Physical Therapy Rehabilitation of An Adolescent Pre-Professional Dancer Following Os Trigonum Excision: A Case Report

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Abstract

Study Design: Case report.

Background: An os trigonum can be a source of pain for dancers due to impingement during repetitive ankle plantarflexion movements. Following excision of an os trigonum, it is important to have a gradual, progressive return-to-dance program for optimal recovery. The purpose of this case report is to describe the post-operative management and return-to-dance progression of an adolescent dancer status post os trigonum excision.

Case Description: An adolescent pre-professional female dancer had an extensive history of left posterior heel pain beginning at age eight that led to surgical removal of an os trigonum at age fifteen. This case report describes the physical therapy interventions used to help her return to full, unrestricted activity.

Outcomes: The dancer had a full return of ankle range of motion, strength, and balance, improved patient reported outcome scores, and was able to fully return to dance participation.

Discussion: Treating a dancer following os trigonum excision should involve a screen for hypermobility, clear communication with the dance instructor, awareness of dance-specific biomechanics, and proper reintegration into dance participation.

Level of Evidence: Therapy Level 5.

Key Words: ballet, foot, ankle, os trigonum

BACKGROUND

An os trigonum is an accessory bone located posterior to the talus. It is the second most common accessory bone found in the foot[42] with an overall prevalence ranging from 12.7 to 23.5% in the general population.[8, 42] Despite a relatively high prevalence in the general population, the sheer existence of an os trigonum does not guarantee symptoms of pain or limited ankle plantarflexion motion.[15, 22, 42] In the dancing population, the overall prevalence of os trigonum is unknown but it has been found to be responsible for 30% of posterior ankle symptoms in classical ballet dancers.[35] An angle of 180° between the tibia and metatarsal shafts is desirable for classical ballet dancers in order to achieve an aesthetically pleasing and biomechanically effective position for balancing en pointe.[19] En pointe refers to the position of maximal ankle plantarflexion resulting in balancing on the tips of the toes while wearing rigid dance shoes. As a dancer approaches full ankle plantarflexion in weight bearing, also known as relevé, the posterior calcaneus approaches the tibia as the talus rotates anteriorly resulting in narrowed space for the posterior ankle structures.[15, 19] When an os trigonum blocks the calcaneus and tibia from full approximation [2, 27] resulting in pain and limited ankle plantarflexion,[15] it is known as os trigonum syndrome.

While there is a plethora of research outlining the pathophysiology and surgical techniques for os trigonum syndrome, [14, 16, 33, 34] there are no research studies to date regarding rehabilitation of dancers following an os trigonum excision. The current literature focuses on general guidelines for physical therapy interventions based on healing times for interrupted tissues. Beyond the acute and subacute phases, there are no dance-specific guidelines to utilize to ensure a gradual and safe return to the dancer's prior level of activity. Physical therapists without a dance

background may have difficulty determining a safe and appropriate return-to-dance progression. The current literature states that a dancer can resume full dance activity between five weeks and six months following os trigonum excision with no indication for the reason for the variance in time frames. [11, 32, 44] Further, few resources address time frames for individual components of returning to full dance activity, such as barre exercises, [11, 33, 44] dance class participation, [2, 11, 15] and pointe work. [2, 40] The purpose of this case study is to describe general treatment parameters and return-to-dance progressions that can be utilized to facilitate return to high-level dance activities following an os trigonum excision.

CASE DISCRIPTION

History

An adolescent female, pre-professional dancer had an extensive history of left posterior heel pain beginning at age eight leading to her decision to surgically remove an os trigonum at age fifteen. Her posterior heel pain was initially diagnosed as calcaneal apophysitis, also known as Sever's Disease, as ankle radiographs were negative for any bony abnormality. Although the pain continued for five years, the family assumed the pain was related to calcaneal apophysitis and she continued to dance three hours a week. However, by the time she was 13 years old, she was dancing 17 hours per week and had initiated dancing en pointe resulting in an increase in symptoms. She returned to her physician for further examination. Another radiograph was performed, but again, no bony abnormality was identified. Therefore an MRI was ordered. On MRI, the os trigonum was clearly identified (Figure 1).

Following identification of the os trigonum, conservative management through physical therapy was initiated. After five months of activity modification and physical therapy, she was able to return to full dance participation with decreased pain and use of a TENS unit as needed.

The following year, she transitioned to a pre-professional ballet studio. She was now dancing 20 hours per week with more time spent en pointe resulting in an escalation of her posterior heel pain. She returned to the physician and received an injection, which allowed her to participate in her upcoming performance. At age fifteen, after completion of a summer dance intensive and increased dance participation to 25 hours per week, she reported reaching 9/10 on an NRS pain scale daily. Four months later, she underwent an os trigonum excision through an open technique with a medial approach. She was seen for a post-operative physical therapy evaluation four weeks status post surgery.

Examination

At the time of the initial post-operative evaluation, a thorough subjective and objective examination was conducted. In the subjective history, dance-specific questions regarding frequency, intensity and duration of dance participation for each specific genre of dance performed were included. The patient reported difficulty with ankle movements, toe flexion, and climbing stairs as well as the inability to participate in dance. The patient's main impairments at time of the initial evaluation included: ankle pain, ankle effusion, antalgic gait pattern, decreased ankle range of motion, limited talocrural joint play, lower extremity weakness, decreased core strength and endurance, lower extremity muscle tightness, and impaired balance and proprioception (Table 1). A screen of joint hypermobility was conducted using the Beighton

scale. This patient scored a 7/9 on the Beighton scale and had been previously diagnosed with Ehlers Danlos, Type III, hypermobile type. Dance technique was not assessed at initial evaluation due to post-operative impairments. However, it was assessed continually throughout rehabilitation process as resolution of impairments and healing time allowed.

Prior to surgery, the patient was participating in approximately 25 hours of dance per week consisting primarily of ballet, including en pointe, with one to three hours a week dedicated to tap and contemporary dance. The patient's main goal for physical therapy was to return to this same level of dance participation post-operatively.

Interventions

The patient was seen for a total of 22 visits, including initial evaluation, spread over the course of 24 weeks following os trigonum excision. The patient was seen twice a week for the first 12 weeks, once a week for weeks 12-16, bi-weekly for weeks 16-20, with a final visit following her first performance at 24 weeks. Treatment consisted of therapeutic exercise, therapeutic activity, modalities, neuromuscular re-education, and manual therapy (Table 2). Return-to-dance tests were utilized in conjunction with Cincinnati Children's Hospital Medical Center Return-to-Sport guidelines to safely progress this injured dancer back to full, unrestricted dance participation.[41] Due to post-operative limitations, these tests were not performed at evaluation, but rather throughout the episode of care.

Return-to-Dance Tests

The Pencil Test (Figure 2) is used to determine if a dancer has at least 90° ankle plantarflexion, which is the ideal amount of plantarflexion required to dance en pointe. While in a long-sitting

position, the dancer performs maximal ankle plantarflexion. A straight-edge, such as a pencil, is placed along the top of the dorsal talar neck. If the straight edge clears the distal most part of the tibia proximal to the malleoli, the dancer passes the test.[36] This patient did not pass the Pencil Test at initial evaluation but achieved by week 4 of rehabilitation.

Three additional tests have been specifically identified as good indicators of pointe-readiness; the Airplane Test, the Topple Test, and the Single-Leg Sauté Test.[36] The Airplane Test (Figure 3, available at www.jospt.org) as described by Liederbach,[25] is an advanced assessment of lower extremity neuromuscular control. The dancer assumes single-leg stance with the trunk and non-support lower extremity extended to be parallel to the ground. The patient then performs five controlled single-leg squats in this position as the arms horizontally adduct toward the ground. A "pass" is considered successfully completing four out of five repetitions without lower extremity alignment deviations or loss of trunk control.[36] This patient passed the Airplane Test during week 12 of rehabilitation. This test was part of the criteria used for consideration of when to initiate plyometrics.

The Topple Test (Figure 4, available at www.jospt.org) as described by Lopez-Ortiz, [28] is an assessment of total body control during a pirouette, a 360° rotation of the entire body while in single-leg balance. A "pass" is considered performing the pirouette with the balance leg in full knee extension, gesture leg in passé position, maintenance of vertical trunk position during the descent from the skill, and proper control of the supporting leg during deceleration.[36] This patient passed the Topple Test during week 12 of rehabilitation, which allowed for the patient to begin turns in center wearing ballet slippers. Later in the rehabilitation process, the patient had to pass this test again while wearing her pointe shoes in order to begin turns in center en pointe.

The Single-Leg Sauté Test (Figure 5, available at www.jospt.org) is an assessment of dynamic trunk control and lower extremity alignment as the dancer performs 16 consecutive single-leg jumps. Richardson defined a "pass" as at least 8 of the 16 jumps executed with a neutral pelvis, upright and stable trunk, proper lower extremity alignment, appropriate toe-heel landing, and having a fully pointed foot in the air.[36] This patient passed the Single-Leg Sauté Test during week 16 of rehabilitation. This was part of the criteria utilized to determine when to give the patient full clearance to return to full participation in floor work.

Return-to-Dance Class Progression

Barre

Barre is the first component of a ballet class. Barre consists of non-impact activity while utilizing assistance of the upper extremity for balance. In this case, the patient returned to basic ballet barre at post-operative week five in physical therapy as she demonstrated adequate ankle ROM, tolerance to weight bearing, and minimal swelling. Barre requires the dancer to perform a significant amount of relevés, pending the dancer's class level. Due to the repetitive nature of relevés incorporated into ballet barre, the patient was initially limited to performing barre skills without relevé in her ballet flat shoes. Double leg relevé was added during week six as she demonstrated ability to perform multiple repetitions of this movement through full ankle plantarflexion range of motion during physical therapy without onset of symptoms. Single leg relevé was added to the ballet barre during week 10 once the patient was able to perform at least 40 single leg relevés. While the highest level of achievement for manual muscle testing of the ankle plantarflexors is 25 single leg heel raises,[18] a dancer must be able to perform significantly

more than 25 single leg heel raises to meet the demands of dance class. Therefore, a higher goal of 40 single leg relevés was established as criteria to clear the patient for full participation in the barre component of ballet class.

Center

Once the patient was reintegrated into barre, the next component of class is known as center. In center, the dancer is required to perform dance skills that are both non-impact and impact. Small jumps performed in center are known as petit allegro. Small jumps consist of both double leg and single leg landings. In center, there is a higher level of neuromuscular control and balance that is required. The dancer no longer has the support of the ballet barre and must complete other skills such as turns and slower, sustained motions known as adagio. Once the patient was able to demonstrate adequate neuromuscular control and strength of the lower extremity by successfully passing the Airplane Test and Topple Test, jumps and turns were incorporated back into dance class. This occurred around week 11 with this patient.

Floor

The last component of the dance class is called floor. During this time, dancers perform large jumps known as grand allegro. This normally requires a single leg landing. Due to the amount of strength and neuromuscular control needed to complete these skills, the patient was reintegrated into floor work last. She was allowed to initiate floor work at week 11 after she passed the Airplane Test and Topple Test. However, patient was not cleared for full participation in floor until week 16 after she passed the Single Leg Sauté Test indicating achievement of adequate lower extremity neuromuscular control during a dance-specific jump task.

Plyometric Progression

Plyometrics were progressed gradually and in order of difficulty to ensure safe participation and decrease risk for injury. The dancer began with low intensity double leg jumps. Following demonstration of proper lower extremity biomechanics, rotary and power components were applied to double leg jumps. Rotary refers to a direction change during the jump and power refers to increased height to allow for changes in leg position. Following safe performance of double leg jumps with rotatory and power components, she was progressed to jumps requiring transition between double leg and single leg such as sauté arabesque and sissonne. Finally, single leg hops were initiated with addition of rotary and power demands when appropriate lower extremity neuromuscular control noted. This patient required five weeks to safely progress from low intensity double leg jump to a single leg power hop.

Pointe Work

The dancer was allowed to initiate pointe work at the barre only during week 12. She had already passed the Pencil Test at week 4, was able to easily perform 40 single leg relevés, and was able to balance with eyes closed for 30 seconds on flat ground. Pointe work was initiated at barre without relevé at first in order to help her feet have time to adjust to the tight fit of the pointe shoe. The following week, pointe work began at the barre with relevés. Pointe at the barre was done first to give the patient external support for balance to allow time for adequate proprioception and technique to be present prior to progressing away from barre en pointe.

Impact activity was still completed in ballet flats during this time to allow the patient to continue working on ankle plantarflexion power production in preparation for impact activity while wearing rigid pointe shoes. Once the patient passed the Single Leg Sauté Test and Airplane Test in pointe shoes, she was cleared for center and floor combinations en pointe. Clearance for turns en pointe in center was granted once Topple Test on pointe shoes was passed. Following successful full class participation during week 15, the patient was cleared for participation in performances during week 16.

For each step in the return-to-dance progression, the patient was able to demonstrate the ability to successfully complete the dance-specific skill without pain and correct biomechanics prior to receiving clearance to perform the skill within their dance class (Table 3). Examples of the dance-specific movements that were utilized throughout the phases of the return-to-dance progression are highlighted in Figure 6.

At the time of discharge, the patient had returned to full class participation and had completed four performances en pointe without any limitations. There were no adverse or unanticipated events that occurred throughout her rehabilitation. The patient was provided with a comprehensive home exercise program and a plan for re-integration into her summer intensive dance program.

OUTCOMES

DFOS

The Dance Functional Outcome Survey (DFOS) is a dance-specific questionnaire, which has been developed for ballet and modern dancers of all training levels. The DFOS consists of 14 multiple choice questions divided into two main sections, general activity (activities of daily living and pain) and dance technique (ability to perform dance-specific movements). It is intended to be used for screening the health status of healthy dancers or to evaluate a patient's disability following musculoskeletal injury to the low back, pelvis, or lower extremity. A preliminary study indicated high reliability, validity, and responsiveness of the DFOS in 20 adult dancers when compared to the SF-36. [4, 5] This patient scored a 16/40 on general activity subscale and 8/50 on dance technique subscale at evaluation. At discharge, she scored 37/40 on general activity subscale and 48/50 on dance technique subscale. Improved ballet technique is observed post-operatively by her ability to achieve full ankle plantarflexion en pointe (Figure 7).

PedsQL

The Pediatric Quality of Life Inventory (PedsQL) was developed to measure the health-related quality of life in children and adolescents (age 2-18 years). The PedsQL is shown to be a feasible, reliable and valid measure of health status in children as young as 5 years old. [45] In young patients with orthopaedic conditions, the PedsQL is known to be responsive and accurately show clinical change over time. [45] From current literature, the PedsQL appears to be the "gold standard" measure of general health status in the pediatric and adolescent population. This patient scored a 68.75% on the PedsQL at initial evaluation and 100% at discharge.

DISCUSSION

There are no research studies to date that address specific rehabilitation parameters for a dancer following os trigonum excision. The current available literature focuses on general guidelines for physical therapy interventions that address primarily the acute and subacute phases. [2, 6, 10, 12, 15, 17, 32, 37] In regards to return-to-dance progression, there is a large variance in reported time frames as well as minimal framework or criteria in which to safely and gradually resume participation in dance.[10, 12, 15, 19, 29, 32, 33, 40, 44] This patient received a structured, dance-specific, physical therapy rehabilitation program tailored to address her identified impairments status post os trigonum excision. The patient was able to achieve her end goal of returning to full dance participation at a pre-professional level.

Imaging

Imaging of the os trigonum played a major role in detection and management of the patient's source of pain. It is recommended that dancers receive imaging in a heel raise position from a lateral view to clearly visualize the bony components of the posterior ankle.[31, 46]

While radiographs can assist in identifying the os trigonum, the accessory ossicle may actually be larger than it appears on the radiograph due to cartilage components that are not clearly delineated on the image. [2, 15, 32, 38] This was demonstrated in our patient as the amount of tissue excised was more than identified on imaging (Figure 8). It is also important to appreciate that the size of the os trigonum does not always correlate with the intensity of the symptoms and that an image positive for os trigonum is not clinically relevant without associated supporting subjective history and objective clinical exam. [10, 12, 15, 33, 38] When utilizing imaging in the case of os trigonum, MRI is the technique of choice [7, 16, 31] due to its ability to delineate the anatomic site of

abnormality and reveal coexisting pathologies. [2, 7, 35] For our patient, this is how the os trigonum was identified.

Return-to-Dance Considerations

Hypermobility

Hypermobility is defined by a score of 5/9 or greater on the Beighton scale.[3] Increased joint laxity is a more common finding in dancers than in the general population and studies show that hypermobile dancers are more at risk for injury compared to non-hypermobile dancers.[9, 20] Progression back to dance also needs to be slower due to delayed tissue healing time and poor proprioception related to their joint laxity. [24, 39] This patient had a score of 7/9 on the Beighton scale with a history of Ehlers Danlos, Type III, hypermobile type. Our patient took a total of six months to fully return to unlimited dance after surgery. This is a longer timeframe compared to a retrospective case series involving 38 dancers who underwent os trigonum excision. On average it took these dancers four and a half months to return to pain free dance following os trigonum excision.[13] Knowing hypermobility could be a limiting factor affecting the time to progress through rehabilitation, completing a Beighton scale on every dancer at the time of initial evaluation is highly recommended. In addition, many dance movements require end-range positions of various joints within the body so excessive demand on hypermobile joints cannot be avoided. Therefore the authors recommend beginning strengthening in neutral range of joint motion through the early stages of tissue healing but eventually progress into the hypermobile range of motion in order to become strong at end-range as required by dance movements.

Communication with Dance Teacher

As the dancer is gradually returning to dance, it is important to have clear communication with the dance teacher regarding rehabilitation progress and specific dance restrictions. [21] Despite beliefs that high level of communication is necessary, medical professionals working with dancers tend to have decreased frequency of communication with associated health care professionals as well as dance teachers. [23] In this case study, the physical therapist provided written notes to the dance teacher with appropriate level of participation in class as well as to the referring physician regarding rehabilitation progress.

Reintegration into Dance

Proper reintegration back into dance is necessary for a successful outcome following surgery. For this to occur, a dance-specific history should be obtained at the time of initial evaluation. The clinician's questions need to target gaining an appreciation for the frequency, intensity and duration of dance participation for each specific genre of dance performed. Gaining insight into upcoming performance and competition schedules as well as specific demands of choreography will also help form end stage return–to-dance goals. In addition, using a dance-specific subjective questionnaire, such as the Dance Functional Outcomes Survey, at the time of initial evaluation and throughout rehabilitation allows treatment to be tailored to subjective reports of difficulty in relation to previous skill level.

Once the demands of dance participation are established, the clinician must also be able to assess the dancer's biomechanics related to dance-specific positions. This may be a daunting task if not familiar with basic ballet positions and the associated terminology. For this specific case, one of the key biomechanical assessments was appreciating the correct position of the talocrural joint

while the patient is in relevé. The weight needs to be balanced across the foot so the dancer is not inverting the foot by shifting weight onto the 5th metatarsal. This is known as sickling (Figure 9A, available at www.jospt.org), and is an improper weight distribution normally associated with decreased neuromuscular control, and in some cases, decreased posterior tibialis strength. Sickling is a common compensation pre-operatively to decrease impingement on posterior ankle structures and increase ankle plantarflexion range of motion.[15, 17, 33] Postoperatively, this should improve as ankle plantarflexion range of motion is restored and proper neuromuscular control is reestablished (Figure 9B, available at www.jospt.org). Interestingly, the wear pattern on the tip of the pointe shoe, known as the toe box, can be evaluated to determine if the dancer is weight bearing properly en pointe (Figure 10).

It is important to begin dance movements within patient's tolerance and physical capabilities as soon as the acute stage of healing is completed to decrease emotional stress and prevent deconditioning. Absence from dance due to injury has been shown to be positively correlated with stress, sleep disturbances, and negative mood states such as tension, depression, and anger.[1] This negative stress from injury can even increase time loss from dance participation.[30] Prolonged periods of inactivity, with resulting decrease in physical fitness, can contribute to increased injury rates during return-to-dance progression.[26, 43] By returning the dancer to class in some capacity, negative stress will be decreased and physical fitness will be maintained thus reducing time lost from injury as well as the risk for re-injury. The dancer in this case reiterated the importance of early return-to-dance. She commented at the end of her rehabilitation how important it was to her mentally to return to the dance studio early in her rehabilitation process to keep her motivated to work towards her end goal of fully returning to dance.

Limitations to this case study include variation in measurement intervals throughout rehabilitation, limited specificity of cardiovascular endurance training to meet the demands of a ballet performance, and generalizability of the rehabilitation program to other genres of dance.

This case described the diagnosis and management of a dancer with a symptomatic os trigonum. Key elements believed to assist in the clinical decision making included 1) screening for hypermobility to properly grade return-to-dance progression at a slower rate 2) establishment of higher than average calf strength goal to meet the demands of dance 3) awareness and correction of dance-specific biomechanics 4) incorporation of dance-specific tests for a criterion-based return-to-dance progression to safely return the dancer to full unrestricted activity.

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TABLE 1 Objective Measures at Evaluation and Discharge

Objective Measures	*Initial*		*Discharge*	
	Left	**Right**	**Left**	**Right**
Ankle Pain, numeric rating scale	0/10	0/10	0/10	0/10
Ankle Effusion, figure 8	46.5cm	45.5cm	NT	NT
Gait, visual observation for 15m	Early heel lift off during midstance, lack of full L LE weight acceptance for propulsion over forefoot during late stance	Increased toe-out angle during stance	WNL	WNL
Ankle Active Range of Motion, deg				
Plantarflexion	70	80	80	NT
Dorsiflexion	4	24	25	NT
Inversion	30	30	40	NT
Eversion	20	35	35	NT
Talocrural Joint Play	Anterior and posterior capsular restriction	WNL	WNL	NT
LE Strength Testing				
Ankle Plantarflexion MMT	3-/5	5/5	5/5	5/5
Ankle Plantarflexion SL Heel Raise	0	32	40	40
Ankle Dorsiflexion MMT	3-/5	5/5	5/5	5/5
Ankle Inversion MMT	4+/5	5/5	5/5	5/5
Ankle Eversion MMT	3-/5	5/5	5/5	5/5
Knee Flexion MMT	4+/5	4+/5	5/5	5/5
Knee Extension MMT	5/5	5/5	5/5	5/5
Hip Flexion MMT	4+/5	4+/5	5/5	5/5
Hip Extension MMT	5/5	5/5	5/5	5/5
Hip Extension (glute bias) MMT	4+/5	4+/5	5/5	5/5
Hip Abduction MMT	5/5	5/5	5/5	5/5
Hip Adduction MMT	NT	NT	5/5	5/5
Hip External Rotation MMT	4+/5	4+/5	5/5	5/5
Core Strength and Endurance				
Double Leg Lower MMT	NT		4-	
Modified Front Plank, sec	NT		120	
Modified Side Plank, sec	NT		60	
LE Flexibility, deg				
Gastrocnemius	-9	20	22	22
Soleus	16	27	44	42
Balance and Proprioception, sec				
Eyes Open	60	60	NT	NT
Eyes Closed	3	9	44	27
AirEx	NT	NT	60	60
Bosu	NT	NT	26	13
Dance Functional Outcome Scale				
General, out of 40	16		37	
Dance, out of 50	8		48	
Return-to-Dance Tests				
Airplane Test, pass or fail	NT	NT	pass	pass
Topple Test, pass or fail	NT	NT	pass	pass

Single Leg Sauté Test, pass or fail	NT	NT	pass	pass
Pencil Test, + or -	+	-	-	-
Biodex				
Left Compared to Right	NT	NT	Power (30°/sec): 22% deficit Strength (60°/sec): 8% deficit Endurance (120°/sec): 0.7% deficit	
Peak Torque:Body Weight Ratio	NT	NT	Within normal limits or exceeded at all speeds	

Abbreviations: NT, not tested; LE, lower extremity; MMT, manual muscle test.

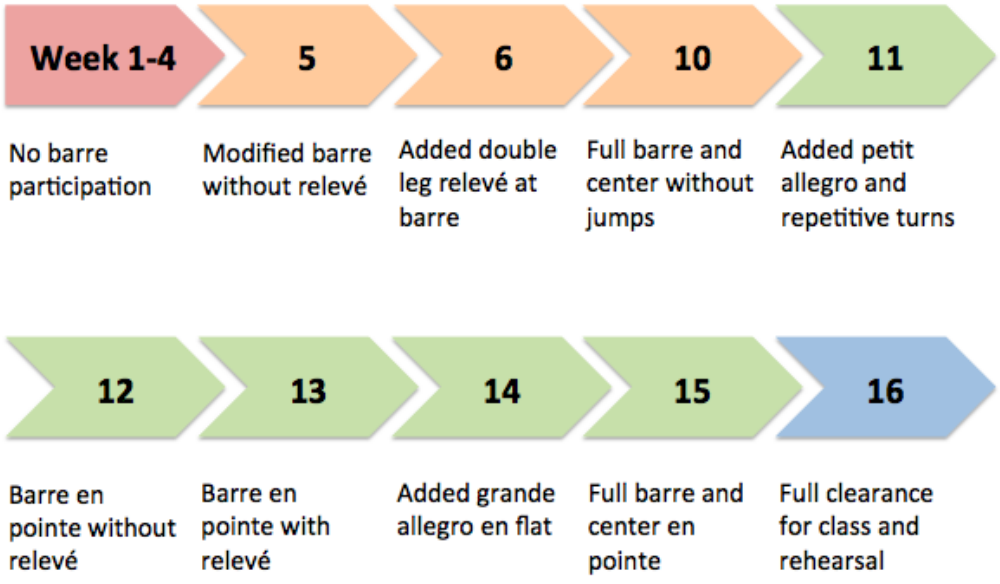
Table 2. Treatment Interventions

Impairment	Acute (1-4wks) eval + 7 treat	Early RTD (5-10wks) 7 treat	RTD (11-15wks) 6 treat	End-Stage RTD (16-20wks) 2 treat
Pain and effusion	cryotherapy, Malleotrain, pre-mod e-stim	cryotherapy, Malleotrain	x	x
Decreased ROM	ankle 4-way AROM, ankle alphabet, ankle circles, BAPS board, talocrural mobilization	talocrural mobilization	x	x
Decreased foot/ankle strength	resisted ankle 4-way, toe yoga, arch doming, slide board toe curl walk and heel-toe walk, DL relevé in parallel and turn out on shuttle	resisted ankle 4-way, toe yoga, slide board toe curl walks and heel-toe walks, DL and SL relevé in parallel on shuttle, DL relevé hold with arm and head movements, DL to SL eccentric heel raise, SL heel raise, supine DL bridge with ankle plantarflexion	DL to SL eccentric heel raise, sidelying ankle inversion/eversion with resistance	x
Decreased hip/knee strength	resisted sidelying clamshells, resisted prone hip extension, supine DL bridge with resisted hip ER, DL and SL shuttle press in parallel and ER, resisted side steps and CKC hip ER stepping	resisted sidelying clamshells, supine SL bridge, DL and SL shuttle press in parallel, resisted side steps and monster walks, resisted CKC hip ER stepping (with and without onto step), wall squat	DL and SL shuttle press	supine SL bridge
Decreased lumbopelvic control	quadruped alternating UE/LE lift, BOSU v-sit in knee flexion and trunk extension	quadruped alternating UE/LE lift with occasional SwissBall support due to LBP, BOSU v-sit in knee flexion with and without trunk rotation, supine bridge with feet on SwissBall, prone walkout on SwissBall	BOSU v-sit in knee extension, BOSU trunk extension with ankle beats, front and side planks but on knees if LBP	full front and side planks but on knees if LBP
Decreased LE flexibility	long sitting calf stretch, standing and slant board gastroc-soleus stretch	slant board gastroc-soleus stretch	x	x

Poor balance	SL balance on ground with eyes open and closed, SL balance on Airex static and passé progression, balance beam walking with various head and LE movements, rocker board balance, panche balance	SL balance with eyes open and closed, SL balance on Airex, SL balance on BOSU static and with passé progression, panche balance, stepping into balance on Airex, SL relevé balance, DL plie in turnout on flat BOSU	penchée balance, SL relevé balance	x
Decreased cardiovascular endurance	upright bike	upright bike	upright bike	upright bike, elliptical, sprints
Impaired CKC functional mobility	stair climbing, anterior heel taps	lateral heel taps, forward alternating lunge with and without arm movements, front/side/back lunge with push off, forward/backward walking lunge, airplane SL squat, Star Excursion Balance Test, DL and SL squat, DL shuttle jumping in parallel and turnout	forward walking lunge with and without medicine ball trunk rotation, backward walking lunge, DL shuttle jumping in 1st and 2nd positions	x

Abbreviations: RTD, return to dance; ROM, range of motion; AROM, active range of motion; DL, double leg; SL, single leg; ER, external rotation; CKC, closed kinetic chain; UE, upper extremity; LE, lower extremity.

TABLE 3. Return-to-Dance Progression



*all levels of dance participation were cleared in clinic first

Figure 1. MRI showing the identified Os Trigonum.

Figure 2. Pencil Test. The pencil is placed on the dorsal talar neck. When the straight edge of the pencil can clear the distal most part of the tibia just proximal to the malleoli, it is considered a “pass” as this represents that there is greater or equal to 90 degrees plantar flexion.

Figure 3. Airplane Test. As described by Liederbach, the dancer assumes a single-leg stance with trunk and non-support lower extremity extended to be parallel to the ground. The patient then performs five controlled single-leg squats in this position as the arms horizontally adduct toward the ground. A "pass" is considered successfully completing four repetitions without LE alignment deviations or loss of trunk control.

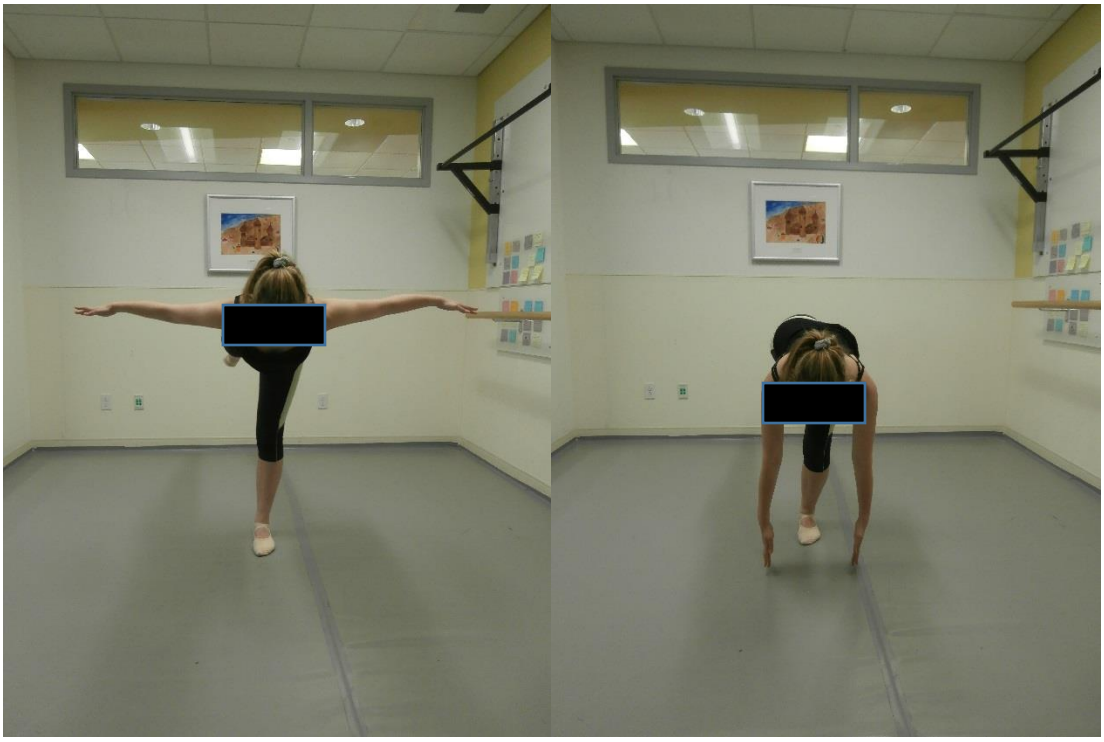


Figure 4. Topple Test. The dancer pictured below is completing a single pirouette and lands with control.

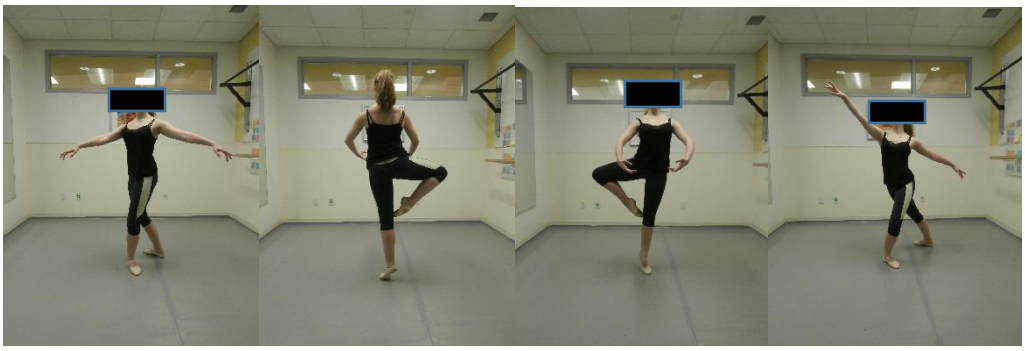


Figure 5. Single Leg Sauté Test. To “pass” at least 8 out of the 16 jumps need to demonstrate a neutral pelvis, upright and stable trunk, proper lower extremity alignment, appropriate toe-heel landing, and a fully pointed foot in the air.

Figure 6. The following are examples of dance specific movements that can be done throughout the different phases of rehabilitation.

Acute

Demi Plié

- shown performed on rotational discs
- can perform with feet in various positions but heels must remain on the ground

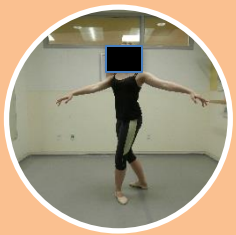
Tendu

- shown to anterior direction
- can also perform to lateral and posterior directions
- foot remains touching ground

Dégagé

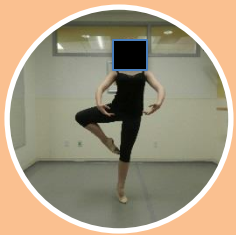
- shown to lateral direction
- can also perform to anterior and posterior directions
- foot pushes off of ground

Early Return to Dance



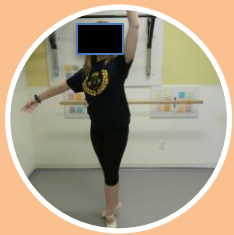
Pirouette Preparation

- initiate without turn
- progress to single pirouette



Piqué Preparation

- initiate without turn
- progress to single piqué turn



Bourrée

- initiate at barre
- progress to across the floor

Return to Dance

Barre

- initiate barre en pointe
- progress from no relevé to relevé

Turns

- initiate turns with double leg support en pointe such as bourré, soutenu, and chainé
- progress to turns with single leg support en pointe such as pirouette and piqué

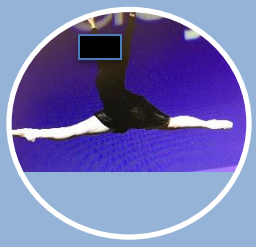
Basic Petit Allegro

- initiate double leg jumps such as sauté, changement and royal
- progress to transitional jumps such as sissonne, glissade, and jeté

End Stage Return to Dance

Advanced Petit Allegro

- include single leg hops in sequence of small jumps
- initiate slowly and increase speed as biomechanics allow



Grande Allegro

- initiate large hops such grand jeté, tour jeté and saut de chat

Full Clearance

- clearance for full participation in class, rehearsal, and performance en pointe is expected

FIGURE 7. Arabesque prior to surgery and arabesque following return to dance after surgery, respectively. Note patient's improved ability to achieve adequate ankle plantarflexion while en pointe.

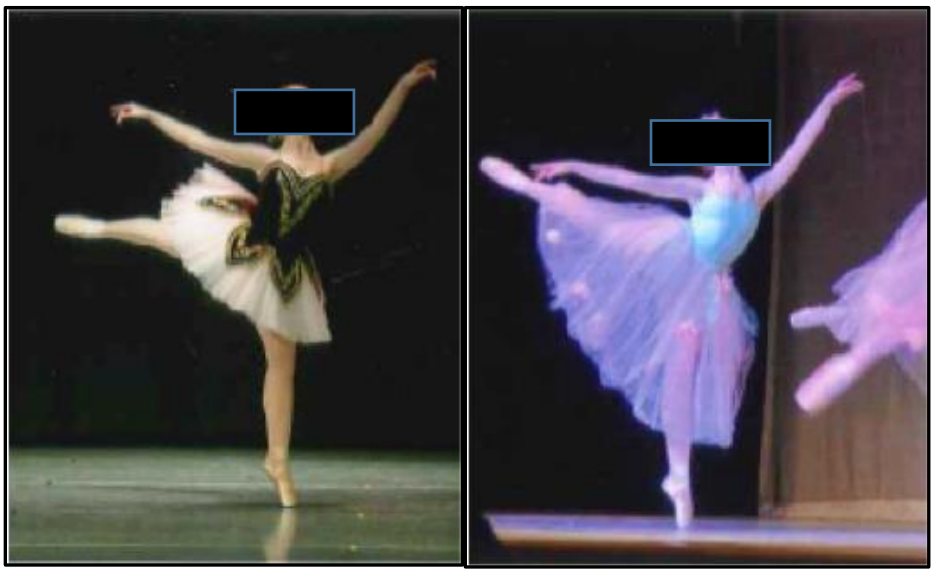


FIGURE 8. Measurement of excised tissue following its removal.

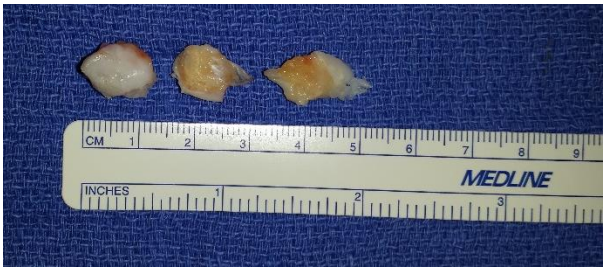


Figure 9. A) Dancer demonstrating incorrect ballet technique for first position relevé. This is known as sickling the ankle when the weight distribution is heavily weighted onto the 5th toe. B) Dancer performing correct technique for first position relevé.

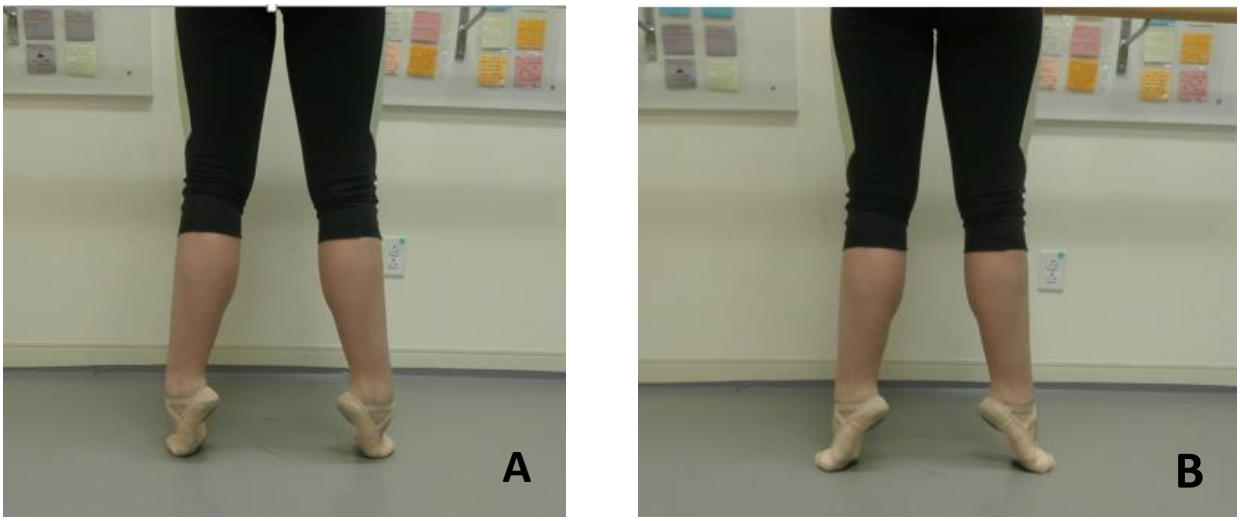


FIGURE 10. Wear pattern on top of pointe shoe used prior to surgery. Notice lack of wear pattern on the left foot as dancer was not getting over her toe box due to a lack of needed plantar flexion to be over the center of her toe box while en pointe.