Use of Bilateral Power Knee® and Proprio Foot® in a Bilateral Transfemoral Amputee

GF O’Neale MD, J Carter CPO, MA Milkevich MD

Background
Recent years have seen the development of powered microprocessor-controlled knee (MPK) and microprocessor-controlled foot (MPF) components. While these are increasingly studied in unilateral lower extremity amputees, there is a dearth of literature on the potential improved function in bilateral transfemoral amputees (TFA) using these systems. Ambulation in bilateral TFA is a physiologically demanding task. In addition, functional activities such as transfers from sitting to standing and bipedal negotiation of varied terrains may benefit from the support of powered MPK and MPF in bilateral TFA. This case presents the experience of the first known patient in the world using Ossur Power Knee® (PK) and Proprio Foot® (PF) bilaterally.

Case Description
DM is a 39-year-old male with a history of bilateral transfemoral amputation in 2015 secondary to trauma. His residual limbs measure two-thirds the length of the femur with well-healed incision and graft sites. Initially, he had been fitted with bilateral preparatory prostheses with gel locking liner suspension and stance control units. Participating in home physical therapy, his wear time was 3-4 hours knee consecutively. He used Lofstrand crutches for ambulation with good balance and a reciprocal gait. Yet, he reported that his mechanical knees would collapse making standing and sitting difficult. As his prior activity level predicted the potential to be a K3 ambulator, DM was prescribed bilateral MPK (OttoBock C-Leg 4) and mechanical feet (OttoBock Triton).

DM continued with bilateral C-Leg/Triton components for three years during which he progressed to ambulating independently with a wide based gait using a cane. On follow up, he reported left shoulder soreness, relying heavily on upper extremities to stand and to walk with the cane; workup revealed tendinitis. He reported low back and hip pain in setting of altered gait mechanics. He noted loss of balance and falls on slopes as well as limited ankle range of motion and knee instability with standing and weight shifting. On exam, despite adequate prosthetic fit, he was noted to have compensatory foot and hip external rotation during limb advancement. He requested a trial with bilateral Power Knee® and Proprio Foot® during which he demonstrated improved ability to stand and ambulate. In light of his prior progress, immediate limitations and goals for greater activity on more varied terrain, DM was ordered bilateral PK and PF.

Six weeks after fitting, DM was walking with a wheeled walker with an improved gait pattern demonstrating reduced base width and only intermittent right foot rotation. He reported decreased frequency of falls and difficult sitting due to knee stiffness. Six months later, his balance was improved, and he ambulated independently with standup type walker. After another five months, he no longer regularly experienced low back and hip pain. He ambulates up to 15 minutes using a rollator for due to ongoing shoulder pain. While he notices the weight of the prostheses when initiating gait, once ambulating the powered function reduces his effort. He reports few challenges. In addition to the powered MPK component, he uses the chair arms assist with standing from sitting. He has occasional near falls when one PK activates without the other. He is unable to ascend or descend steps or uneven terrain, reporting difficulty initiating stair mode on both PK.

Discussion
Sit-to-stand transfers require significant lower extremity strength and range of motion. This complex movement involves leaning trunk forward to shift center of gravity, shifting weight onto heels, and extending hip and knees to upright stance. Reliance on upper extremities to provide the needed power for sit-to-stand transfers may lead to undue pressure as seen in this patient. Wolf et al. found PK provided greater knee power than C-Leg during sit-to-stand tasks in unilateral transfemoral amputees. Highsmith et al. found that hip moments during sit-to-stand were not statistically significantly different between PK and C-Leg, though noted differences could be individually meaningful. There was difference in hip moment in stand-to-sit between control and C-Leg, but no significance between PK and control suggesting that PK requires hip action more similar to controls than C-Leg. Further comparison between PK and C-Leg would clarify this potential benefit in bilateral TFA.

Ankle knee mechanisms are an important consideration when prescribing prostheses in bilateral TFA. Use of MPF such as Ossur’s PF in conjunction with PK may provide further mechanical advantage for standing and walking on slopes than with powered MPF alone. Comparing commercial MPF in unilateral transfemoral and transfemoral amputees, Ernst et al. described auto-adaptive dorsiflexion stop and range of motion as the primary functions that allow for standing on slopes. PF features a motor which incrementally adapts ankle angle on slopes during swing phase while locking the joint to prevent rotation during stance. This may contribute to improved balance and reduction in falls as well as ability to traverse a greater variety of terrains.

In unilateral TFA, Jayaraman et al. found that when compared to MPKs, powered-knee-ankle prostheses provided gait kinematics more similar to normal gait pattern in intact limb, reduced asymmetry in mechanical loading and muscle loading in lower back and lower extremities, and allowed for a greater range of cadence. While it is unclear whether these benefits translate to patients with bilateral amputations, our case reports improved performances in gait and pain that may point to such benefit. Our review of the literature found only one conference presentation and paper by a single research group on powered prostheses for bilateral TFA. Together the studies present the design and validation of paired powered knee-ankle prostheses for bilateral TFA with preliminary data suggesting improvement in gait mechanics as compared in passive prostheses.

Conclusion
The combination of powered MPK and MPF prostheses may better support transitions between sitting and standing, provide greater power for ascending stairs as well as more stability on slopes. Improvements in overall gait mechanics help to alleviate abnormal muscle loading leading to reductions in pain. To our knowledge this case report represents the first instance in the literature describing the use of Ossur PK and PF in a bilateral TFA. More research is needed on bilateral powered MPK and MPF prostheses in bilateral TFA to promote the highest level of function in motivated individuals with this level of amputation. From our observations, additional studies assessing gait characteristics, sit-to-stand function and stair navigation in bilateral TFA would be beneficial.

Acknowledgements
Thanks to Kurt Gruben at Ossur for providing preliminary research on PK. Thanks to DM for sharing his experiences.

References
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