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Abstract

Background: Dynamic hip screw (DHS) fixation is commonly used in the elderly population to manage intertrochanteric fractures. Additionally, it is regularly used in the adolescent population as a treatment for aneurysmal bone cysts. However, the physical therapy management and outcomes of adolescents following DHS fixation has not previously been researched, especially in a population desiring to return to high level, sport participation. **Purpose:** The purpose of this case study is to describe the physical therapy management and outcomes of an adolescent male following DHS fixation to treat a large aneurysmal bone cyst with a primary goal of returning to basketball. **Case Description:** A 14-year-old male presented to physical therapy approximately 8 weeks following left DHS fixation. The patient exhibited significantly impaired left lower extremity strength, stability, and balance that limited his functional activity. The deficits also prevented his participation in recreational activity, such as sport competition. **Interventions:** The patient underwent approximately 6 months of outpatient physical therapy 2 times per week. The patient progressed through three phases of rehabilitation: strength and balance, plyometrics, and sport specific activities. **Outcomes:** At six months, the patient exhibited restored left lower extremity strength and balance, compared to the right. He ambulated with no gait deviations and performed several return to sport tests on his affected lower extremity at or near a 10% difference of his unaffected. **Discussion:** Due to the patient's progression in physical therapy, he was cleared to return to high school basketball with no restrictions. This case outlines the management and outcomes of one adolescent male following DHS fixation, with a goal of returning to high school athletics.

Keywords: Dynamic hip screw fixation; aneurysmal bone cyst; physical therapy; rehabilitation; return to sport

Background

Aneurysmal bone cysts are described as benign, blood-filled bone lesions that typically expand or grow. The lesions produce cavities within the bone that fill with blood as the space increases.[1] While the cysts are non-cancerous, they tend to grow rapidly, and immediate treatment is frequently recommended.[2] Aneurysmal bone cysts most commonly occur in the pediatric population, with a median age of 13 years at diagnosis and 90% presenting before the third decade of life. [3] The cyst can occur in any bone; however, aneurysmal bone cysts tend to occur in long bone, such as the femur.[2] In the literature, aneurysmal bone cysts are described as either primary or secondary lesions. Primary lesions are the most common arising in 70% of the cases, as where secondary lesions occur in 30% of cases. Primary lesions arise spontaneously due to translocations, and current research supports the idea that these are independent neoplasms. [4] Conversely, secondary lesions occur as a consequence of other tumors. They may arise next to existing chondroblastomas or osteoblastomas.[2]

The presentation of aneurysmal bone cysts most commonly include pain, swelling, and stiffness contained to the affected bone segment. Since the cyst leads to destruction of the bone architecture, fractures of the affected bone can occur.[2] Aneurysmal bone cysts can develop over growth plates in the most commonly affected adolescent population, which can result in limb length discrepancies as an additional secondary complication.[5] Various imaging techniques are utilized for diagnosis, such x-rays, MRIs, and CT scans. Following diagnosis, the primary medical treatment goals include halting lesion progression, decreasing pain, and reducing recurrence rate.[2]

One of the most common treatment approaches for large aneurysmal bone cysts is surgical removal due to the reduced risk of recurrence. First, the cyst and affected bone are removed. Then, the segment is replaced by metal or bone in order to fill the void and support the bone. For large cyst located in the femoral neck, a dynamic hip screw (DHS) fixation is regularly performed to allow for early mobilization and greater function.[6,7] This is because DHS maintains an individual's ability to perform dynamic, rotational movements.[8] Currently, DHS fixation is an established treatment for intertrochanteric fractures and considered to be the gold standard for managing these fractures in the elderly population.[9-11] Functional outcomes of DHS fixation have been researched in an elderly cohort.[11,12] However, there is currently a lack of knowledge on functional outcomes in an adolescent population following the procedure.

DHS fixation is a widely accepted surgical intervention for the treatment of aneurysmal bone cysts in adolescents, and the procedure is most commonly seen in the older adult population following an intertrochanteric fracture. However, appropriate postoperative physical therapy management and outcomes are not well understood, particularly involving an adolescent patient cohort. Thus, the purpose of this case study is to describe the physical therapy management and outcomes for an adolescent male following DHS fixation to treat an aneurysmal bone cyst, with the goal of returning to high school basketball.

Case description

The patient was an endomorphic 14-year-old male that presented to an outpatient physical therapy clinic approximately two months following a left dynamic hip screw fixation. The procedure was performed to treat a large aneurysmal bone cyst located on his left proximal femur. Following his procedure, the patient was non-weightbearing and used a wheelchair for both household and community mobility for nearly six weeks. Then, he progressed to weight-bearing as tolerated and ambulated with crutches for another two weeks. The patient gradually increased his weight-bearing status and at eight weeks was cleared to perform all activity to tolerance after imaging showed healing of the surgical site. While the patient was not referred to physical therapy initially, his surgeon sent him following a follow-up visit for gait training and hip abductor strengthening.

Prior to his diagnosis of an aneurysmal bone cyst and subsequent surgery, the patient reported intermittent hip pain for approximately one year. The patient noticed sharp, shooting pain into his groin with high impact weight-bearing activities, such as running and jumping. The patient reported that initially his symptoms never lasted longer than a few minutes, so he was able to continue all his

recreational activities without limitation. However, over the first month of his middle school basketball season, he began to experience increased frequency and duration of symptoms. He and his family also noticed that he was consistently limping due to the intensified pain. At that point, he sought medical care for his symptoms. The patient's condition was diagnosed through several imaging techniques, including radiographs, MRI, and CT scan. Medical professionals determined that due to the size of the cyst, injections would likely not be effective, and surgery was deemed the most appropriate intervention for the patient.

Examination and Evaluation

Subjective

During the initial evaluation, the patient was accompanied to his physical therapy session by his mother. The patient rated his left hip pain as 0/10 and reported no complications with wound healing. The patient stated that his greatest limitations were stairs and walking, which he believed were due to poor strength. The patient's mother added that her son was "waddling" ever since the surgery, which had not seemed to be improving. While the patient did not report any pain in his left hip, he did state that his right hip and low back had been becoming increasingly more painful since his surgery. During the evaluation, the patient mentioned that his primary goal was to participate in his high school basketball season the following school year and return to jumping on his trampoline. The patient's past medical history was unremarkable for any other medical conditions. The patient's prior orthopedic history included a significant left ankle sprain almost two years prior, which he received several weeks of outpatient physical therapy for at the time of the injury. However, the patient noted that his single leg jumping quality had been reduced on his left lower extremity since the ankle sprain occurred, compared to his right.

Objective

At initial evaluation, the patient was no longer using an assistive device when ambulating household or community distances. However, the patient exhibited a waddling gait pattern characterized by an increased base of support and significant lateral trunk lean over his left lower extremity during left stance phase of gait. The patient demonstrated an atypical gait pattern when ambulating on level surfaces, but the abnormality was amplified when ascending and descending stairs. During his evaluation, the patient also required one hand on the stair railing to ascend and descend stairs with an alternating pattern in order to maintain balance.

Suspected range of motion, strength, and balance impairments were then specifically tested after observing the patient complete functional mobility tasks, such as ambulation and stairs. The patient's bilateral lower extremity passive and active range of motion was assessed at the initial session and found to be within normal limits. However, the patient's initial manual muscle testing was as follows:

Table 1. Patient's Lower Extremity Manual Muscle Testing at Initial Evaluation (8 weeks post-operatively)

Muscle Group	Right	Left
Hip abductors	4/5	2+/5
Hip extensors	4/5	4/5
Hip external rotators	4/5	3+/5
Hip flexors	4+/5	4+/5
Knee extensors	5/5	4/5
Knee flexors	5/5	5/5

Furthermore, when asked to maintain single limb stance on his left lower extremity, the patient was unable to perform the balance assessment for greater than three to five seconds. The patient demonstrated a reaching strategy in order to assist him maintain stability during the activity, as significant bilateral arm movement was observed with each trial. The patient was able to maintain single limb stance on the right lower extremity for 90 seconds without the use of a reaching strategy. The test was discontinued once the patient reached 90 seconds.

Clinical Impression

Upon completion of the examination, it was determined that the patient presented with impairments both directly and indirectly related to his surgical procedure. It was concluded that the patient had reduced left hip strength, with his left hip abductors being the most affected muscle group. These deficits were likely the result of the left hip musculature being cut in order to perform the necessary hip surgery. It was also determined that the patient had impaired left lower extremity balance and a reduced ability to accept weight onto his injured limb. In combination, the various factors appeared to be the cause of the patient's functional limitations displayed during the examination.

Additionally, the patient's reduced right hip strength seemed to be secondary to the patient's prolonged inactivity following his procedure. It was hypothesized that the patient's reports of right hip and low back pain were most likely the result of compensatory strategies that the patient developed following his surgery. It was postulated that the patient would likely display decreased endurance and activity tolerance at his physical therapy sessions due the patient's prolonged weight-bearing restrictions and subsequent inactivity.

Following the initial examination, the overarching physical therapy objective was to help the patient achieve his goal of returning to high school basketball. Therefore, the primary physical therapy goals were to improve the patient's bilateral hip strength, left lower extremity balance, and left lower extremity weightbearing tolerance so that the patient could safely perform basketball specific skills, such as running, cutting, squatting, and jumping.

Interventions

The patient was seen in physical therapy two times per week for a duration of six months. Along with physical therapy interventions, the patient also began organized upper and lower body strength training with his basketball team later on in his episode of care. Due to the patient's length of physical therapy treatment, his phases of rehabilitation are generally outlined below. Prior to each therapy session, the patient arrived early and rode a stationary bicycle for steadily increasing distances. This served a dual purpose as both a dynamic warm-up and a means to improve cardiovascular endurance.

Phase 1 Strength and Static Balance (months 0-2)

Secondary to the patient's low pain ratings and full range of motion, strengthening exercises were the primary focus of his early rehabilitation. The patient initially performed isolated, open kinetic chain hip strengthening exercises on the table, such as clamshells and side lying leg lifts. Then, he progressed to compound, closed kinetic chain exercises that were more functional, such as squatting and hip hinging variations. As the patient's strength and technique improved, load was steadily increased during physical therapy sessions. The patient gradually progressed from double leg to single leg strengthening activities with single leg squats being emphasized in the latter sessions of this phase.

Balance exercises were initiated during this phase of rehabilitation, as well. The patient initially performed static balance activities in order to restore his capacity to accept weight onto his left lower extremity and improve his proprioception. Some examples of exercises early on included weight shifts and single limb balance on even surfaces. His static balance exercises were gradually progressed to single limb balance with perturbations, on foam, and finally on a Bosu ball. The patient's balance exercises were steadily advanced to high level, dynamic movements during this phase. This comprised of activities such as multidirectional lower extremity reaching, single leg Romanian dead lifts, and tri-planar lunges.

Phase 2 Plyometrics (months 3-4)

The second phase of rehabilitation was focused on plyometric training in order to expose the patient to compound, explosive movements commonly utilized in the sport of basketball. The patient initially began double leg jumps on a Shuttle MVP machine, which is a supine leg press with resistance that is utilized for plyometric training. The patient then progressed from double leg jumping to single leg jumping activities. Some jumping exercises in this phase included line jumps, box jumps, hurdle jumps, and ladder drills in multiple planes.

An emphasis in this phase of physical therapy was put on restoring normal jumping and landing mechanics in the patient, especially with left single leg jumping activities. Early on, the patient demonstrated contralateral pelvic hip drop, hip adduction and internal rotation, and knee abduction when performing left single leg jumps. This meant that the patient had the tendency to demonstrate dynamic knee valgus with jumping activities. The patient also had difficulty with pushing-off on his left lower extremity, which resulted in reduced jumping power and distance. These biomechanical concerns steadily improved overtime as the patient gained functional strength in his left lower extremity.

Phase 3 Return to Sport (months 5-6)

During the final phase of the patient's rehabilitation, the primary focus was to expose the patient to high level, sport specific activity. The patient's sessions incorporated multiple jumps, speed drills, and basketball specific activity. This often included a circuit format. The duration of rest between different activities during the therapy sessions were gradually reduced in order to improve the patient's endurance. Some examples of exercises during this phase include lateral shuffling, backwards running, and forward running with and without a sports cord. As well, as cutting drills and performing multiple single leg jumps consecutively.

Outcomes Assessment

Several outcomes measures were selected for this case based on the patient's primary impairments, functional physical therapy goals, and self-reported goal of returning to high school basketball. The various outcome measures obtained at the patient's time of physical therapy discharge are discussed in greater detail below.

Manual muscle testing

Manual muscle testing was utilized throughout the patient's time in physical therapy to monitor changes in strength of specific muscles that were deemed to be weak during the initial examination. After six months of physical therapy interventions, the patient's manual muscle testing was as follows:

Table 2. Patient's Lower Extremity Manual Muscle Testing Following Six Months of Physical Therapy Interventions

Muscle Group	Right	Left
Hip abductors	5/5	5/5
Hip extensors	5/5	5/5
Hip external rotators	5/5	5/5
Hip flexors	5/5	5/5
Knee extensors	5/5	5/5
Knee flexors	5/5	5/5

Balance

The patient's balance was reassessed following six months of physical therapy for a few reasons. First, due to the importance of postural and balance control in everyday tasks. Additionally, poor balance has been shown to be associated with a greater risk of injury and reduced motor performance when completing athletic skills. [13,14] Therefore, the patient's static balance was measured using the single leg stance test.

The single leg stance test was chosen as an assessment of static balance and postural control due to the ability to compare to age appropriate norms, as well as the ability for the uninvolved limb to easily be used as a control. Normative data research indicates that males from the ages of 12-18 should be able to maintain single leg balance for 120 seconds.[15] The patient's left lower extremity single leg balance improved from five seconds to 90 seconds during his time in physical therapy. The patient was cut-off at 90 seconds. This performance compared well to his right lower extremity time and normative data for his age group.

Gait

Due the patient's reported walking limitations and his observed gait abnormalities at initial examination, the patient's gait quality was an important outcome measure in this case. During his time in physical therapy, the patient was steadily able to make improvements in his gait pattern. Following six months of physical therapy, the patient no longer ambulated with a left lateral trunk lean, which appeared to be due to increased hip abductor strength and improved weight acceptance onto his left lower extremity. Additionally, the patient's base of support was reduced exhibiting an improvement in dynamic stability. The patient was also able to ascend/descend stairs with an alternating pattern and no upper extremity support, without deviations. It should be noted that the patient continued to demonstrate a mild lateral lean during left single limb stance phase of running and a reduced ability to push-off of his left lower extremity. It was hypothesized by the clinician that his running mechanics may continue to gradually improve with time and continued exposure to the activity.

Return to Sport Testing

The patient completed return to sport testing on two separate days within the same week. On the first day, the patient performed the Y balance assessment. On the second testing day, the patient completed several jumping tests. These tests were demonstrated to the patient by the clinician in order to ensure understanding. Per testing protocol, three trials of each assessment were completed with a short rest break in between.

The Y balance test was selected as a dynamic, lower extremity balance assessment because of research indicating that it is a reliable measure of predicting injury in youth athletics, including basketball players.[16,17] An article in the *Journal of Sport and Orthopedic Physical Therapy* showed evidence that high school basketball players exhibiting a difference of greater than 4cm between lower extremities were at a 2.5 times greater risk of lower extremity injury. The article also established a cutoff score of 94% performance between the injured and uninjured lower limb.[16] After six months of physical therapy, the patient completed the Y balance assessment in the clinic. This assessment included three trials of anterior, posteriomedial, and posteriolateral lower extremity reaches on both the right and left. The patient exhibited equality between the right and left lower extremity, as he was able to complete the multidirectional reaching tasks on the left lower extremity within 5% of the right lower extremity.

The single jump, triple jump, and crossover jump tests were used in this case as another means to assess the patient's readiness to return to sport. The purpose of these tests is to quantitatively measure a patient's lower extremity power and agility. It also allows for easy comparison of the affected lower extremity to unaffected. The tests have all been shown to have high reliability with an interrater correlation coefficient of .91, .95, and .94 cited in previous literature, respectively.[18] The tests were chosen in this case due their functional carryover to the sport of basketball. The goal is to exhibit a hopping distance on the affected lower extremity equal to or greater than 90% of the unaffected.

This is because evidence has shown that a difference of greater than 10% between extremities correlates with an increased risk of lower limb injury.[19]. After six months of physical therapy, the patient exhibited the following measurements on the return to sport jumping tests:

Table 3. Return to Sport Jumping Distances and Comparison Ratio Following Six Months of Physical Therapy Interventions

Test	Affected Leg(cm)	Unaffected Leg (cm)	Affected:Unaffected (%)
Single Leg Jump	137	152	90
Triple Jump	351	396	89
Crossover Jump	290	323	90

Along with the jumping comparisons between the uninjured and injured limb, jumping quality was also assessed as the patient completed the single jump, triple jump, and crossover jump tests. Following six months of physical therapy, the patient was able to adequately land all jump attempts during the three return to sport testing procedures on his injured limb without any loss of balance. This was a vast improvement from his early single leg jumps in which he often required upper extremity or right lower extremity assistance to maintain balance with left single limb jumping. At the six-month mark, he also exhibited no left dynamic knee valgus during the various jumping tests. This indicated an improvement in his jumping quality, as well.

The Landing Error Scoring System (LESS) is a tool used to analyze one's lower extremity biomechanics during double leg landing and jumping tasks. It is most commonly used to identify movement patterns that may predispose one to non-contact lower extremity injury.[20] The test is scored on a 0-19 scale, with a score of five or less used as a cut off to establish low risk vs high risk individuals.[21] For this particular test, a lower score correlates to a reduced risk of injury. After six months of physical therapy, the patient's LESS score was a 2/19, which further supported that the patient had adequate jumping and landing mechanics. The patient exhibited mild lateral and sagittal plane flexion with his landing that caused him to receive the two points.

Clinical Decision Making

Based on the patient's improved functional mobility and performance on the various return to sport tests, the clinical decision was made that the patient demonstrated the necessary motor skills to return to sport without an increased injury risk. Foremost, the patient displayed equal lower extremity manual muscle testing and balance between the left and right lower extremities following six months of physical therapy interventions. He was able to perform functional mobility skills without deviation or upper extremity support, including ambulation and stair management. He reported that his right lower extremity hip pain and low back pain had completely resolved during his time in physical therapy.

The patient's lower extremity multi-directional reaching distance between the injured and uninjured lower extremity during the Y Balance Assessment was greater than the 94% cutoff score cited in previous research. The patient performed the single leg jump, triple jump, and crossover jump return to sport tests on his affected lower extremity at 89-90% of his unaffected, which placed him at or near the established 10% difference cut-off. As previously described, the patient's improved quality of movement was also factored in when making a clinical decision about his readiness to return to sport during the objective jumping tests. The patient no longer displayed mechanical faults that may predispose him to injury. Additionally, the patient completed the LESS with a score that placed him in a low risk category for non-contact, lower extremity injury. Following discussion with the patient, it was deemed that he exhibited the required confidence to return to sport, as well.

Therefore, the patient was cleared to return to high school basketball without limitation and discharged from physical therapy. Due to the timing of the year, the patient still had several months before the high school basketball season began. It was determined that the patient would continue to lift with the team and participate in basketball scrimmages without restriction. The patient and his family were educated on the importance of pain recognition and returning to physical therapy if issues arose throughout the season. The patient and his family fully supported the return to sport and discharge decision.

Discussion

Since there are currently no established guidelines or protocols for adolescents following a dynamic hip screw procedure, the clinician had to heavily rely on clinical judgement to effectively treat this patient. An important aspect of this case was the utilization of several objective outcome measures to help guide clinical decisions. The use of these various outcome measures served as a useful means to assess the individual's functional recovery in physical therapy. Previous research has investigated functional recovery in the elderly cohort following dynamic hip screw fixation using the Zuckerman Functional Recovery assessment, which evaluates an individual's mobility and activities of daily living. The researchers found that Zuckerman Functional Recovery scores at six months post operatively were significantly reduced, compared to pre-operatively.[11] The Zuckerman Functional Recovery Score assessment was not specifically utilized in this case; however, the patient demonstrated restored mobility at six months. Additionally, he reported no difficulty with activities of daily living. This suggests that younger patients may possess the potential to recover more quickly following dynamic hip screw fixation, compared to the elderly cohort.

Furthermore, several return to sport measurements were influential in this case, as well. They provided an objective and quantifiable way to assess the patient's risk of lower extremity injury during high school basketball participation. The various tests helped the clinician gain confidence in recommendations due to the functionality of the tests and research supporting their use in return to sport decisions. The patient scored near or above 90% on all return to sport testing following six-months of physical therapy. This compared well to athletes of similar age following anterior cruciate ligament reconstruction that were seeking clearance to return to their respective sport.[16,17,19]

A previous study that analyzed the single leg jump, triple jump, and crossover jump in male high school athletes proposed normative values for the three tests. These normative values include 181±20cm for the single leg jump, 583±72cm for the triple leg jump, and 522±77cm for the crossover jump.[22] While the patient in this case study was only 14 years of age, his performance on the three jumping tests were well below this established normative data for high school males. However, the patient performed below the norm on both the affected and unaffected lower extremity. Therefore, opposed to distance, the quality of the patient's jumps and side to side comparison were more heavily weighted in the clinician's decision to return the athlete to sport.

One important factor to analyze in this case was the dosage of physical therapy that was required for the patient to meet his goal of returning to high level, sport competition. While the patient steadily progressed, he attended outpatient physical therapy two times per week for approximately six months. This dosage of physical therapy treatment may not be feasible for many individuals. One major contributing factor to this lengthy recover may have been the patient's motivation level. The patient consistently showed effort in his physical therapy sessions but reported performing prescribed exercises at home infrequently. Perhaps if the patient dedicated more time to his rehabilitation and skill development outside of physical therapy, the dosage of physical therapy may have been reduced. Future studies are needed to determine if the patient's progression in physical therapy was typical or atypical following this unique procedure.

Another aspect that must be discussed in this case is the effect of repetitive, high impact forces on the dynamic hip screw hardware. Since dynamic hip screw fixations are most commonly performed in the elderly cohort, the longevity of the dynamic hip screw hardware is likely not a large concern for the individual. However, the patient in this case was an active, fourteen-year-old male. The forces imposed

on the dynamic hip screw will likely be of greater duration and extent compared to the less active, elderly cohort. Future research to establish the effects that returning to high level sport competition have on the longevity of the dynamic hip screw hardware would be beneficial, as well. If high impact activities may lead to subsequent surgeries to replace the metal hardware, then that would be an important factor for patients and physical therapists to consider when developing a plan of care.

Conclusion

While expected physical therapy outcomes following a dynamic hip screw fixation in adolescents are not well researched, this case exhibited the results of one individual after undergoing the surgical intervention to remove an aneurysmal bone cyst. The patient originally presented to physical therapy two months post-operatively. Initially, he demonstrated notable impairments in his strength and balance, as well as abnormalities with his performance of functional activities. However, following six-months of outpatient physical therapy, the patient was able to restore his lower extremity strength, stability, and balance. This allowed him to increase his quality and quantity of functional activity, such as walking and stairs. Additionally, the patient was able to perform high level, sport specific activities, such as running, jumping, and cutting. Most importantly, the patient achieved his primary goal of returning to high school basketball with no limitations or restrictions.

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