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Physical Therapy Interventions and Outcomes in a Patient with Transfemoral Amputation Following Sound Side Total Knee Arthroplasty: A Case Report

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ABSTRACT

Background. Following transfemoral amputation (TFA), contralateral limb overuse leads to osteoarthritis (OA). Explanations include gait abnormalities, increased knee load, and hopping activities without prosthesis. Unilateral TFA patients may require total knee arthroplasty (TKA) to improve function.

Purpose. Determine benefits of standard physical therapy (PT) and augmented by high intensity, whole-body strengthening program.

Case Description and Methods. Patient with TFA, limited community ambulator and left knee OA, underwent TKA to restore function. PT examinations, interventions, and outcomes at 1-week pre-TKA to 1-year post-TKA; outcomes measures were Single Leg Stance Test (SLST), Four Square Step Test (FSST), Timed Up and Go Test (TUG), and Six Minute Walk Test (6MWT).

Findings. Patient achieved functional independence, gait, lower extremity strength and active range of motion (AROM) goals.

Outcomes and Conclusion: Outcomes in TUG and FSST equaled age and sex matched non-amputees. Standard TKA PT protocols contributed to patient success, while high intensity, whole-body strengthening program contributed to patient achievements.

TOTAL WORD COUNT: 148 words

Clinical Relevance Statement

This case study suggests rehabilitation interventions in a relatively healthy unilateral LEA with sound side TKA may be appropriate at a higher level of intensity, than often prescribed, to regain functional independence.

TOTAL WORD COUNT: 32 words

Introduction

In the United States (U.S.), there are approximately 185,000 lower extremity amputations (LEA) per year, and in 2009 associated healthcare costs were over $8.3 billion. Amputations occur in patients with diabetes, vascular disease, trauma, cancer, congenital disorders, and infections.[1] Angoules et al. reviewed 10 studies encompassing 451 patients, they examined the incidence of amputation following necrotizing fasciitis. The authors found that 22.3% of patients underwent limb amputation after failed attempts to control infection and avoid limb loss.[2] Patients with LEA experience secondary impairments of osteoarthritis (OA) of the sound side limb. In unilateral LEA, it is important to recognize early onset OA and how function could improve with surgical intervention.[1] OA is a chronic and degenerative synovial joint condition, primarily affecting articular cartilage. Late stage OA presents with persistent pain, which can be immobilizing.[3]

Abnormal gait patterns and joint mechanics, and lack of prosthetic confidence increases risk for knee OA in LEA patients.[1] Dynamic analysis of transfemoral amputation (TFA) gait demonstrated decreased gait speed, cadence, and stride length, and increased stance phase on sound limb.[4] New prosthetic technology has been developed to address unequal weight bearing through extremities in LEA to help prevent contralateral knee OA.[1] However, not all patients have access to this technology. Similarly, rehabilitation access may also be disparate leading to highly individualized courses of prosthetic care, rehabilitation and outcomes.[1]

This case presents functional improvements in a TFA patient with contralateral TKA following standard physical therapy (PT) interventions supplemented by high intensity, whole body strength training.

Methods

Patient History: The patient was a 56-year-old male with history of competitive power lifting and CrossFit® participation. He contracted necrotizing fasciitis in the right knee while treating an infected patient as a physical therapist. He underwent 15 limb salvage surgeries over three years. However, the infection returned, necessitating vital limb amputation. In this patient, a TFA, 5.08cm above the right knee joint was performed, altering his gait pattern and contributing to the progression of left knee OA.

Patient was referred to PT with a diagnosis of left knee pain and OA. Magnetic Resonance Imaging (MRI) and radiographs confirmed advanced OA. Pre-surgical PT interventions focused on improving sound limb strength and range of motion. A TKA was agreed upon by physical therapist, patient, and orthopedic surgeon.

Range of Motion and Muscle Testing: Left knee active range of motion (AROM) and passive range of motion (PROM) were measured using long arm goniometry for flexion and extension, following the Norkin and White method.[5] Manual muscle testing was performed by one physical therapist to determine strength using the Kendal method.[6]

Performance Based Outcome Measures: The Single Leg Stance Test (SLST), reported to be valid and reliable, was used to measure the patient's ability to stand on one leg without loss of balance. Those unable to perform the task for at least five seconds are at increased risk for falls. The Timed Up and Go (TUG) test was used to measure the patient's fall risk by using dual task dynamic activity. The TUG test is found to be reliable and valid measure of physical mobility in older LEA adults.[7] Dynamic balance was further measured by assessing the patient's ability to step over a one-inch object in different directions during the Four Square Step Test (FSST). The FSST has also demonstrated validity and reliability.[8] Finally, the 6 Minute Walk Test (6MWT) was used to assess sub-maximal aerobic capacity and endurance by measuring distance walked in six minutes and has also demonstrated validity and reliability.[1,7]

Goals: Patient goals included decreasing left knee pain and swelling, improving lower extremity muscle strength and AROM, independence in activities of daily living (ADL), normalizing gait, regaining the ability to run 1.56 m/s (1.61km) on the treadmill in 20 minutes with minimal upper extremity support, maneuvering a single flight of stairs with single hand held assist, ambulating 30.48m on uneven surfaces while carrying 11.34kg, and completing a 5k with walking sticks in under 60 minutes.

Intervention: The patient attended PT two times per week for eight weeks to improve function. The plan of care began with education which included a home exercise program (HEP), explanation of exercises, and timeline of pre and post-operative interventions. Patient PT included stretching, strengthening, joint mobilization, and gait training interventions. [1] Electrotherapeutic modalities were also utilized to reduce pain and swelling.[9]

The initial eight weeks focused on standard post-TKA treatment.[10] This included soft tissue massage, scar tissue mobilization and instrument assisted soft tissue mobilization (IASTM®). Passive manual and active assisted stretching were implemented to improve patient left knee A/PROM. To improve strength, left lower extremity therapeutic exercises were implemented.[10] Pain, edema and effusion management included cryotherapy and interferential electric stimulation.

Weeks 9-17 PT interventions focused on core and advanced lower extremity strengthening. This included therapeutic exercises such as planks, shuttle walks with elastic band resistance, bridges, step ups, static standing on a half Bosu® ball, and side walking in both directions with and without a handrail. Gait and balance impairments were addressed using single leg stance, tandem stance, dynamic tandem walking, walking on a treadmill with upper extremity support, step overs, and walking on uneven surfaces.

Weeks 18-33 supervised PT included outdoor obstacle course activities. These sessions included commando crawling (9.14m), flipping industrial tires and telephone poles for 30.48m each, walking on a 4.57m slack line (1.83m from the ground) with arm support, scaling an 2.44m wall, navigating a 4.57m balance beam (0.38m from the ground) with no upper extremity assistance, dragging a 22.68kg cement ball in increments of 60.96m. Sessions began with one repetition of each activity and progressed to five repetitions. Standard PT interventions were continued as needed to address acute pain and edema in the left knee. After week 33 the patient began independent obstacle course training for 20 weeks with a physical therapist colleague. This occurred two times per week, with five components of the obstacle course performed per session.

Results

Examination and Systems Review: At initial evaluation, pre-TKA, the patient complained of pain and decreased performance of activities of daily living (ADL). Using a numerical pain scale, the patient reported 7/10 left knee pain. With increased physical activity, he reported 10/10 pain.[7] The patient ambulated without an assistive device and with a right lower extremity prosthesis. The patient was initially classified as a limited community ambulator with potential for increased gait function. He demonstrated antalgic gait and hip hiking to clear the prosthesis in swing phase. The patient's prosthetic prescription included trial use of a Genium microprocessor knee (Otto Bock. Duderstadt, Germany). One-year post-TKA, the patient progressed to unlimited community ambulation with normalized gait and lacked notable deviations.[1] Impairments resulted from right TFA and left TKA. Post TKA surgery, the patient attended 32 weeks of supervised PT.

Range of Motion and Muscle Testing: Pre-TKA measurement of AROM left knee showed limited flexion (105°) and extension (-19°), and PROM flexion (111°) and extension (-15°) (**Table 1**). One-month post-TKA examination the patient demonstrated improvements in A/PROM of L knee flexion (114°, 115°) and extension (-3°, 0°). Two muscles, the Gastrocnemius and Anterior Tibialis both remained at 5/5 strength preoperatively and throughout the follow up period. Decreased strength was measured in the left posterior tibialis (4/5), gluteus maximus (4-/5) and psoas (4-/5) muscles. Strength gains were measured in the left peroneals and soleus (5/5), gluteus medius (4-/5), gluteus minimus (4-/5), and the left quadriceps muscles (5/5).[6]

One-year post-op, AROM of left knee improved to 123° flexion and 1° of hyperextension and PROM of 129° flexion and 2° of hyperextension. Muscle strength improved in the left peroneal (5/5), hamstring (4+/5), and quadriceps muscle groups (5/5), in addition to the soleus (5/5), glute min (4/5), glute med (4+/5), glute max (5/5), and psoas muscles (5/5).

Table 1: Left Lower Extremity Measurements Taken at Each Follow Up Period.

Follow up Period	Knee A/PROM		Manual Muscle Test								
	Flexion	Extension	Posterior Tibialis	Peroneals	Soleus	Gluteus Medius	Gluteus Minimus	Gluteus Maximus	Psoas	Hamstrings	Quadriceps
1 wk Pre-op	105°/111°	-19°/-15°	4+	4	4+	3	3	4	4+	4-	4
1 mo Post-op	114°/115°	-3°/0°	4	5	5	4-	4-	4-	4-	4-	5
3 mos Post-op	126°/131°	1°/3°	5	5	5	4-	4-	5	4	4	5
6 mos Post-op	126°/131°	1°/1°	5	5	5	4	4+	5	5	4	4
1 year Post-op	123°/129°*	1°/2°	4+	5	5	4+	4	5	5	4+	5

*****Edema due to prior workout

Performance Based Outcome Measures: Comparative values for the SLST, TUG, FSST, and 6MWT from one week pre-operatively to one year post-operatively are recorded in **Tables 2 and 3, and Figure 1.** Initial performance-based outcome measures revealed declines in static and dynamic balance and endurance. The patient exhibited decreased ability to perform outcome measures 1-month post-operative: SLST (right and left, 2.0s), TUG test (11.5s), and the 6MWT (318.20m). However, he did show improvement in performance of the FSST (from 8.09 to 7.27 sec). Gait training and increases in strength and range of motion resulted in functional improvement one-year post-TKA as noted in the SLST (right 7.7s, left 35.3s), TUG (6.8s), FSST (6.05s), and 6MWT (525.10m).

Table 2: Progression on the Single Leg Stance Test. Three trials of each leg were assessed at each follow up session. Values are mean (std dev) of the three trials and are reported in seconds.

Follow up Period	SLST	
	L	R
1 wk Pre-op	11.7(4.93)	2.0(0.00)
1 mo Post-op	2.0(0.00)	2.0(0.00)
3 mos Post-op	28.7(2.31)	2.0(0.00)
6 mos Post-op	29.7(0.58)	5.3(0.06)
1 year Post-op	35.3(1.15)	7.7(0.58)

Figure 1: Progression on the Timed Up and Go and Four Square Step Test. Three trials of each outcome were assessed at each follow up period. Values are depicted as mean (std dev).

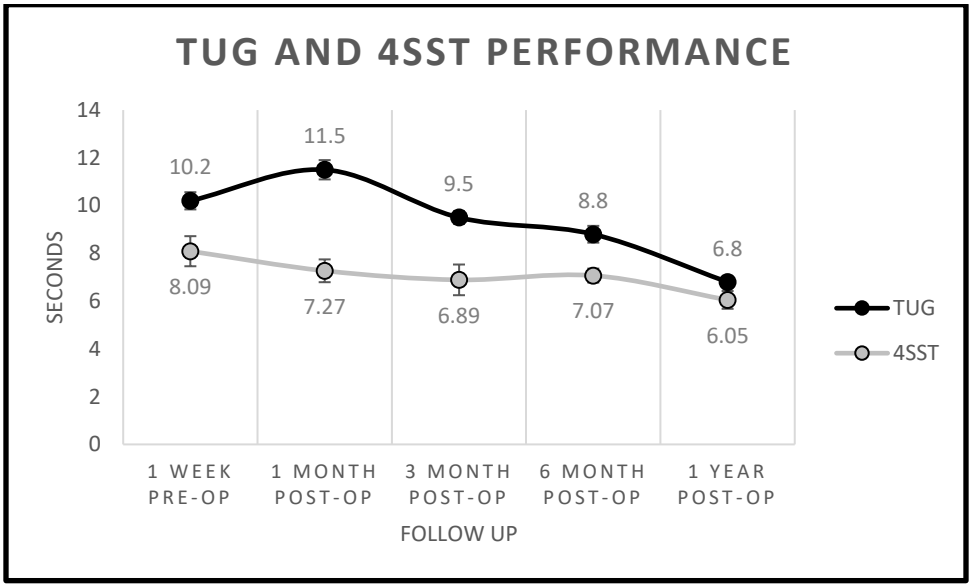

Table 3: Progression on the Six Minute Walk Test

6MWT	1 week pre-op	1 month post-op	3 month post-op	6 month post-op	1 year post-op
Distance (m)	383.50	318.20	426.90	450.80	525.10
Velocity (m/s)	1.15	0.96	1.29	1.25	1.46

Goals: Upon discharge, patient was compliant with HEP and reached 100% of his goals. Most notable being the completion of a 5k race (with walking sticks) in 52 minutes.

DISCUSSION

Patients with unilateral LEA are at risk for contralateral knee OA, which leads to pain and decreased function.[1] In this case, pain in sound limb (pre-TKA) resulted in decreased performance based test measurements. There is a dearth of evidence demonstrating the course of rehabilitation and associated functional improvements in TFA patients post-TKA.

Range of Motion and Muscle Testing: *The American Academy of Orthopaedic Surgeons (AAOS)* determined the normative range of motion for knee flexion and extension to be 135° and 10° respectively.[5] One year post-TKA the patient achieved increased active and passive range of motion for both knee flexion (126°, 129°) and extension (1°,

1°). The patient did not meet the normative average of knee AROM in adults but gained the full knee extension required for normalized gait and achieved active knee flexion between the necessary range of 100-120° required for running.[11] With TFA patients hip muscle strength is a strong predictor of gait speed and dysfunction.[1] The patient's overall improvements in hip strength likely contributed to a more normalized gait, specifically gluteus minimus and medius. Hip extensor strength is the strongest predictor of prosthetic walking speed, and likely attributed to increased scores on performance based outcome measures (TUG and 6MWT). Strong hip abductors allow for proper lateral weight shift and normalized step length during gait.[1]

Performance Based Outcome Measures: The SLST average value for this patient's age range (50-59y) in non-amputee males is 38.1s (eyes open). The patient's initial SLST score of the right lower extremity (2s) was due to lack of prosthetic side ankle and hip strategies and indicates risk of falls. The patient was unable to achieve scores equivalent to 38.1s (right 7.7s, left 35.3s) however both sides achieved increased time in SLST. Therefore, it seems fall risk may still be a factor; however, balance was improved.[7]

The mean TUG score of community dwelling adults 60-69 years old is eight seconds, with a score of greater than 19s indicating fall risk.[1,7] The patient was able to decrease his scores on the TUG test to less than 8s (6.8s). He additionally decreased his score on the FSST (6.05s) to less than that of those 50-65 years old (7.49s).[8] Notably high intensity, versatile whole-body strength training paired with standard post-TKA PT likely contributed to this patient's ability to achieve functional levels of an age and gender matched non-amputee on the TUG and FSST. New research demonstrates that patients performing the FSST while wearing a Genium microprocessor knee (12.00s) performed better than standard grade microprocessor knees (C-Leg, 12.26s).[12]

During the 6MWT the patient initially walked continuously without resting for 383.5m, which is below the normative distance of 572m for males without amputations of similar age, weight, and height.[7] Patient's with TFA are reportedly 43% slower than their healthy peers. Although the patient ambulated at a lesser distance, he did achieve an average gait speed (87.5m/min) greater to those of healthy adults (83m/min).[1] One year post-TKA he increased the distance walked (525.1m) but was 108.0m short of the distance achieved by his non-amputee peers.

Goals: Patient compliance with HEP and PT were expected to be above normal due to his occupation and likely contributed to successful achievement of all goals. In particular the patient completed a 5k race (with walking sticks) in 52 minutes, eight minutes faster than his goal of 60 minutes.

Limitations: This case study allowed a detailed exploration of this patient's course of rehabilitation post-TKA already being a prosthesis user following TFA. However, case reports commonly do not afford statistical analyses, calculation of effect sizes and generalizability to the larger clinical population. Studies with larger samples describing the

outcomes of total joint arthroplasty in patients with LEA are needed to determine the potential benefit of these procedures in this patient population.

CONCLUSION

Following total knee arthroplasty, this patient who was already a proficient transfemoral prosthesis user was followed for a year post-operatively. In addition to ROM and strength testing, outcome measures included single limb stance testing, timed up and go, 4 square step test and 6 minute walk test. Notable improvements were the normalized ROM, strength, TUG, and 4SST. Generally, while the SLST and 6MWT did not achieve the magnitude of values reported for non-amputees, significant improvements were seen, and the patient achieved unlimited community ambulation including exercise and activity participation beyond normal locomotion.

Results of the patient with unilateral TFA and contralateral TKA provide evidence of the importance of comprehensive standard-of-care PT paired with functional training augmented by a high intensity, versatile whole-body strengthening. This allowed for a more enhanced ability to perform all ADLs and mobility post-TKA. Further research is required to establish rehabilitation protocols specific to this population of patients.

TOTAL WORD COUNT: 2,198

REFERENCES

1. Lusardi M, Jorge M, Nielsen C. *Orthotics & Prosthetics in Rehabilitation.* 3rd ed. St. Louis, MO: Amirsys/Elsevier Suanders; 2013.
2. Angoules A, Kontakis G, Drakoulakis E, et al. Necrotising Fasciitis of Upper and Lower Limb: A Systematic Review. *Injury*. 2007;38: S18-25.
3. Heidari B. Knee Osteoarthritis Prevalence, Risk Factors, Pathogenesis and Features: Part I. *Caspian J Intern Med* 2011; 2: 205-12.
4. Bae T, Choi K, Hong D, et al. Dynamic Analysis of Above-Knee Amputee Gait. *Clin Biomech.* 2007;22: 557-66.
5. Norkin C, White D. *Measurement Of Joint Motion A Guide To Goniometry.* 4th ed. Philadelphia, PA: F.A. Davis Company; 2009.
6. Kendall F, McCreary E, Provance P, et al. *Muscles Testing And Function With Posture And Pain*. 5th ed. Baltimore, MD: Lippincott Williams and Wilkins; 2005.
7. Shirley Ryan Ability Lab. Sralab.org. https://www.sralab.org.
8. Langford Z. The Four Square Step Test. *J Physiother*. 2015;61: 162.
9. Bellew J, Michlovitz S, Nolan T. *Michlovitz's Modalities for Therapeutic Intervention.* 6th ed. Philadelphia, PA: F.A. Davis Company; 2016.
10. Agrillo J, Barrera S, Dynan M. *Rehabilitation Protocol: Total Knee Arthroplasty (TKA)*. Lahey Hospital & Medical Center; 2015.
11. Neumann D, Kelly E, Kiefer C, et al. *Kinesiology Of The Musculoskeletal System*. 3rd ed. St. Louis, MO: ELSEVIER; 2017.
12. Gouelle A, Highsmith M. Compléter l'interprétation Des Tests Cliniques Usuels Par Analyse Métrologique : Performance et Stratégie au Four Square Step Test Chez L'amputé Transfémoral. *Neurophysiol Clin*. 2018;48: 328-9.