A polycentric hydraulic hip joint increases prosthetic gait biomechanics and functional capabilities for hip disarticulation amputees compared to the current standard of care

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Creation Date: April 2023, Date of Reassessment: April 2028

Clinical Question: In patients with a hip disarticulation amputation, does a polycentric hydraulic hip joint improve gait biomechanics and functional capabilities compared to a single axis, constant friction hip joint?

Background: People with hip disarticulation amputations often have limitations in activities of daily living associated with walking, climbing stairs, and sitting down.[1] In addition, published literature shows that the higher the amputation level, the lower the acceptance rate of using a prosthesis.[2] Less than 50% of people with a hip disarticulation amputation use a prosthesis in everyday life.[3] Lower user acceptance rates are caused by prosthetic limitations like poor gait pattern, socket discomfort, high energy consumption, and more walking aids required.[2-4] For the last several decades, hip disarticulation prostheses have been made with a forward tilted monocentric hip joint, which moves in one plane, allowing only flexion and extension. This motion limitation often leads to body compensations such as increased lumbar involvement or posterior pelvic tilt during prosthetic swing phase.[5-6] Polycentric hydraulic hip joints have a four-bar linkage hip joint with a hydraulic unit that provides controlled resistance to motion during both stance and swing phase.[4] Due to the added motion of this style of hip joint, it has the potential to reduce some of the gait abnormalities commonly associated with hip disarticulation prostheses.

Databases Searched: PubMed, JPO
Search Terms: (hip disarticulation OR hemipelvectomy) AND (gait) AND (outcome OR rehabilitation) AND (helix OR hip joint) AND (comparison OR evaluation OR analysis OR efficiency OR case report) NOT (infection OR cancer). The included articles are a representative sample.
Inclusion/Exclusion Criteria: English, peer-reviewed and published, 2010 to present

Synthesis of Results: Literature shows that gait using a hip disarticulation prosthesis with a monocentric hip joint has significant asymmetry compared to the intact side.[4] However, significant enhancements with regards to the gait patterns of hip disarticulation amputees are shown when walking with a polycentric hydraulic hip joint compared to the monocentric joint.[3,4] Enhancements included improved hip extension control, more moderate hip flexion velocity during swing phase, and increased stance flexion in the prosthetic knee, which leads to improved gait kinematics and increased stability.[3] Using a polycentric hydraulic hip joint "provided a gait pattern more similar to that of able-bodied persons."[3] In addition to biomechanical gait analysis, outcome measures showed reduced TUG times and increased walking velocity using a polycentric hydraulic hip joint.[2] For qualitative data, patient scores from the Locomotor Capabilities Index (LCI) showed increased advanced ambulation skills and activities considered difficult for hip disarticulation amputees when fit with a polycentric hydraulic hip joint, resulting in increased independence. Overall outcomes of participants fit with a polycentric hydraulic hip were statistically improved.[2] However, for some patients, the continued discomfort of wearing a prosthesis or the increased motion of a polycentric hydraulic hip joint ultimately led to rejection.[4] Due to the low incidence of hip disarticulation amputations and complexity of their prostheses, there has not been considerable research done on this patient population. Some limitations to these studies include the small subject populations, the lack of comparative polycentric hip designs, and inconsistencies in prosthetic adjustment periods that can greatly effect outcome measure results as well as overall component selection and socket fit.

Clinical Message: Use of a polycentric hydraulic hip joint is likely to improve the gait biomechanics of hip disarticulation prosthetic wearers. Existing evidence has low subject populations with varying results, but qualitative and quantitative outcome measures with a polycentric hydraulic hip joint show higher patient-reported functional level of activities of daily living and self-selected walking speeds compared to the monocentric constant friction standard of care. The patient still must overcome the obstacles associated with prosthetic use at the hip disarticulation level, but the use of a polycentric hydraulic hip joint may prove to provide a more biomechanically effective alternative compared to monocentric options for these prosthetic users.

References:

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Evidence Table

	Ludwigs, 2013[2]	*Ludwigs, 2010*[3]	*Gailledrat, 2013*[5]
Population	13 subjects, 2 hemipelvectomy and 11 hip disarticulations, mean age = 44, mean years wearing a prosthesis = 18, 10 male patients and 3 female, MFCL potential between K2-K3	Six unilateral, hip disarticulation amputees, experienced prosthetic users	Three hip disarticulation amputees, age 33-37, two male and one female
Study Design	Crossover randomized controlled trial	Crossover randomized controlled trial	Crossover control trial
Intervention	Helix 3D hip joint with C-Leg and ESR foot	Helix 3D hip joint	Helix 3D hip joint
Comparison	Current prosthesis with monocentric hip joint (including 7E7, Littig hip, and 3R30 joints)	Same socket and distal components, changed to 7E7 hip joint	Current prosthesis with Canadian socket and 7E7 hip joint
Methodology	Patients were given a new prosthesis with a Helix Hip Joint, C-Leg, and ESR foot. After a mean acclimation period of 11 weeks, the timed clinical assessments on stairs and ramps, 10-m walk test, and mobility questionaries were completed with the new prosthesis and results were compared to outcomes with the current prosthesis.	Patients used one hip joint per day for two days of study in random order using their own sockets. Two force plates and six optoelectronic cameras with 23 reflective markers were used for kinetic and kinematic measurements. Patients were asked to ambulate at a self-selected walking speed through the gait lab.	Patients admitted for four consecutive days of training and adaptation to new prosthesis with Helix joint and C-Leg. Training included gait stairs and climbing. Outcome measures completed on day 4. The spatiotemporal parameters were measured using a GaitRite Walkway.
Outcomes	Locomotor Capabilities Index (LCI), functional assessments, dependence questionnaire, 10m walk test	Time distance parameters, pattern of the hip joint, knee joint, and pelvic tilt in the sagittal plane	Functional Independence Measure, satisfaction questionnaire, 2-minute walk test, gait pattern assessment using GaitRite Walkway
Key Findings	With Helix, total of LCI-5 improved from 46 to 55 (p=0.003). Advanced ambulation skills (p=.005) and activities considered difficult for hip disarticulation (p=.008) showed significant improvement with new prosthesis. Time required for walking down the ramp and staircase was reduced with the Helix joint system. Seven subjects were able to increase their walking velocity.	The differences between the two hip joints for velocity and prosthetic and contralateral step length were insignificant. The 7E7 reaches maximum extension at 17% of the gait cycle, but Helix reaches at 46% of gait cycle. Hip flexion is initiated at 7E7 at 70% of gait cycle, but flexion with Helix is initiated immediately after maximum extension. Increased stance flexion of the knee is observed with Helix compared to 7E7. The maximum range of pelvic tilt is significantly (p=.028)	Satisfaction score and distance in the 2MWT increased for two patients and reduced for one with the Helix. One patient had improved gait parameters but the other two had deterioration of gait parameters with the Helix. All 3 patients decided to discontinue the use of the Helix long term, mostly because of comfort problems in the socket. Two of the patients did not like the unexpected hip flexion experienced and found it difficult to adapt to the new component.

	Ludwigs, 2013[2]	*Ludwigs, 2010*[3]	*Gailledrat, 2013*[5]
		increased with 7E7 when compared to the Helix.	
Study Limitations	All the contributors are from Ottobock which may present bias. Patients decided themselves when fully acclimated to new prosthesis. Patients received entire new system which may be hard to distinguish which benefits are coming from the hip joint itself.	Patients only had two days to acclimate to the new hip joint.	Did not control for original prosthesis design (two patients already had a C-Leg), limited patient population, reduced success from lack of socket comfort