frequent ankle sprains and surgery, patients are likely to develop decreased proprioception in the ankle joint. One way to measure the decrease in proprioception is to do a modified version of the Chattecx Balance System and put the patient into a single leg balance. The amount of sway exhibited or the in ability to hold oneself for a period of time, about 10 seconds on a force plate, is the bench mark. This was evident in a study done by Hertel et al.[23] The study found that patients when given a local into the lateral ligaments of the ankle, increased their and bodily sway. The intratester and intertester reliability of the instrument and reported correlation coefficients of .92 and .90, respectively.[23] The post hoc analysis of the findings revealed a significant lateral adjustment of center of balance during the static tests under anesthesia and a significant medial adjustment during the two dynamic conditions under anesthesia ($p < .05$).[23] Because the patient in this report could not hold the position for 10 seconds she was rated as poor-fair. Neurological and sensation testing revealed no deficits

Both active and passive ROM measurements were taken as described by Youdas for plantarflexion, dorsiflexion, inversion and eversion.[24] For patients with orthopaedic conditions the universal goniometer has been shown by Youdas to have high intratester reliability for active range of motion measurements (ICC= 0.78- 0.90) for patients with orthopaedic conditions, but also has a poor inter-tester reliability (ICC=.42-.82).[24] Initial active and passive ROM measurements are found in Table 1 and are compared with active and passive ROM measurements found by Youdas for the patients within the same sex and age group.[24] All AROM and PROM measurements were done by the author except for the initial evaluation to help minimize intra-tester effect.

Evaluation

It was the treating therapists' clinical judgment that the patient showed impairments that were consistent with the clinical diagnosis of post operative tarsal coalition and achilies lengthening. The impairments include ankle AROM and PROM deficits, disrupted balance, inefficient standing posture, decreased flexibility, decreased muscle strength, swelling, impaired gait and decreased function.

Prognosis:

The rehabilitation potential for the patient has been reviewed by the treating therapists and has been rated at good. This determination is based on patient age, desire to get better and overall attitude with compliance to HEP.

Diagnosis:

The patient falls under Preferred Practice Pattern 4I “Impaired Joint Mobility, Motor Function, Muscle Performance and Range of Motion Associated With Bony or Soft Tissue Surgery”. This is according to the Guide to Physical Therapy Practice.[25] Practice pattern 4I would encompass the patients’ dysfunctions of decreased ROM, decreased strength and endurance due to inactivity, impaired joint mobility, limited in independence in activities of daily living, pain and swelling. The specific ICD-9 treatment codes that the patient would fall under would be: 718.47 Contracture of Joint Ankle and Foot, 719.47 Pain Joint Ankle and Foot and 738 Other Acquired Deformities.[25] According to the Guide to Physical Therapy Practice, prognosis for this patient is good with expectation that 80% of the people placed into this category will achieve anticipated goals between 6 and 70 visits. The patient should be able to see improvements within 1 to 3 months.[25] The patients loss of balance and impaired gait deficits can be placed under Preferred Practice Pattern 5A “ Primary Prevention/Risk Reduction for Loss of Balance and Falling.”[25] Practice Pattern 5A would encompass the impairments of difficulty negotiating in community environment, difficulty negotiating terrains, generalized weakness and impaired gait. The specific ICD-9 codes according to the Guide to Physical Therapy Practice would be: 781.2 Abnormality of Gait and 781.3 Lack of Coordination.[25] Due to the patients’ age, prior level of function, overall health and other factors the prognosis of this patient will reduce the risk of falls and have more efficient gait is good. The Guide to Physical Therapy Practice determines improvements should be noted within 2 to 18 sessions or one week to six weeks.[25]

Goals:

The evaluating therapist identified two problems during the initial evaluation, of which both had a short term goal with anticipated achievement in 4 weeks and long term goal with anticipated achievement in 8 weeks. Problem 1: ADL/Functional status- short term goal was increase dorsiflexion ROM from 10 to 15 degrees actively in order to improve gastroc/soleus flexibility and increase functional squat to 75% with heel contact. The long term goal was to increase soleus flexibility to WNL in order to be able to squat fully with heel contact.

Problem 2 was identified as gait/locomotion. The short term goal for this problem was increase plantarflexion muscle strength to 4+/5 in order to improve push off to slight limitations with gait. The long term goal was improve plantarflexion muscle strength to 5/5 in order to achieve full push off during gait.

As progression to function improved goals were modified and changed per patient achievement and therapist acknowledgement.

Plan of Care:

The treatment planned outlined in the initial evaluation was to focus on maximizing function, muscle function improvements, normalization of gait, normalizing pain, relieving pain, proprioception/balance improvements and range of motion/mobility improvements. Chosen interventions to help plan of care include: cardio exercises, patient education, functional activities, gait training, a home exercise program, isometrics, manual resistance, joint mobilization techniques, neuromuscular re-education, PNF, machines, theraband exercises, weights, proprioceptive/closed kinetic chain activates, resistive activities, ROM activities, soft tissue mobilization techniques, stretching and flexibility activities and therapeutic exercises. Interventions were performed for 2 to 3 times per week for 8 weeks. Each session was from 45 minutes to one hour.

Interventions:

Interventions were aimed at decreasing pain, increasing joint and muscle ROM and strength, gait and balance. Table 3 illustrates a full spreadsheet of the specific exercises and weeks in which they were performed.

Interventions used to decrease pain were soft tissue massage, mobilizations using Maitland's' grade II and modalities such as ice and hi-volt electrical stimulation. There are several theories on how mobilization of a joint can reduce pain.[26] Some of the theories state that a reduction in pain occurs through activation of pain inhibitors in either the central or peripheral nervous systems or through chemical changes in the nociceptors found in the periphery.[26] However, to date no single answer for the pain control has come up. In a study conducted by Paungmali et al.[27], with mobilization of the elbow, found that patients had decreased pain, increased grip strength which was limited to pain and increased pain thresholds. Patients had a 48% increase in grip strength with pain and a 15% increase in their pressure pain threshold when compared to the placebo group and the interclass correlation for the pressure pain threshold .90.[27] This shows that mobilizations with some form of movement can have analgesic effects.

The Maitland mobilizations performed were consistent with treatment positioning found in Susan Edmond's book " Joint Mobilizations and Manipulation".[28] Therefore the patient was seated in the long sit position, with her ankle off the table, the talocrural joint was placed into the resting position, the clinicians' stabilizing gripped the talus at the posterior surface and the mobilizing hand gripped the anterior surface of the distal lower leg. The clinician then applied grade II traction to the joint while the stabilizing hand holds the talus in position while the manipulating hand glides the tibia and fibula in the posterior direction. The resultant force for grade II is slow, large amplitude oscillations with in the free range of the joint at a rate of 2-3 seconds and continued for up to 2 minutes. The cycle was then repeated two more times.

The patient responded favorably to the mobilization techniques used. After the second week there was no need for further mobilizations for pain. So grade II mobilizations were taken out the treatment program. Grade III mobilizations were initiated at week 5 and done through out the duration of treatment to assist in making gains in ROM. This slow large amplitude oscillation has been shown to help achieve increased ROM at joints that are dysfunctional.[28] There are articular and periarticular changes that occur in a joint when it is immobilized.[26] The theory behind mobilizations is that these movements are thought to reverse changes in the joint by improving movement between the capsular fibers. Along with this, the theory holds that the synovial tissue stretches in a selective manner causing a gradual rearrangement of collagen fibers from crossed pattern to a more parallel pattern allowing the joint to more freely.[26] Dananberg, in a study found that patients with similar dysfunctions as this patient and with Achilies tendon lengthening, had achieved twice as much dorsiflexion with mobilizations, than similar patients who stretched for at least 5 minutes over 6 months.[29]

Soft tissue massage to lengthen the peroneals and achilies tendons was used to reduce musculotendinous pain in those muscles and to increase AROM of the ankle. STM has been shown to provide patients with delayed onset of muscle soreness relief caused from overuse or in this case from not being used to back to function.[30] Soft tissue massage to the tendons helps to move excess fluid in and around the muscle insertion allowing for better muscle function and increased ROM. In a study done by Preyde in 2000, massage therapy and soft tissue mobilization were the two best clinical treatments to help reduce or eliminate pain, decrease intensity of pain and improvement in overall function in patients with low back pain, with all three having a p value $<.001$.[31]

The other controls for pain included hi-volt electrical stimulation and ice. The e-stim was applied with one pad over the achilies and soleus tendons just proximal to the calcaneus and the other over the dorsal aspect of the foot distal to the joint line. Literature does suggest that e-stim can be used for pain control in patients with arthritis, soft tissue inflammation and postoperative pain.[32, 33]Alternating current (AC) was used during the treatment session. The AC is the continuous bidirectional flow of charged particles where the change in the direction of flow from + to – occurs at least once per second.[34] For this patient, she received amplitude modulated AC or interferential. Small pads were used due to the area around the ankle being a small as well as eliminating the chance for muscle contraction stimulation. The cathode or positive pad was placed on the dorsum of the foot around the ankle joint because it is the active electrode and is usually the site of the lowest threshold for depolarization and is where the first stimulation is likely to occur.[34] Pad placement was a result of trial and error as to the best location for pain control. After the spots were found, e-stim was used until discharged from the program at week 4.

Ice packs were utilized for the full duration of treatment. However, they were used in conjunction with the e-stim during the first four weeks. The patient had her leg on an elevator as she sat up on a plinth. The ice bags were placed where the e-stim pads were located, dorsum of the foot and the achilies tendon distal to the muscle belly. Ice therapy has been known to help reduce pain acting as a counter irritant.[35] Ice is used in the treatment setting because it has been shown to lower the temperature of soft tissue, subcutaneous tissue, muscle and joints. The result is arteriolar vasoconstriction, decrease in metabolism and vasoconstictive agents, which reduce inflammation and outward fluid filtration and helps elevate the patient pain threshold for less periods of discomfort.[34] Due to the lack of body bulk around the ankle the ice was applied for 12 minutes.

Active range of motion exercises for the ankle joint included ankle inversion and eversion drills and the patient making capital letters through the alphabet with her involved ankle. Both drills were performed with the patient seated, with her foot of the edge of the plinth to help achieve maximum ROM. The patient also performed the exercises with her knee slightly bent to help avoid unwanted movement from the hip joint.[36] Both the AROM exercises were stopped after the third week and issued to the patient for her HEP. This was done to maximize time in therapy for gait training and balance.

The patients' treatment also involved a BAPS board or wobble board for therapy. She started the board therapy at level 2 and performed plantarflexion and dorsiflexion as well as clockwise and counterclockwise. All motions were done thirty times. The wobble board training was started at week one and continued throughout 8 weeks. At week 6 the patient was able to increase the level of the wobble to level 3. Wester et al[37], found that the wobble board has been shown to reduce the residual symptoms of an ankle injury as well as increase functional stability of the ankle and provide fewer recurrent sprains.

Strengthening began with theraband exercises in all directions. The patient would long sit on the plinth and would put the resistance band around the balls of her feet and would resist the band in the opposite direction. The patient performed 2 sets of 15 in all directions, starting with the red theraband. At week two she moved up to green and continued with that throughout treatment. Resistance training has been used for ankle rehabilitation for years and theraband work usually follows isometric exercises in sequence. Topp et al, found that resistance training with theraband in elderly patients helped to improve dorsiflexion, gait velocity and strength over the control group, with the control group only exhibiting half of the gains in improvement that the study group had achieved.[38]

Strength was also worked on with heel raises. Heel raises are an excellent way to induce gastroc muscle firing.[39] Eccentric lowering of body weight has been shown to be a very good therapy tool for increasing muscle strength. In one study of patients with biceps femoris dysfunction, patients were assigned randomly to either the experimental or the control group. The experimental group were given an eight week program of eccentric exercises and were found to have increases in the one rep. max as well as increased ROM in the knee joint with p values $<.001$ and $= .001$ respectively.[40] The patient would stand at the edge of the plinth and perform bilateral heel raises 2 sets of 10 reps. The patient increased the difficulty of the exercise herself by not requiring hand support by week 3. At week 5, her exercise repetitions were increased to 15. Functional squat was added at week 3, when strength improvements were noticed. The patient stood by the plinth and performed a squat as low as she could go until her left heel would lift off the ground. The patient performed 2 sets of 10 reps with increases in the repetitions at weeks 4 and 8. This is not only a strengthening exercise but provides a measuring tool for the range of dorsiflexion the patient is getting at the joint while in a weight bearing position.[39] The last two weeks the patient performed toe walks 3 sets of 20 repetitions to help work on intrinsic muscle strength as well as gastroc/soleus strength.[39] For this exercise the patient would rise up on her toes and lunge forward with her left leg and would land on her toes. She would then walk her right leg forward to match the left, while reaming on her toes. That would be one repetition. The process was repeated up and down the hallway of the clinic until the sets were completed.

Balance training involved a balance board, foam roll and 5 point reach on the Gary Grey Mat. Balance board training was undertaken due to the inability of the patient to perform a single leg stand without hand support and for a diminutive time. The patient would first stand with the board working balance in the anterior/posterior direction. She would try and maintain the position without hand support for 90 seconds. Then the board would be placed so the patient was working on lateral balance and the time would be repeated. By week 3 the patient was able to maintain the full 90 seconds with minimal hand support. At discharge she was able to maintain the positions for the full time without support. Balance board training has been shown to reduce the recurrence of ankle sprains as well as increase proprioception of the ankle joint in female volleyball players in a study done by Verhagnen in 2004.[41]

The Gary Grey mat, uses multi joint movements which in turn integrate muscle groups into movement patterns that are functional.[42] In its simplest form this functional training teaches the patient to handle his or her own body weight.[42] The patient would stand in the middle of the mat and with her right foot step straight ahead. The patient would then rotate her trunk all the way to the right and to the left with her arms out in front of her. The patient would then step back to the center and the series would continue with her stepping to a 45º angle to the right, then step straight out to the right, then to a backward 45ºangle and then straight back. The process would then be repeated with the left foot. The first four times on the mat the patient had difficulty maintaining balance. As strength and proprioception returned she was able to maintain the positions without having to reset her feet.

Balance training also included the use of a half foam roll. The patient would perform a single leg stand at the edge of the plinth with her left foot on the flat part of the foam roll. She would perform 2 sets of 30 seconds balance for each leg, then the roll was placed with the convex side down and the drills were repeated. At week 5 a weight shift over on the foam roll, with the convex side down, was initiated to help with gait training and increase ankle mobility. Dynamic balance activities can significantly improve the balance control in patients that are elderly or atheletic.[43, 44] The balance activities of the foam roll and the Gary Gray mat were both instituted during week 2 and were carried throughout the rest of the program. Progressions were as tolerated by the patient.

For the full treatment time stretches to the gastroc/soleus muscles were completed. The patient performed a seated gastroc towel stretch, the gastroc slant board and the standing gastroc and soleus stretch. The patient performed each stretch 3 times and held each stretch for 30 seconds. All stretching and activities followed a brief cardio/dynamic warm-up that the patient completed. The first 4 weeks the patient rode the cycle for 5 minutes at level 4. This was progressed to 10 minutes at a higher level at week 2. From week 5 on the patient performed her warm-up on the stair master for a period of 5 minutes.

Outcomes:

At the time that this case report was written the patient had been discharged from physical therapy secondary to return to pre-morbid conditions and achievement of all goals. Outcome measures and all data used for the purposes of this paper were collected during an 8 week period. The initial examination measurements were taken on the patients' first visit to the physical therapy clinic and were not done by the author but by the supervising therapist on site. Subsequent measurements including the discharge measurements were taken by the author.

At the final examination the patient reported the absence of any pain in the (L) anterior ankle region. The patient did report tenderness to palpation (TTP) (1/3) around medial malleoli more specifically the posterior tibialis tendon. The patient also reported intermittent soreness to the achilies tendon proximal to the heel but reports that the soreness has not limited her from activities.

At the final examination the patient had much improved and more efficient gait. Patient was able to ambulate with adequate push-off with the (L) LE following stance phase and had increased hip flexion during swing phase. The patient reported that she had no problem with walking or standing for an extended period of time. The patient reported that she felt ready to return to light running but on follow up with MD was advised to avoid light running and continue with independent home program for three more weeks.

Functional Testing of the patient revealed that with functional squat the patient was able to achieve 90% of the squat while maintaining heel contact (B). Improved single leg balance was identified as 90 seconds with both legs and did not require hand/finger support. Balance board training has increased ankle balance in the patient and according to Crean[45], balance board training can improve function in as much as 94% of patients in the study, following a soft tissue injury to the ankle.

Measurements for ankle AROM and PROM are shown in table for initial, final and all measurements in between. ROM improvements were seen in (L) dorsiflexion which went from 10º at initial to 18º at discharge, plantarflexion 15º to 30º and eversion which went from 15º to 23º. (Table 1) PROM for plantarflexion went to 38º without pain at end range and inversion to 35º without pain at end range. (Table 2)

Manual muscle testing showed improvements in all directions of testing. (L) inversion and eversion were final tested at 4+/5, and plantar/dorsiflexion were final tested at 5/5.

The (L) talocrural and subtalar joints improved from hypomobile to slight hypomobility. The (L) gastrocnemius/soleus complex improved from mild restriction to full excursion, matching the excursion that is achieved on the right LE.

Discussion:

The incidence of tarsal coalition is uncertain.[7] One would expect the incidence for children would be less than that of adults, due to subtalar motion not yet being restricted.[7] However coalitions, genetically induced, are produced by the failure of the primitive synovial joint to form and should be observable in early embryonic development.[3] With growth the affected bones show a faster rate of epiphysis closure than non affected bones. After closure the joint space narrows until complete bony fusion occurs.[3] Tarsal coalitions and the associated peroneal spastic flatfoot should be well understood both clinically and radiographically. Children presenting to the clinician with numerous complaints of ankle sprains should be screened for coalition, especially if past history involves increased athletic activity. This insight will enable the treating clinician to properly diagnose tarsal coalitions and provide the appropriate treatments.[3]

In this case report, the patient presented with impairments commonly associated with status post excision of a coalition and achilies lengthening. The past medical history done during the initial examination also revealed many common symptoms associated with a person presenting with a coalition prior to surgery. These impairments included frequent ankle sprains, increased pain, decreased ROM, balance, flexibility, joint integrity, muscle performance, gait abnormalities and swelling. Interventions chosen for the patient were focused on restoring the patient's specific impairments. As indicated by the functional outcome measures, some of the impairments were improved during the 8 week treatment session.

A case report is not designed to show direct cause and effect relationships between interventions and outcomes. However, this case report does show that the patient was able increase functional ROM, muscle strength/endurance and balance. The patient was also able to demonstrate a more efficient gait pattern at the time therapy concluded. These improvements are likely due to the physical therapy interventions, as these treatment interventions were directed towards the specific impairments.

The patient achieved all goals set forth by the clinician and the patient herself. The only goal not attained was her goal of being able to run again, due to restrictions placed on her by her primary MD. However, she did demonstrate that a light jogging routine would be well tolerated. First, the patient did improve her (L) dorsiflexion by 3º without pain and her (L) inversion by 10º without pain at end range. The patient was able to maintain ROM measurements in all other motions without pain as well.

Second, the patient was able to improve her functional squat to 90% with her heel on the ground. This was an improvement from the initial 50% with heel lift at the start of treatment. Third, the patient demonstrated improved balance in the single leg balance test by increasing from poor-fair to good bilateral. The time achieved for both LE was 90 seconds without a hand support. Lastly, the patient showed an average of 1+ increase in muscle strength in all motions for the (L) LE. All improvements led to her demonstrating a more efficient gait upon discharge.

The patient also showed improvements in palpation to tenderness. The patient reported no pain to touch around the achilies tendon and lateral malleoli. However, at discharge the patient had minimal tenderness to touch along the posterior tibialis tendon. There was a slight portion of the anterior ankle joint line that had tenderness as well. This was possibly a result of the surgery because the tenderness experienced was along the incision scar. The scar itself was well healed and did not have fusion from the healing process.

The gait pattern of the patient changed dramatically as improvements in ROM came. The patient presented with decreased toe off, decreased stance time, decreased hip flexion and foot flat contact at initial evaluation. At the conclusion of treatment the patient was able to demonstrate a more efficient gait. However, the patient would still have sessions where aching was reported with increased walking time and distance. In an article by Kinoshita[46], female athletes can be predisposed to tarsal tunnel syndrome especially when involved in sports that require jumping and running. The same holds true for patients that have an abnormal gait pattern due to increased pain. At the time of the loading response, in normal gait, the body's center of mass is moving downward and the ground reaction force is higher than the persons body weight.[47] The inability of the person to properly flex the ankle increases the absorption of the ground reaction force at the ankle instead of dispersing it up the chain of the leg. Pain will likely be experienced especially in ankle that is post op.

An area specifically addressed during treatment was the patients' balance. The relationship between standing posture and balance is complicated. The inability and unwillingness for the patient to properly support herself potentially was a result of two dysfunctions, however only one area was treated. The patient had a past medical history of frequent ankle sprains. This frequency agrees with the findings of Hinterman[48] found, that in patients with chronic unstable ankles the problem becomes less mechanical and more of a proprioceptive issue. Her balance and proprioception training involved the balance board, which has been shown to decrease recurrences in ankle sprains and help improve the proprioception to the joint.[41] Treatment also included the BAPS which has been shown to increase muscle activity around the ankle joint, this in turn helps to stabilize the joint from further trauma by making up for the laxity in the ligaments.[49] The results from this work showed ability for the patient to perform a single leg balance for up to 90 seconds without requiring hand support.

The second area, the one not addressed during treatment, was the patients' core control. Core stability has been defined as a stabilization of the trunk that allows production, transfer, and control of force and motion to distal segments down the kinetic chain.[50] Therefore, neuromuscular control of the trunk is based feedback control and without proper feedback from distal segments the trunk does not function properly. In a study done by Zazulak et al,[51] the authors found that there is a correlation between subjects with prior ankle sprains and a delay in the onset of the glut muscles as well as greater lateral body sway. This research shows that physical therapists who encounter patients with frequent ankle sprains, especially females because the study also showed that females were more likely to have weaker core strength[51], should provide some core training to help stabilize the body and increase the active neuromuscular control of the lower extremities. This could have decreased the aching in the ankle the patient had at discharge, after prolonged walking. This area for treatment should look to be utilized in therapy for patients that have dysfunction in the lower extremities.

The treatment plan followed protocol for the treatment of achilies tendon repair as described by Kisner and Colby.[36] This is strength of this study due to the already researched and proven methods for treating this orthopedic condition. The patient made tremendous gains in the time spent during treatment. Although some numerical values for ROM are less than normal it is function that is important. The efficient gait demonstrated at discharge and the ability to provide better ankle stability agrees with the protocol already established for success. Other areas of treatment in terms of pain and strength all followed already established treatment protocols that have been proven to be effective for this condition and similar patients.

A weakness of this study is that there was no functional outcome scale, such as the SF-36, used to document changes from the start to the end of therapy. Only general measurements were taken with common methods such as ROM with a universal goniometer, general extremity strength assessment with manual muscle testing, and coordination testing consistent with neuromotor standards. These tools can be subjective, and all though the authors' results were compared to a senior clinical therapist, there is room for error. Another weakness in this study was the lack of exercises to help strengthen up the kinetic chain. As stated previously core strengthening can alter neuromotor control to the lower extremities. Additional studies may want to look at the effects of core stability and the role the ankle plays in that stability.

Conclusion:

This case report provides information regarding a patient with a tarsal coalition excision and achilies tendon lengthening. The patient had the primary impairments of ankle AROM and PROM deficits, disrupted balance, inefficient standing posture, decreased flexibility, decreased muscle strength, swelling, impaired gait and decreased function. The interventions used during this treatment included ankle AROM exercises, balance training, ankle strengthening, manual therapy, gait training and modalities. This report showed that those physical therapy interventions chosen helped the patient achieve to within normal function of the use of her ankle following surgery. Additionally, this report shed light on the aspect of core stability and its relation to ankle injuries, especially in the female athlete. Despite the popularity of core training there is little research that shows exactly how effective it is for healthy athletes and preventing injury.[52] Zazulak[51], found that female athletes are more likely to have knee injuries with a weak core, versus male athletes. However, the study did not show the relation between ankle instability and a weak core. This should be taken into consideration as a future research project, whether core work will decrease instability in the ankle joint.

This patient did achieve her goals except one, to return to running. Treatment for this patient with the protocol provided did help to increase strength, ROM and improve gait, however due to her primary physician she was told to avoid running for four more weeks. This is despite the fact that she was able to demonstrate to the treating PT that she was able to run on the involved ankle without pain for a short time. With continued application of the HEP she would have been able to fulfill all her goals but again was held back per her doctors' orders. It is also possible that the addition of core stabilization exercises could have helped further the progress of the patient.

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Table 1- Active ROM Measurements (L) Ankle.

	Initial Evaluation	Midterm Evaluation	Discharge Evaluation	Normal ROM *	Initial to Final Change
Date	**05/21/07**	**06/22/07**	**07/11/07**		
Dorsiflexion	15°	18°	18°	20°	3°
Plantarflexion	15°	30°	30°	50°	15°
Inversion	15° ERP	23°	25°	35°	10°,-ERP
Eversion	15° ERP	15°	23°	15°	8°,-ERP

ERP- end range pain
***- ROM measurements based on the American Academy of Orthopedic Surgeons measurements for the ankle joint.**

Table 2- Passive ROM Measurements (L) Ankle.

	Initial Evaluation	Midterm Evaluation	Discharge Evaluation	Normal ROM	Initial to Final Change
Plantarflexion	35° ERP	35° ERP	38°	50°	- ERP
Inversion	35° ERP	35°	35°	35°	- ERP

Table. 3								
	Week 1	2	3	4	5	6	7	8
Range of Motion								
Ankle Inversion/Eversion 2x15	x	x	x	o	o	o	o	o
Alphabet (capital letters) x1	x	x	x	o	o	o	o	o
PROM all directions 6 min	x	x	x	x	x	x	x	x
Gastroc Standing Stretch 3x 30 sec.		x	x	o	o	o	o	o
Gastroc Slant Board 3x 30 sec.	x	x	x	o	o	o	o	o
Gastroc /Soleus towel stretch 3x30 sec.	x	x	o	x	x	x	x	x
PRE's								
Theraband DF/PF IV/EV 2x 15 ea	x	x(+)	x	x	x	x	x	x
Heel Raises 2x 10	x	x	x	x	x(+)	x	x	x
Cycle	x	x(+)		o	o	o	o	o
Stairmaster	o	o	x	x	x	x(+)	x	x
Neuromuscular Reeducation								
Stabilization BAPS DF/PF clockwise	x	x	x	x	x	x(+)	x	x
and counterclockwise x30 ea.								
SLB on half foam roll	o	x	x	x	x(ws)	x(+)	x	x
Balance board ant/post, lateral 90secsea.	x	x	x	x	x	x	x	x
5 point reach on Gary Gray mat	o	x	x	x	x	x	x	x
5 sets held for 5 seconds each								
Toe walks 3x 20 steps	o	o	o	o	o	x	x	x
Contra kicks x4, 20 reps	o	o	x	x	x	x(+)	x	x
Functional Squatting 2x 15	o	o	x	x(+)	x	x	x	x(+)
Manual Therapy								
TC/ST Jt mobs II-III	x	x	o	o	x	x	x	o
STM 6 min	x	x	x	o	x	x	x	x
Modalities								
E-stim Hi-volt 12 min	x	x	x	x	o	o	o	o
US direct 3 MHz, continuous 6 min	o	o	o	x	x	x	x	x
Ice 12 min	x	x	x	x	x	x	x	x

X- Treatment Performed
X(+)- Treatment Increased
O- Treatment not Performed
WS- Weight Shift Added