Functional Outcome Measurements of a Veteran With a Hip Disarticulation Using a Helix 3D Hip Joint: A Case Report

Leif Marshall Nelson, DPT, ATP, CSCS, Neil T. Carbone, CP

ABSTRACT

There are no previously published studies measuring functional outcomes with the Helix 3D hip joint prosthesis for an individual with a hip disarticulation amputation. The veteran is a 30-year-old male with a traumatic hip disarticulation amputation. The timed up and go and the 2-minute walk tests were performed at the time of delivery of the permanent Helix 3D hip joint prosthesis, again at 8 weeks, and at 15 weeks. Both tests were also performed at 15 weeks with the veteran using an Otto Bock 7E7 single-axis hip joint prosthesis. The veteran showed consistent improvement with the Helix 3D hip joint in timed up and go times from initial fitting (mean 23.4 seconds) to 8 weeks (mean 17.9 seconds) and to 15 weeks (mean 15.1 seconds). The veteran had similar 2-minute walk distances at all trials, resulting in an overall average walking speed of 1.06 m/second. At week 15, by using the 7E7 hip prosthesis, the veteran ambulated at 0.56 m/second. Using the Helix Hip 3D, the outcome measures used in this study suggest that the veteran will be independent in activities of daily living, successful with community ambulation, and is at low risk of future hospitalization. (*J Prosthet Orthot*. 2011;23:21–26.)

KEY INDEXING TERMS: amputation, function outcome, Helix 3D, hip disarticulation, physical therapy, prosthesis, timed up and go, 2-minute walk, single axis, walking speed

It is common for prosthetic technologies to evolve in times of war. As of May 3, 2010, there have been 997 soldiers with amputations from Operation Iraqi Freedom and Operation Enduring Freedom treated in military treatment facilities. Of these soldiers, 22 sustained hip disarticulations.[1] This means that 2.2% of all limb amputations for this population, both upper and lower limb, at a level greater than a digit, are hip disarticulations.

It has been previously reported that just 0.5% of all lower-limb amputation surgeries are hip disarticulation.[2,3] The small percentage of these anatomically high lower-limb amputations is likely due to the fact that 78% to 94% are secondary to rare tumor resections, and very few are vascular or traumatic in nature.[2,4] Probably because of the low incidence of hip disarticulations, there have been few advancements in hip disarticulation prosthetic hip joints and correspondingly very few research studies. Traditional hip prostheses are single axis and allow movement in just one plane. Otto Bock's Helix 3D hip joint has a newly developed "so-called spatial four-axis mechanism with hydraulic stance and swing phase control," which allows for movement in multiple planes, and a polycentric function to allow for limb-length reduction during swing phase.[5] An exhaustive PubMed literature search yielded no published case studies, or any other analysis, of subjects using the Helix 3D hip joint.

Persons with hip disarticulation amputations tend to have limitations in walking, climbing stairs, and seating ability.[4] Outcomes, however, have been shown to be dependent on the mitigating cause of the amputation. Individuals with vascular hip disarticulations have a higher mortality rate and are less likely to be ambulatory.[6] Traumatic hip disarticulation is the least studied, but Schnall et al.[7] reported a case study of a young male with a traumatic hip disarticulation who was able to attain functionally independent ambulation with compensatory gait deviations. The cases of traumatic hip disarticulation are similar to those of persons with amputation secondary to tumor resection in the sense that both typically have minimal or no comorbidities. Amputations secondary to tumors historically have a better prognosis, with subjects able to maintain high levels of activity and participation in activities of daily living (ADLs).[4,6] Persons with hip disarticulation amputations secondary to tumor resection are also found to be successful prosthetic users.[8] Being a successful prosthetic user for ambulation is an important goal in the rehabilitation process, as persons with amputations prefer ambulation over wheelchair mobility,[9] despite the fact that wheelchair mobility was shown to be more energy efficient than ambulation with a prosthesis in a geriatric population with hip disarticulation amputations.[10]

The purpose of this case study is to report the functional outcomes of a veteran with a traumatic hip disarticulation

LEIF MARSHALL NELSON, DPT, ATP, CSCS, and NEIL T. CARBONE, CP, are affiliated with the Department of Veterans Affairs, VISN 3 Prosthetics and Sensory Aids Service, New York, New York.

Disclosure: The authors declare no conflict of interest.

Correspondence to: Leif Marshall Nelson, DPT, ATP, CSCS, 423 East 23rd Street, 14 South Prosthetics, New York, NY 10010; e-mail: leif.nelson@va.gov

amputation receiving prosthetic and rehabilitative care during a period of 15 weeks. An additional comparison in functional ability is explored contrasting a four-axis polycentric Helix 3D hip joint and a 7E7 hip joint, which is a popular single-axis hip joint from the same manufacturer, at week 15.

PATIENT DESCRIPTION AND ASSESSMENT

The patient is a 30-year-old male veteran with a left-side hip disarticulation amputation. He experienced a gunshot wound damaging the left femoral artery in December 2008. After multiple limb salvage surgeries, the patient underwent a left hip disarticulation surgery in January 2009. The initial consultation with a certified prosthetist was in February 2009, and the veteran presented with no significant comorbidities. The veteran underwent 5½ months of preprosthetic training including standard physical therapy and occupational therapy. Inpatient therapy included ADLs training, wheelchair mobility, therapeutic exercise, single-limb standing balance, and gait training with bilateral crutches. The veteran was discharged in June 2009 and received a trial of a temporary prosthesis in July 2009. The prosthesis consisted of a temporary socket, Helix 3D hip joint, C-Leg, and Trias foot. At that time, the veteran was able to walk with a narrow-based quad cane with supervision. The veteran received gait training and standard physical therapy two times per week for 3 months. The prosthesis was kept in physical therapy clinic during this 3-month time period.

A permanent prosthesis was issued to the veteran to use on a daily basis on October 15, 2009. This prosthesis consisted of the same components used in the temporary prosthesis, but with a permanent socket (Figure 1). The veteran performed the timed up and go (TUG) and 2-minute walk tests immediately after fitting and 30-minute acclimation period followed by a 10-minute rest period. During the acclimation period, the veteran was allowed to walk and practice transfers at his self-selected pace.

The TUG test was performed from an armed chair with an 18-inch seat height and a 25-inch arm height. The patient was seated in the chair with his back resting against the chair. On the word "go," the patient stood, walked 3 m, which was marked on the floor, turned around, returned to the chair, and sat. The timer was stopped when the patient's back was against the chair. The event was timed with a standard digital stopwatch and recorded to tenths of a second. Three trials were performed and recorded. The 2-minute walk test was performed in a clear 50-m hallway. The distance was recorded in meters, and the time was monitored using the same standard digital stopwatch.

Measurements were taken at the time of the initial fitting of the Helix 3D permanent prosthesis, and follow-ups were performed at 8 and 15 weeks. At week 15, the veteran's permanent socket was fit with an Otto Bock 7E7 hip joint, with the same C Leg and Trias foot (Figure 2). The veteran was given 30-minute acclimation period followed by a 10-minute rest break. After the rest period, the TUG and 2-minute walk tests were performed on the 7E7 prosthesis.

Figure 1. Side view of the veteran with permanent socket, Helix 3D hip joint, C Leg, and Trias foot.

The veteran was scheduled to receive physical therapy on an outpatient basis of two times per week during the entire time period the data were collected. He

Figure 2. Side view of the veteran with permanent socket, 7E7 hip joint, C Leg, and Trias foot.

attended a total of 19 documented physical therapy sessions. Both outcome measures were conducted by a licensed physical therapist, and the prosthesis was fitted by a certified prosthetist.

RESULTS/OUTCOMES

Three trials were recorded for the TUG test, whereas just one trial was recorded for the 2-minute walk test in an effort to minimize the effects of fatigue. Table 1 shows TUG times recorded on October 15, 2009 (week 1), December 10, 2009 (week 8), and January 27, 2010 (week 15). Figure 3 is a comparison of the veteran's average TUG times, including the week 15 initial trial with the 7E7 hip joint. Two-minute walk distance is portrayed in Figure 4, and those data were used to calculate walking speed represented in Figure 5.

Table 1. Timed Up and Go times of each trial, mean, and standard deviation

	Timed up and go test (time in seconds)				
	Trial 1	Trial 2	Trial 3	Mean	Standard deviation
Week 1 Helix	26.4	23.8	20.1	23.4	3.2
Week 8 Helix	19.1	18.3	16.4	17.9	1.4
Week 15 Helix	15.6	14.2	15.6	15.1	0.8
Week 15 7E7	24.8	27.3	26.4	26.2	1.3

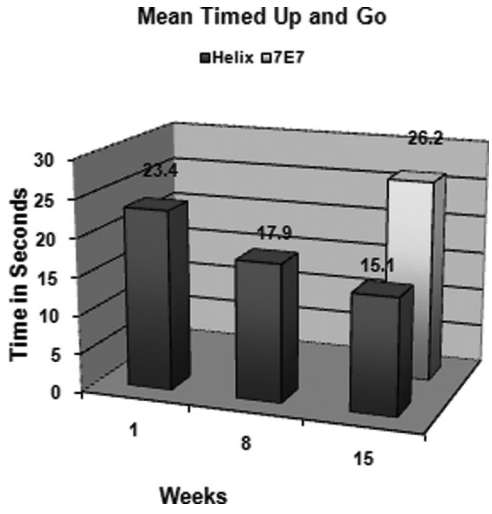

Figure 3. Comparison of mean Timed Up and Go times using Helix hip prosthesis. Week 15 includes the initial trial with the 7E7 hip prosthesis.

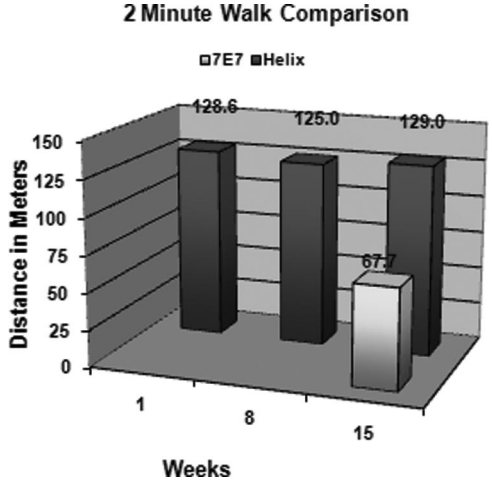

Figure 4. Actual distance covered in the 2-minute walk test.

DISCUSSION

Although no function outcome measures have been validated specifically for persons with hip disarticulation

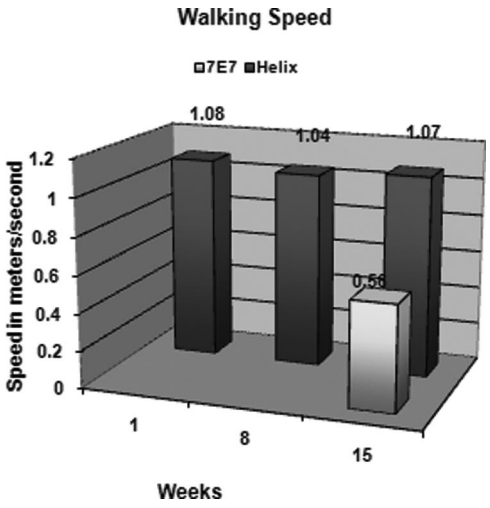

Figure 5. Calculated walking speed.

amputations, the TUG and the 2-minute walk tests were chosen by the authors because they are simple to perform in a clinic setting and are both well studied. The 2-minute walk test has been proven to have good interrater and intrarater reliability in transtibial amputees.[11] In addition, the 2-minute walk test has been determined to be a good indicator of gait speed[12] and an appropriate measure of functional capacity.[13,14] The TUG test has been proven to be both reliable and valid in a population with unilateral transtibial and transfemoral amputation.[15] In addition, the TUG test has also been used as a measure to determine risk of falling. In a healthy geriatric population, TUG times of 15 seconds or higher indicated a greater risk of falling,[16] and in a population status posthip fracture, 24 seconds was determined to be the cutoff for a higher risk of falls.[17] Both outcome measures have been shown to correlate well with other measures of physical functioning.[18,19]

The veteran in this case report had a progressively improving TUG test time during the 15-week time period while using the Helix Hip 3D prosthesis. In addition, the standard deviation decreased from 3.2 in week 1 to 0.8 in week 15, indicating the veteran became more consistent in performing the TUG test. His average TUG test time at initial permanent Helix Hip 3D prosthesis fitting was 23.4 seconds, which is just below the high fall risk threshold for the pathologic population[17] but well above the high risk for falling indictor for the healthy population. At the 15 week mark, average TUG test time was 15.1 seconds, which is approaching the cut off for lower risk of falls as determined for a healthy geriatrics population, with one trial below the 15-second threshold (14.2 seconds).[16] The veteran's improving TUG times were still slower than what would be considered a normal value for a healthy individual. The youngest population with calculated normative values for the TUG is 60- to 69-year old, with the range being 7.1 to 9.0 seconds.[20] The veteran did, however, outperform geriatrics with transfemoral and transtibial amputations (mean time 28.3 seconds and 23.8 seconds, respectively) because of peripheral vascular disease as reported in the TUG reliability and validity study by Shoppen et al.[15]

Brooks et al.[18] described the use of the 2-minute walk test as a measure of functional improvement in persons with unilateral transtibial, unilateral transfemoral, and bilateral lower limb amputations of unstated cause (n = 290). Mean findings were reported at baseline (27.9 m), discharge from rehabilitation (41.1 m), and follow-up (69.9 m). Distances for the veteran in this report were similar for all trials on the Helix Hip 3D prosthesis (128.6, 125.0, and 129.0 m). Thus, the veteran did not show similar improvements in this measure over the time of his 15 weeks of rehabilitation; however, he did achieve a far greater distance for all comparisons with the population with amputations reported by Brooks et al.

The authors suggest the following rationale to explain why the veteran in this report may have shown improvement in the TUG and not the 2-minute walk test. The TUG has a component of transferring from sit to stand, and stand to sit in addition to ambulation. The veteran may have shown improvement as he gained experience and expertise transferring with the prosthesis with physical therapy and home use. Brooks et al.[18] found the greatest increase in 2-minute walk test at the 3-month status posthospital discharge follow-up outpatient clinic assessment. Such improvement in the 2-minute walk test was not observed in this report (Figure 4). This could be related to the veteran attending just 19 physical therapy appointments over a time period that he should have attended 30. The patient in this report also differs from the Brooks et al. population. The majority of subjects had transtibial amputations, average age of 66.3 years, and presented with at least one significant comorbidity. A home use log would have been a useful tool to determine how many hours per day the veteran was using the prosthesis, because lack of use may also be a factor in lack of improvement in overall distance ambulated in the 2-minute walk test.

Using the 2-minute walk test to calculate walking speed is beneficial, as walking speed is well studied with established norms.[21–24] The veteran in this case study ambulated at an average speed of 1.06 m/second using the Helix Hip 3D prosthesis, which is slower than the average speed for his age and sex[24] but is much faster than reported speeds for hip disarticulation amputees using single-axis hip joints.[7,25,26] The average self-selected walking speed for individuals with hip disarticulation amputations secondary to malignant tumor resection, as reported by Nowroozi et al.,[25] is 0.79 m/second. On the Helix Hip 3D prosthesis, the veteran's calculated walking speeds indicated that he had a low risk of being hospitalized, was more likely to be independent in ADLs,[21] and that he would be successful in community ambulation.[22] He was likely, however, limited in his ability to cross the street.[23]

A weakness in this case report is that the veteran was not introduced to the 7E7 prosthetic hip until week 15, whereas he was able to acclimate to the Helix Hip 3D hip joint during the

entire 15-week time period. The clinic team following the veteran in this report decided to trial 7E7 hip joint at week 15 as a means of comparison to determine whether the veteran would be as successful with a single-axis hip joint. With that noted, it may be more appropriate to draw comparisons between day 1 with the 7E7 at 15 weeks and the Helix Hip 3D at day 1. Using those data, the TUG times were similar, with the Helix Hip 3D at week 1 performing slightly better (Figure 3). Of note, the veteran's average TUG time on the 7E7 prosthesis indicated that he was at a high risk of falling.[16,17] There is a significant discrepancy in the 2-minute walk test distance as the veteran ambulated 90% farther using the Helix 3D hip (Figure 4). This logically carries over to a similar difference in walking speed (Figure 5). The walking speed of the veteran on the 7E7 prosthesis is similar to those reported for a demographically similar veteran ambulating with a comparable prosthesis. Schnall et al.[7] reported at 3 months postinjury, a walking speed of 0.57 m/second, and at 38 months postinjury, a walking speed of 0.86 m/second in a 27-year-old soldier, status posttraumatic hip disarticulation, ambulating on a single-axis hip joint with an Otto Bock C-Leg. Based on walking-speed studies, both the veteran reported by Schnall et al. and the veteran in this study are more likely to be hospitalized, more likely to be dependent in ADLs,[21] and they will be limited community ambulators[22] while using single-axis hip joints. The difference in walking speed suggests a potential difference in functional independence based on the choice of prosthetic hip joint.

CONCLUSION

The veteran with a hip disarticulation in this case report showed improvement in TUG times using the Helix Hip 3D, C-Leg, and Trias foot prosthesis during the 3-month course of physical therapy and prosthetic care. The veteran also ambulated at a speed that has been determined to indicate independence in ADLs, successful community ambulation, and a decrease in the chance of hospitalization when using the Helix Hip 3D prosthesis. As per the functional outcome measures, the veteran did not achieve the same level of functional independence with the trial of the single axis 7E7 hip joint.

Future studies should consider measuring gait symmetry through kinematic analysis and energy expenditure while ambulating with the Helix 3D hip joint when compared with a single-axis hip joint.

ACKNOWLEDGMENTS

The authors thank Steven Baptiste, DPT, for his role in data collection and his role as the primary physical therapist for this veteran during the time of this case report. Baptiste was working in the VA New York Harbor Healthcare System's Physical Medicine and Rehabilitation Service.

REFERENCES

1. Public Affairs Office, Walter Reed Army Medical Center, May 14, 2010. http://www.wramc.army.mil. Accessed: December 13, 2010.
2. Wakelin S, Oliver C, Kaufman M. Hip disarticulation—the evolution of a surgical technique. *Injury* 2004;35:229–308.
3. Dillingham T, Pezzin L, MacKenzie E. Limb amputation and limb deficiency: epidemiology and recent trends in the United States. *South Med J* 2002;95:875–883.
4. Yari P, Dijkstra P, Geertzen J. Functional outcome of hip disarticulation and hemipelvectomy: a cross-sectional national descriptive study in the Netherlands. *Clin Rehabil* 2008;22: 1127–1133.
5. Blumentritt S, Ludwigs E, Bellmann M, Boiten H. *The New Helix3D Hip Joint*. Dortmund: Orthopadie-Technik; 2008: 1–5.
6. Denes Z, Till A. Rehabilitation of patients after hip disarticulation. *Arch Orthop Trauma Surg* 1997;1116:498–499.
7. Schnall B, Baum B, Andrews A. Gait characteristics of a soldier with a traumatic hip disarticulation. *Phys Ther* 2008;88: 1568–1577.
8. Hamamura S, Chin T, Kuroda R, et al. Factors affecting prosthetic rehabilitation outcomes in amputees of age 60 years and over. *J Int Med Res* 2009;37:1921–1927.
9. Stokes D, Curzio J, Berry A, et al. Pre prosthetic mobility: the amputees' perspectives. *Disabil Rehabil* 2009;31:138–143.
10. Chin T, Oyabu H, Maeda Y, et al. Energy consumption during prosthetic walking and wheelchair locomotion by elderly hip disarticulation amputees. *Am Med J Phys Med Rehabil* 2009;88: 399–403.
11. Brooks D, Hunter J, Parsons J, et al. Reliability of the two-minute walk test in individuals with transtibial amputation. *Arch Phys Med Rehabil* 2002;83:1562–1565.
12. Kosak M, Smith T. Comparison of the 2-, 6-, and 12-minute walk tests in patients with stroke. *J Rehabil Res Dev* 2005;42: 103–107.
13. American Thoracic Society. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002;166: 111–117.
14. Butland R, Pang J, Gross E, et al. Two-, six-, and 12-minute walking tests in respiratory disease. *Br Med J (Clin Res Ed)* 1982;284:1607–1608.
15. Shoppen T, Boonstra A, Groothoff J, et al. The timed "up and go" test: reliability and validity in persons with unilateral lower limb amputation. *Arch Phys Med Rehabil* 1999;80: 825–828.
16. Whitney JC, Lord SR, Close JC. Streamlining assessment and intervention in a falls clinic using the timed up and go test and physiological profile assessments. *Age Ageing* 2005;34: 567–571.
17. Kristensen M, Foss N, Kehlet H. Timed "up & go" test as a predictor of falls within 6 months after hip fracture surgery. *Phys Ther* 2007;87:24–30.

18. Brooks D, Parsons J, Hunter J, et al. The 2-minute walk test as a measure of functional improvement in persons with lower limb amputation. *Arch Phys Med Rehabil* 2001;82: 1478–1483.

19. Podsiadlo D, Richarson S. The timed "up & go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991;39:142–148.

20. Bohannon R. Reference values for the timed up and go test: a descriptive meta-analysis. *J Geriatr Phys Ther* 2006;29:64–68.

21. Studenski S, Perera S, Wallace D, et al. Physical performance measure in the clinical setting. *J Am Geriatr Soc* 2003;51: 314–322.

22. Perry J, Garrett M, Gronley J, Mulroy S. Classification of walking handicap in the stroke population. *Stroke* 1995;26:982–989.

23. Lernier-Frankiel M, Vargas S, Brown M, et al. Functional community ambulation: what are your criteria? *Clin Manag Phys Ther* 1986;6:12–15.

24. Bohannon R. Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants. *Age Ageing* 1997;26:15–19.

25. Nowroozi F, Salvanelli M, Gerber L. Energy expenditure in hip disarticulation and hemipelvectomy amputees. *Arch Phys Med Rehabil* 1983;64:300–303.

26. McAnelly R, Refaeian M, O'Connell D, et al. Successful prosthetic fitting of a 73-year-old hip disarticulation amputee patient with cardiopulmonary disease. *Arch Phys Med Rehabil* 1998;79:585–588.