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Clinical Decision Making Process in a Patient with Severe Hip OA and PAD Complications of Contralateral Lower Extremity: A Case Report

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Abstract

Background and Purpose: Osteoarthritis (OA) is a degenerative joint pathology frequently treated in outpatient physical therapy (PT). However, patients with this joint disease occasionally present with multiple co-morbidities. Peripheral arterial disease (PAD) is an example of a co-morbidity which can impact the PT evaluation and plan of care. The objective of this case report is to highlight the decision-making process and outcomes for a patient with severe hip OA and history of PAD complications. **Case Description**: The patient is an 82-year-old male with Grade IV primary OA of left hip and history of a right popliteal aneurism in 2010 secondary to PAD. The aneurism resulted in significant ischemic and neurologic damage distal to the knee. This requires him to wear an AFO on his right lower extremity due to foot drop. The patient experienced progressively worsening left hip pain and dysfunction over the past four years. Despite the surgeon's recommendation, he elected to forego L hip replacement and pursue conservative management in physical therapy. His goal was to reduce hip pain and improve ability to walk. **Outcomes**: Patient Specific Functional Scale (PSFS) ratings increased (6.3 – 9.5) and pain ratings on the Numerical Rating Scale (NRS) decreased (7 - 2) following 3 weeks of manual therapy, strengthening, and flexibility exercises. Likewise, moderate improvements were seen in both hip ROM and MMT scores. **Discussion**: Multiple considerations were made regarding this patient's history and presentation when developing his POC. This POC was significantly effective in the acute relief of pain and improvement in patient-selected functional activities. Further follow-up with patient would help to determine success with long-term relief of pain and management of functional improvements.

Background

Chronic osteoarthritis is among the most common joint diseases in the adult population, affecting >65% of individuals over the age of 55, with the prevalence gradually increasing until age 80.[1] There is limited epidemiological studies examining the prevalence of hip specific OA; however, a study in 2014 of individuals in the Framingham Study Community cohort indicates that 19.6% displayed radiologic evidence of hip OA.[2,3] This disease process results from a chronic microtrauma and degeneration of articular cartilage in areas of increased loading and stress within the affected joint(s), subsequently leading to increased chondrocyte activity, sclerosis of subchondral bone, and bone spurring (osteophyte production) occurring at joint margins. An accumulation of these changes within the joint over time cause abnormalities in the articulation and kinematics of the joint surfaces and have been linked to increases in pain, joint restrictions and dysfunction, specific muscle weakness, and participation restrictions.[4]

Treatment of osteoarthritis may be either surgical or non-surgical. Surgical intervention includes either hip resurfacing or a total hip replacement, with the latter being the gold standard for the geriatric population.[5] Non-surgical interventions commonly include medications, corticosteroid injections, walking aids, and physical therapy.[6] The decision for a course of treatment for this disease largely depends on the stage of disease progression, level of patient dysfunction, severity and chronicity of pain, associated comorbidities and medical history; however, PT occasionally plays a role in pre- and post-operative care and frequently in conservative care regardless of disease stage.[6]

A prospective observational study assessing the prevalence of various comorbid conditions present in patients in outpatient therapy clinics in 20 different states indicates that most patients present in PT with a concomitant condition.[7] This is important for health care professionals to take into consideration due to the impact any number of these conditions may have on the plan of care for a given patient. One possible comorbid condition relevant to this case is peripheral arterial disease.

Peripheral arterial disease (PAD) is a condition resulting in the buildup of atherosclerotic plaques in the arterial circulation of the lower limbs. These plaques effect the blood flow to tissues of the lower extremities and in some cases, can result in complete blockages of vessels or weakening of the arterial wall, which can lead to an aneurysm.[8] These aneurysms most commonly occur within the popliteal artery in the lower limbs and are at increased risk of rupturing when intra-arterial pressure is increased.[9] When blood flow is compromised to any portion of the body, precautions must be taken to protect those areas and prevent further complications associated with the disease.

Regular supervised exercise is one of the best recommended remedies for managing PAD symptoms and reducing risk of secondary complications by gradually promoting positive physiologic changes in our cardiovascular system, including potential growth of collateral circulation and changes in vascular stress.[10] As healthy individuals exercise, the body's normal physiologic response is to respond with an increase in systolic blood pressure (BP). This increase in BP results in increased shear forces in our arterial circulation. In compromised vasculature with atherosclerotic plaque buildup, this increase in shear force can further damage vessels or even dislodge some of these plaques, which can lead to serious, often life-threatening circumstances.[11] Thus, altering these physiologic risk factors through exercise can have a significant impact on prognosis for the disease.

Previous research has created a foundation for guiding the rehabilitation of individuals with early stage osteoarthritis in various joints of the body.[12] Likewise, current literature exists on the impact of PAD on the physiology of the cardiovascular system, the benefit of physical activity for treating the symptoms of PAD, and various factors that must be taken into consideration when treating individuals with PAD.[13,14,15,16] However, limited research exists on the effectiveness of PT on the late stages of osteoarthritis, and the presentations of individuals with PAD can vary significantly, which can create a challenge when developing a plan of action for PT treatment. Therefore, with consideration of the guidelines proposed in existing literature for these two disease processes, the purpose of this case report is to highlight the decision-making process and outcomes for a patient with severe hip OA and history of PAD complications.

Patient History

The patient is an 82-year-old male referred to therapy for evaluation and treatment of primary left (L) hip osteoarthritis. He had a medical history including non-melanoma skin cancer, PAD, and a R popliteal aneurysm with surgical removal and bypass of the artery. In 2010, the patient began feeling noticing pain in his right (R) posterior lower leg behind the knee and down into his foot, which became increasingly more intense and was accompanied by his lower limb changing several different colors. He was rushed to the hospital and underwent emergency surgery for a R popliteal aneurysm removal and R popliteal artery bypass to save his limb. He was hospitalized for 42 days following the surgery before he was stable enough to return home. Consequent to the initial vascular event, the patient suffered significant ischemic damage to the lower limb, largely affecting the tibialis anterior muscle and peripheral nerves in the lower limb, and leading to severe dysfunction of the right limb distal to the knee including foot drop.

The patient was fitted with an AFO for his R lower limb to account for his foot drop. This was effective in reducing foot drop but created a functional leg-length discrepancy. The patient has attempted to correct for this discrepancy with some success over the past 7 years with an over the counter orthotic. Since that time, the patient has also had multiple screenings per year for any secondary manifestations of the disease in both the ipsilateral and contralateral popliteal arteries and the abdominal aorta due to the high prevalence of occurrence in these areas after an initial popliteal aneurysm.[8] Those screenings in the last 3 years have noted a stable plaque formation in left popliteal artery that has changed minimally and is not currently of significant concern of changing with activity or current diet per physician's note. His PAD is currently being treated with Warfarin and Coumadin.

Within the past 5 years, the patient began experiencing progressively worsening lateral left (L) hip pain primarily over the greater trochanteric region. He was initially treated for greater trochanteric bursitis with 2 separate Cortisone injections, both of which had no success in reducing the patient's symptoms/pain. In the past two years, he has received 5 intra-articular cortisone injections into L hip with another planned later this calendar year, which have all given the patient significant relief. The patient had yet another injection planned 3 weeks after his initial evaluation. Radiologic imaging of the patient's L hip was recently taken, revealing Grade IV osteoarthritis. He was told by his physician that he is a good candidate for a total hip replacement, but due to his history, the patient elected to forego surgical intervention and pursue conservative treatment of the hip with physical therapy.

At the time of evaluation, the patient presented with L-sided lateral hip pain that was variable in intensity throughout the day. He reported that he was generally very stiff and sore in the morning with mild to moderate intensity pain that alleviated somewhat once he walked around a bit. He expressed that his pain would increase in intensity if he walked roughly 1 mile or more, walked up and/or down stairs or inclines, stood for too long in one place, or attempted to ride the bike at the gym. Relieving factors of his hip pain were reported as sitting and resting after being on his feet for an extended period and taking Tylenol on occasion.

The patient reported that he lives with wife at home in a single-story home with safety features included such as grab bars in the shower, a slick-resistance shower mat, bilateral railings on the single-step entrance into his home, and minimal rugs in the house. He has good family support and states that when he was stable enough for physical activity after his lengthy stay in the hospital in 2010, he and his wife began exercising 4-5 times/week. The patient's exercises included swimming laps in the pool and riding a recumbent stationary bicycle at a local rec center, the latter of which he has discontinued in recent months secondary to increased hip pain. After his recent move, less than 1 month prior to beginning therapy, the patient states that his exercise routine has been affected due to difficulty finding a new location that meets his needs.

The patient is retired, and his daily activities and hobbies include helping his wife with things around the house, yard work, swimming, travelling on bus tours with his wife, and attending cross country meets at various colleges to watch his granddaughter run. He and his wife generally walk more than 1 mile at these meets, but he had been experiencing increased difficulty navigating the courses without assistance from a golf cart. He is otherwise independent with all activities of daily living and

reports no falls in the past few years. The patient denied any smoking and drinking habits, recent bowel/bladder changes, fever/chills, unexpected weight loss, or predominant night pain. He expressed goals for therapy including desire to return normal exercise routine of swimming and cycling at the gym and walking at cross-country meets with minimal to no L hip pain. The results of the systems review are found in Appendix 1.

Chart Review

After a quick review of the patient's physician's note and consult note prior to the evaluation, a diagnosis of L hip primary osteoarthritis (what was initially proposed to be L trochanteric bursitis prior to radiologic imaging) had been established. Based on the findings in the physician's note, the patient was having difficulty with walking longer distances and navigating inclines/declines in the community secondary to pain. It was inferred that the patient likely had deficits/limitations in hip strength, lower leg strength, hip ROM, sensation of R lower limb, flexibility, gait abnormalities, and decreased activity tolerance.

Examination – Tests and Measures

Gross AROM and goniometric measurements of the hip were both assessed in supine and in prone. Palpation of the L hip revealed mild tenderness over L greater trochanter. The patient utilized the NPRS to rate his pain both at rest and with activity on an 11-point scale. The NPRS has been shown to have excellent interrater and intrarater reliability, adequate to excellent test-retest reliability, excellent criterion validity, and a minimal clinically important difference (MCID) of 1.7 pts for chronic pain conditions including osteoarthritis.[17,18] A gait assessment was observed as the patient walked in the hallway of the facility. Gross lower extremity strength was also assessed using both manual muscle testing and several general tests including a double leg squat, single limb stance, and bridging in supine. One of the main outcome measures utilized for this patient was the PSFS. The PSFS is not a hip-specific functional outcome measure, nor does it have literature supporting its validity when used for hip-specific conditions; however, this scale is used on all patients at the facility in which this patient presented for PT. The PSFS has excellent validity and test-retest reliability for chronic pain conditions for which the diagnosis of this patient meets the criterion for, and it has a minimal detectable change (MCD) of 2 pts with a standard error of measurement (SEM) of 0.41.[19] The findings of the initial tests and measures are highlighted in Appendix 2 with supporting evidence for each test detailed in Appendix 3.

Several standardized outcome measures would have been appropriate to implement on the initial visit for this patient population; however, due to the presentation of the patient, patient limitations in function were efficiently diagnosed and no further tests were deemed necessary at that time. According to recommendations by the Journal of Orthopedic Sports Physical Therapy (JOSPT) for the treatment of hip pain, mobility deficits, and osteoarthritis, standardized tests that would have been beneficial to use are the Lower Extremity Functional Scale (LEFS) and the Hip Disability and Osteoarthritis Outcome Score (HOOS).[12] The LEFS is a questionnaire containing 20 questions, scored from 0-20. It shown to have excellent test-retest reliability and interrater reliability when used for assessing changes in hip osteoarthritis scores, and it has a MCD of 9.9.[20] The HOOS is a self-report questionnaire containing 40 items scored from 0-100 with a score of 100 being completely symptom free. This questionnaire is a modification of the Western Ontario and McMaster Universities Index (WOMAC) specifically designed to target hip-specific conditions. It contains 5 subsets of questions including pain, symptoms, activities of daily living (ADLs), sports/recreation, and quality of life (QOL). The questionnaire has excellent test/retest reliability and a total MCD of 15.1, 10.5, 9.6, 15.5, and 16.2 for the respective subsets.[21]

Three functional tests were utilized at the date of discharge, including the Timed Up and Go (TUG) test, the 10-Meter Walk Test (10-MWT), and the 4-Square Step test. These tests were utilized for providing additional information of factors that may have needed to be further addressed with additional therapy sessions. The TUG test is a test requiring a patient to stand from a chair, ambulate

10 feet, turn around, and return to their chair. It used for assessing mobility, balance, and fall risk in older patients. A self-selected gait speed of <1 m/s is indicative of a need for intervention to improve fall risk, and a speed <0.6 m/s is indicative of a high fall risk. This test has excellent test-retest and inter-rater reliability for osteoarthritis of the hip.[22] The 4-Square Step Test is a dynamic balance test that assesses an individual's ability to move and step over objects in various planes of motion. The test is carried out by having a patient move clockwise and counterclockwise over 4 canes in the form of a "+" on the ground. The patient must touch the ground with both feet in each box as quickly as they can and may not touch any cane in the process. This test has been shown to have excellent test-retest and inter-rater reliability as well as excellent concurrent validity with the TUG test.[23] The 10-MWT is a useful measure to assess both patient-selected gait speed and fast gait speed for a variety of conditions. There is little data supporting the reliability of this test for individuals with osteoarthritis; however, there is evidence indicating the average gait speed for age-matching healthy individuals. For the healthy population with an age range of 80-99, the self-selected gait speed average is 0.986 m/s, which is an appropriate comparison for the patient in this case report.[24]

Clinical Impression

Following the examination, several of the initial inferences established after reviewing the physician's note were supported. The patient presented with moderate deficits in hip strength, primarily in extension and abduction, moderate deficits in hip active range of motion, gait abnormalities, postural abnormalities, and flexibility limitations, resulting in increased repetitive joint loading during all weight bearing activities. The patient's signs and symptoms upon presentation were consistent with the referred diagnosis of primary hip OA. The patient was a good candidate for physical therapy based upon his musculoskeletal limitations.

Accounting for all the various factors included in this patient's history, evaluation, and examination, the plan of care was for the patient to be seen twice per week for 45-minute sessions for up to 8 weeks. The decision was made to proceed with primarily land-based therapeutic exercise with focus on neuromuscular re-education and strengthening of hip extensors and abductors, stretching exercises for hip flexor and abductor tightness, manual therapy for improved joint mobility and ROM, patient education on symptom management, the potential for gait training with a cane if exercises/stretching were ineffective at reducing symptoms in his L hip, and development of a comprehensive home exercise program (HEP) in order to alter the patient's mechanics, reduce repetitive mechanical loading, and improve stability of the hip joint. Therapeutic exercises would begin in primarily reduced weight-bearing positions to reduce excessive joint loading and would progress to include an increased number of functional weight-bearing activities as pain decreased and mobility increased. It was also decided that at least one bout of aquatic therapy would be incorporated into the plan of care (POC) due to the patient's primary mode of current exercise being swimming at the local recreation center. This would provide the patient with guidance on different forms of exercises to perform while in the pool that would be specifically beneficial to his current functional limitations as a complement to swimming laps.

Based upon the patient's active lifestyle, family support, past medical history, PSFS ratings, motivation to return to all prior activity without hip pain, stability of symptoms, and understanding of plan moving forward in PT, the patient was expected to have good prognosis for reducing L hip pain to minimal intensity levels and improving function and mobility. After obtaining a thorough patient history, it was determined that patient's PAD symptoms were well controlled and there was stable progression of the disease based upon the trend of his most recent lab work and imaging of his lower extremity arterial circulation within 1 month prior to starting PT. The patient had positive prognostic factors including his active lifestyle, support from his wife, and his motivation to meet his goals for therapy. His negative prognostic factors included his medical history, PAD, and decreased function of R LE distal to the knee.

Intervention

Interventions were selected based upon this patient's specific limitations and participation restrictions. According to 2017 revision of the clinical practice guidelines established for hip OA in JOSPT, level A evidence supports the use of flexibility, strengthening, endurance exercises, and manual therapy techniques to address hip impairments of muscle weakness, limited ROM, and limited flexibility.[12] Aerobic exercise had been the patient's sole mode of exercise over the past several years, so it was decided that the procedural interventions would be primarily targeted on therapeutic exercise, stretching, and manual therapy techniques to improve hip ROM and alter the mechanical loading of the L hip joint.

The interventions chosen for the initial session targeted the muscular imbalances and range of motion restrictions of the patient's hips. The interventions consisted of a hip flexor stretch in the modified Thomas test position, a bridging exercise, a mini squat while holding onto the countertop, and a hip extension exercise in standing while holding onto the counter. The hip flexor stretch was chosen in this position based upon the patient's lack of flexibility, due to attempts at minimizing position changes during the examination process, and due to this position allowing for stretch of both the iliopsoas and rectus femoris muscles, which were both contributing to the patient's hip flexor tightness.[25] The patient felt comfortable on his back and could grasp the back of his R thigh with both hands to stabilize his pelvis without pain in either hip. Other options for stretching of hip flexors included assuming the prone or kneeling position, which the patient did not feel as comfortable with at the time due to his hip pain. The bridging exercise was chosen also in part due to minimizing the change of positions during the examination as well as its ability to increase the activation of both hip extensor and abdominal musculature.[26] A squat was performed due to its functional implications during transfers. The standing hip extension exercise was a functional way to increase hip extensor activation in a weight bearing position while also working on hip abductor activation for hip stability in single limb stance.[27]

At the first follow-up visit, the patient's HEP was reviewed and questions regarding the HEP were addressed. The patient reported having difficulty only with the standing hip extension exercise due to his tendency to catch his R toe on the ground when attempting to lower the R leg back to the floor. Modifications were made to the exercise to address the limitation of his foot drop on the R by having the patient lean forward onto the bed/counter, which eliminated the need to return to the R foot to a flat position on the floor. During this session, standing hip abduction and side-lying clamshells were both implemented to target hip abductor weakness (specifically gluteus medius), which has been shown to alter hip kinematics, specifically in single-limb weight-bearing activities such as gait.[27] Manual therapy techniques were also implemented during this session. These included posterolateral and inferior hip distraction in supine with active and passive hip flexion as well as posterolateral hip distraction with passive internal rotation. Both techniques are referred to as mobilization with movement (MWM) and have been shown to have positive correlations to acute decreases in pain, increases in hip ROM, and improvements with TUG testing.[28]

Based upon patient's positive response to MWM during the second and third visits, this procedural intervention was continued during each of the following visits focusing on land-based activities. A single bout of aquatic therapy was utilized during visit number 4 to complement patient's swimming routine. Existing literature indicates that aquatic therapy with pool temperature between 33.5 and 35.5ºC is a safe and effective method of reducing pain, reducing joint stiffness, improving range of motion, and performing therapeutic exercise in a weight-reduced environment.[29] The patient was submerged into the pool to the level of his umbilicus, which studies have indicated as a level that reduces body weight by 50-55% due to the buoyancy of the water.[30] The patient was then taken through an exercise routine consisting of underwater treadmill walking at a comfortable gait speed for 10 minutes and therapeutic strengthening exercises aimed at complementing the exercises he was doing outside of the pool. The decision to utilize aquatic therapy in a warm-water environment was based upon the patient's stable symptomology of his PAD. Peripheral arterial disease is generally a contraindication to aquatic therapy;[31] however, due to the patient's regular screenings for arterial patency and stable progression of his PAD per physician's notes, one bout of partial-body immersion

was deemed appropriate for education on various pool-based exercises. The patient was educated prior to entering the pool to give timely warnings if he began to experience any increase in hip or leg pain or any other abnormal sensations from being submerged in the warm water.

Following the bout of aquatic therapy, an appropriate progression of land-based exercises was implemented as tolerated by the patient to include the addition of Theraband-resisted hip strengthening exercises. The patient frequently returned to the clinic with self-reports of progression to a stronger band at home with his exercises as they became easier for him to do. Continued utilization of MWM played a large role in the duration of his plan of care, while also implementing soft tissue massage techniques to the tensor fascia latae (TFL) in order to loosen some of the tension on the iliotibial (IT) band, which the TFL attaches to at its proximal end.

During visit number 5, the patient reported that he had been having some minor issues with the way his AFO was fitting. The patient reported at that time that he had been wearing the same AFO for 7 years since his emergency surgery to bypass and remove his popliteal aneurysm. His main complaint revolved around the functional leg length discrepancy that occurred as a result from wearing it, which he attempted to correct with a heel lift and spacers in his L shoe. It was discussed with the patient that a thorough examination of his AFO would be beneficial to address his concerns and possibly make alterations to meet his specific needs. At that time, a referral was made to his orthopedic MD for a follow-up.

Following visit 5, the patient elected to proceed with the steroid injection into his left hip despite his progress in therapy. It was discussed at visit 5 with the patient his rationale for making this decision, and despite educating him on the risks of the injections, which he was already aware, he followed through with his decision due to his past success at long-term relief with the shots.

At the date of discharge, a re-examination of the patient's tests and measures were taken. The patient was also taken through three functional tests assessing gait speed and balance including the TUG test, 10-meter walk test, and 4-square step test. These tests have been recommended in the most recent revision of JOSPT's clinical practice guidelines for Hip OA. As shown by the results in Appendix 2, the patient had no indications of fall risk following testing, which it was then deemed appropriate to discharge the patient with continued adherence to his HEP.

Outcomes

Following 5 weeks of physical therapy, the patient had met all goals for PT and felt at least 95% improved overall with his pain management, mobility, and ability to perform all daily activities without limitations from his L hip. He had made significant improvements with his AROM and strength, and he also made self-reported improvements in ability to walk at least 1 mile at cross-country meets without hip pain, which was his main goal for PT. Other notable changes include the patient's improvement in hip flexor flexibility, as indicated with the Modified Thomas Test, and posture during weight bearing activities. A detailed layout of the patient's objective measurements at discharge are highlighted in Appendix 2.

Discussion

As seen from the advancement of the plan of care and resulting outcomes in Appendices 3 and 4, the patient demonstrated consistent progression from week-to-week throughout the duration of his care. The initial plan of care was set for a total of 8 weeks; however, based on his self-reported and clinically observed improvements, the patient was discharged after only 5 weeks of therapeutic interventions with expectations of continued adherence of his HEP. Several clinical decisions went into the determination of how best to proceed each week with the patient's plan of care that appear to have made a significant impact on the patient's success in PT; however, it was the patient's high level of compliance with his HEP that led to his rapid improvements throughout his plan of care.

The first decision made that correlated to an improvement in flexibility was the decision to begin stretching of the hip flexors and strengthening of the hip extensors during the first PT session. These

exercises were low-impact activities that the patient could easily understand and perform despite limitations in mobility and function of his R LE secondary to complications from his history of PAD.

The second decision, which complemented the hip flexor stretching well and likely contributed to improvements in hip flexibility, was the decision to proceed with manual therapy techniques during the second visit. The patient returned after only one session of manual techniques reporting that he felt as if he grew a couple of inches and his pain had substantially decreased. A study by Beselga et al. found similar results with individuals undergoing two forms of mobilization with movement showing statistically significant improvements in both reduction of pain on a NRS (2 pts) and improvements in hip flexion and internal rotation range of motion (12.2º and 4.4º respectively).[28] Since this visit was only one week from the initial evaluation, this self-reported improvement appears to be highly correlated to the addition of manual techniques in the prior visit.

The third decision that made a large impact in this patient's care was the use of aquatic therapy for one session. This decision was useful in that it incorporated one of the patient's favorite forms of exercise into his care and contributed to patient buy in for continued adherence to his home exercise plan. Though aquatic therapy is generally considered a contraindication to patients with PAD, it was decided that the stability of the patient's symptoms allowed for this intervention to be utilized in a short session without high risk of complications. The patient was very receptive to the idea of doing therapy in the pool and learning a routine that he could do in the pool on his own.

Though various resistance-based exercises were utilized in this patient's plan of care to target hip extensor strength, it is likely that most of the patient's strength gains, as observed with MMT and exercise technique, were improvements in neuromuscular control of this muscle group rather than pure gains in strength or hypertrophy of the muscles. It could also be argued that the success in the late stages of the patient's plan of care could be due to the injection that he received in his hip; however, the significant pain relief that he expressed came prior to him receiving the injection, and he did not note any significant reduction in pain following the injection. This injection would potentially skew the results of a future follow-up with the patient to determine any lasting effects of the therapeutic interventions carried out in PT.

Conclusion

This case report promotes the use of stretching, strengthening, and manual therapy in the treatment of a patient with severe hip OA, albeit a lack of evidence for this specific patient population, showing statistically significant improvements in mobility, strength, pain ratings, and function. It also highlights several important clinical decisions that had to be made based on the complex history of the patient. Follow up with this patient in the future as well as future studies with patients with unilateral grade 4 hip osteoarthritis would help to determine the long-term effects of therapeutic intervention on this patient population and whether the patient was able to successfully manage his symptoms and functional improvements with continued utilization of his HEP.

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Appendix 1 Summary of the systems review taken during the initial examination process.

Cardiovascular/Pulmonary	Hx of PAD.
Musculoskeletal	L lower extremity (LE): Impaired Gross LE Strength: Impaired bilaterally Gait: Impaired: Decreased R knee flexion and push off in R terminal stance due to hinged AFO on LE. Decreased stride length. Flexed hip posture of ~10-15 degrees throughout gait cycle bilaterally. Slightly widened base of support. Increased hip flexion on R to clear R toe. Mild Trendelenburg bilaterally. No stumbles or appearances of any loss of balance. Consistent cadence. Flexibility: Impaired: IT band and hip flexor tightness bilaterally Hip AROM: impaired Knee AROM: grossly within functional limits
Neuromuscular	R LE: Impaired, not formally assessed in PT, but patient reports decreased sensation to touch below the R knee. Wears his AFO for all weight-bearing activities
Integumentary	L LE: not impaired R LE: Impaired distal to knee.
Communication	Not impaired
Affect, Cognition, Learning Style	Not impaired: Pleasant individual with good alertness and orientation. Prefers to have written and visual instructions for home exercise plan.

Appendix 2 Detailed results of the tests and measures taken at both the initial visit and date of discharge.

Tests/Measures	**Initial testing**	**4-week follow-up**
Goniometry (ROM)	Movement Left Right Hip extension -4° -8° Hip Flexion WFL WFL Hip IR 20° 10° Hip ER 45° 20° Knee AROM WFL WFL Ankle PF/DF not measured	Movement Left Right Hip extension 2° 0° Hip Flexion WFL WFL Hip IR 30° 30° Hip ER 50° 50° Knee AROM WFL WFL Ankle PF/DF not measured
Lower extremity manual muscle testing (MMT)	Muscle group Left Right Hip flexion 4/5 3+/5 Hip extension 3+/5 3/5 Hip Abduction 3/5 3/5 Knee Extension 5/5 not tested Knee Flexion 4/5 not tested Ankle PF 5/5 3/5 Ankle DF 4-/5 1/5	Muscle group Left Right Hip flexion 4+/5 4-/5 Hip extension 4+/5 4-/5 Hip Abduction 4/5 4/5 Knee Extension 5/5 4+/5 Knee Flexion 4+/5 4/5 Ankle PF 5/5 3/5 Ankle DF 4+/5 1/5
Numeric Rating Scale (NRS – for pain)	Pain at rest: 3 Pain with activity: 7	Pain at rest: 0 Pain with activity: 2
Patient Specific Functional Scale (PSFS)	Walking 1 mile: 7.5 Using recumbent bicycle and swimming at the gym without pain: 5 Mean Score: 6.3	Walking 1 mile: 9.5 Using recumbent bicycle and swimming at the gym without pain: 9.5 Mean Score: 9.5
Ober's Test	(+) bilaterally for IT band tightness	(+) bilaterally for IT band tightness
Modified Thomas Test	(+) bilaterally for iliopsoas and rectus femoris tightness	(-) bilaterally for iliopsoas and rectus femoris tightness
Faber's Test	(+) for groin pain on L	(+) for groin pain on L
Double-Leg Squat	Knees translate 3" anterior to toes, knees deviate medially, buttocks translate minimally posteriorly, hips rotate externally R>L and ankle pronation R>L 2nd to lack of DF on R LE with AFO.	Knees stay behind toes, minimal medial knee deviation, increased posterior buttock translation, minimal external rotation at hips bilaterally, minimal pronation at ankles
Timed-up-and-go (TUG) Test	Not assessed at initial visit	8.18 seconds
10-Meter Walk Test (10-MWT)	Not assessed at initial visit	Self-selected speed: 1.35 m/s - Individual trials - 4.62 s; 4.52 s; 4.19 s Fast speed: 1.61 m/s - Individual trials - 3.79 s; 3.74 s; 3.60 s
4-Square Step Test	Not assessed at initial visit	9.3 seconds - Individual trials - 9.02; 9.59

Appendix 3 Tests and measures utilized in the examination process with supporting evidence for each.

Test/Measure	Purpose	Inter-/Intra-rater Reliability (ICC)	Test-Retest Reliability	Construct Validity	MCID/MCD
Numeric Pain Rating Scale	Patient-reported pain	Excellent (0.84)	Adequate to Excellent (0.79-0.92)	N/A	1.7 pts for chronic pain conditions
Patient Specific Functional Scale (PSFS)	Patient-reported function	N/A	Excellent (0.97)	Excellent	2 pts for chronic pain conditions
Ober's Test	Tests for tight/ inflamed ITB or TFL	Excellent for Intra-rater (0.94) Good for Inter-rater (0.73)	N/A	N/A	N/A
Thomas Test	Measure flexibility of Iliopsoas & Rectus Fem.	Limited studies (n=2): very good inter-rater; moderate reliability	N/A	N/A	N/A
Faber/s Test	Provocation test to detect pathology of hip, lumbar spine, or SI	Intra-rater good to excellent (0.76-0.86)	N/A	N/A	N/A
Timed Up and Go (TUG)	To identify individuals with fall risk	Excellent (0.92-0.99)	N/A	R=0.75 gait speed correlation	>10 sec = high fall risk for hip OA
10-meter walk test	Assessment of gait speed	N/A	N/A	N/A	0.05 – 0.13
4-square step test	Dynamic gait assessment in multiple planes	Excellent inter-rater (0.99)	Excellent (0.98)	Excellent concurrent validity with TUG (0.88)	>15 seconds indicates high fall risk
Western Ontario and McMaster Universities Index (WOMAC)	Measure of pain, stiffness, and function of Hip	N/A	Excellent (0.9)	Adequate with Gait Speed (0.32)	9.1 pts on scale of 0-50
Lower Extremity Functional Scale (LEFS)	Measure of ability to complete daily tasks	Excellent Inter-rater (0.84)	Excellent (0.86)	N/A	9.9
Hip Disability and Osteoarthritis Outcome Score (HOOS)	Hip-specific extension of WOMAC with addition of QOL and recreational subsets	Good	N/A	Good	Pain: 15.1 S/S: 10.5 ADLs: 9.6 Rec: 5.5 QOL: 16.2

Appendix 4 A detailed summary of the interventions selected at each visit with their corresponding dosages along with the patient's home exercise plan.

Week	Interventions	Mode/Frequency	HEP
1	Visit 1		
	Hip flexor stretch in Mod. Thomas Test Position	2 x 30 seconds	All 4 exercises performed on initial visit
	Supine double leg bridge	2 x 5 w/ 5 sec holds	
	Standing hip extension at countertop	1 x 10 each	
	Standing mini squat at counter	2 x 5	
	Visit 2		
	Supine bridges	2 x 10 (3 sec hold)	Added: Sidelying clamshells Standing hip abd
	Sidelying clamshells	2 x 10 (3 sec hold)	
	Standing hip extension at counter (modified to lean forward onto counter to avoid catching toe)	2 x 10 each leg	
	Standing hip abduction	2 x 10 each	
	Mini squats at countertop	2 x 10	
	Posteroinferior hip distraction with belt in supine w/ light AROM hip flexion	3 x 15 seconds	All HEP activities were to be performed BID
	Posterior hip distraction w/ PROM hip IR	3 x 15 seconds	
2	Visit 3		
	Bridges with resisted abduction (red theraband)	2 x 10	Added: Bridges with band Sidelying resisted clamshells
	Sidelying resisted clamshells (red theraband)	2 x 10 each side	
	Mini squats at countertop	2 x 10	
	Prone hip extension w/ pillow under hips	1 x 10 each leg	
	Posteroinferior hip distraction with belt in supine w/ light AROM hip flexion	3 x 15 seconds	
	Posterior hip distraction w/ PROM hip IR	3 x 15 seconds	
	Visit 4		
	- Aquatic Therapy (Depth – Navel)		Added: Entire pool program for supplement to current swimming routine
	Forward gait in pool (comfortable pace) while holding onto metal bar	10 minutes	
	Hamstring stretch	1 x 20 seconds ea	
	Hip flexor stretch	1 x 20 seconds ea	
	Figure-4 stretch for piriformis	1 x 20 seconds ea	
	Adductor stretch	1 x 20 seconds ea	
	Heel raises	1 x 15	
	Alternating high knee marches	1 x 15	
	Hip circumduction (abd/ER/ext)	1 x 10	
	Standing hip extension	1 x 10 each leg	
	Squats	1 x 15	
	Visit 5		
	Warm-up on recumbent bike	5 minutes (resistance 5)	No additional exercises added this visit
	Bridging with resisted abduction (green band)	2 x 10	
	Inferolateral hip distraction in supine	5 x 20 seconds	
	Posterior hip distraction w/ PROM hip IR	5 x 20 seconds	All HEP activities were to be performed BID
	Soft-tissue massage to L TFL/Glute Minimus/ Glute medius	x 10 minutes	

3	<u>Visit 6</u> Warm-up on Recumbent bike Bridging with band (Blue band) Bridge with alternating SLR (L leg only) Squat Reverse lunge off 4” step then 6” step for engagement of posterior hip musculature in weight bearing Inferolateral hip distraction in supine Posterior hip distraction w/ PROM hip IR Inferior hip distraction in supine	 4 minutes (resistance 8) 2 x 10 w/ 5 resisted clamshells 1 x 10 2 x 10 1 x 10 both heights 5 x 30 seconds 5 x 30 seconds 3 x 30 seconds	 Added: Progression to blue band with bridging Bridging with SLR All HEP activities were to be performed BID
4	<u>Visit 7</u> Bridge with SLR Prone hip extension SLR working on no extensor lag Squats Inferolateral hip distraction in supine Posterior hip distraction w/ PROM hip IR Inferior hip distraction in supine	 1 x 8 each leg 2 x 10 each leg 1 x 8 each leg 2 x 10 5 x 30 seconds 5 x 30 seconds 3 x 30 seconds	 Progression of clamshells to Green band All HEP activities were to be performed BID
5	<u>Visit 8</u> - Reassessment/Discharge ROM measurements taken TUG test 10-Meter Walk Test - Comfortable speed - Fast speed 4-Square Step Test Patient education about maintaining adherence to HEP		 No Additional Exercises added All HEP activities were to be performed BID