

## Medical Policy



### Title: **Microprocessor-Controlled Prostheses for the Lower Limb**

**PRE-DETERMINATION of services is not required, but is highly recommended.**

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*See also [Myoelectric Prosthetic Components for the Upper Limb medical policy](#)*

#### **Professional**

Original Effective Date: January 1, 2021

Revision Date(s): January 1, 2021;

April 1, 2021

Current Effective Date: January 1, 2021

#### **Institutional**

Original Effective Date: January 1, 2021

Revision Date(s): January 1, 2021;

April 1, 2021

Current Effective Date: January 1, 2021

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Populations	Interventions	Comparators	Outcomes
Individuals: <ul style="list-style-type: none"> <li>With transfemoral amputation</li> </ul>	Interventions of interest are: <ul style="list-style-type: none"> <li>Prosthesis with a microprocessor-controlled knee</li> </ul>	Comparators of interest are: <ul style="list-style-type: none"> <li>Prosthesis with a conventional knee</li> </ul>	Relevant outcomes include: <ul style="list-style-type: none"> <li>Functional outcomes</li> <li>Health status measures</li> <li>Quality of life</li> </ul>
Individuals: <ul style="list-style-type: none"> <li>With transfemoral amputation</li> </ul>	Interventions of interest are: <ul style="list-style-type: none"> <li>Prosthesis with a powered knee</li> </ul>	Comparators of interest are: <ul style="list-style-type: none"> <li>Prosthesis with a conventional knee</li> </ul>	Relevant outcomes include: <ul style="list-style-type: none"> <li>Functional outcomes</li> <li>Health status measures</li> <li>Quality of life</li> </ul>

<p>Individuals:</p> <ul style="list-style-type: none"> <li>• With tibial amputation</li> </ul>	<p>Interventions of interest are:</p> <ul style="list-style-type: none"> <li>• Prosthesis with a microprocessor-controlled ankle-foot</li> </ul>	<p>Comparators of interest are:</p> <ul style="list-style-type: none"> <li>• Prosthesis with a conventional foot-ankle</li> </ul>	<p>Relevant outcomes include:</p> <ul style="list-style-type: none"> <li>• Functional outcomes</li> <li>• Health status measures</li> <li>• Quality of life</li> </ul>
<p>Individuals:</p> <ul style="list-style-type: none"> <li>• With tibial amputation</li> </ul>	<p>Interventions of interest are:</p> <ul style="list-style-type: none"> <li>• Prosthesis with a powered ankle-foot</li> </ul>	<p>Comparators of interest are:</p> <ul style="list-style-type: none"> <li>• Prosthesis with a conventional ankle-foot</li> </ul>	<p>Relevant outcomes include:</p> <ul style="list-style-type: none"> <li>• Functional outcomes</li> <li>• Health status measures</li> <li>• Quality of life</li> </ul>

## **DESCRIPTION**

### **Summary**

Microprocessor-controlled prostheses use feedback from sensors to adjust joint movement on a real-time as-needed basis. Active joint control is intended to improve safety and function, particularly for patients who can maneuver on uneven terrain and with variable gait.

### **Objective**

The objective of this evidence review is to determine whether powered prostheses improve the net health outcome in individuals with lower-extremity amputations.

### **Background**

#### **Lower-Extremity Prosthetics**

More than 100 different prosthetic ankle-foot and knee designs are currently available. The choice of the most appropriate design may depend on the patient’s underlying activity level. For example, the requirements of a prosthetic knee in an elderly, largely homebound individual will differ from those of a younger, active person.

Key elements of a prosthetic knee design involve providing stability during both the stance and swing phase of the gait. Prosthetic knees vary in their ability to alter the cadence of the gait, or the ability to walk on rough or uneven surfaces. In contrast to more simple prostheses, which are designed to function optimally at one walking cadence, fluid and hydraulic-controlled devices are designed to allow amputees to vary their walking speed by matching the movement of the shin portion of the prosthesis to the movement of the upper leg. For example, the rate at which the knee flexes after “toe-off” and then extends before heel strike depends in part on the mechanical characteristics of the prosthetic knee joint. If the resistance to flexion and extension of the joint does not vary with gait speed, the prosthetic knee extends too quickly or too slowly relative to the heel strike if the cadence is altered. When properly controlled, hydraulic or pneumatic swing-phase controls allow the prosthetist to set a pace adjusted to the individual amputee, from very slow to a race-walking pace. Hydraulic prostheses are heavier than other options and require gait training; for these reasons, these prostheses are prescribed for athletic or fit individuals. Other design features include multiple centers of rotation, referred to as “polycentric knees.” The mechanical complexity of these devices allows engineers to optimize selected stance and swing-phase features.

## **Regulatory Status**

According to the manufacturers, microprocessor-controlled prostheses are considered a class I device by the U.S. Food and Drug Administration (FDA) and are exempt from 510(k) requirements. This classification does not require submission of clinical data regarding efficacy but only notification of FDA prior to marketing. FDA product codes: ISW, KFX.

## **POLICY**

**Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.**

- I. Electronic prosthetics meeting criteria below may be allowed when provided by a certified Orthopedic / Prosthetic Device Supplier.
  
- II. **Knee**
  - A. A microprocessor-controlled knee may be considered **medically necessary** in individuals with transfemoral amputation who meet **all** of the following requirements:
    1. Functional level of K3 or K4:
      - a. Has the ability or potential for ambulation with variable cadence, typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion (K3)  
**OR**
      - b. Has the ability or potential for prosthetic ambulation that exceeds the basic ambulation skills, exhibiting high impact, stress, or energy levels, typical of the prosthetic demands of the child, active adult, or athlete (K4)  
**AND**
    2. Physical ability, including adequate cardiovascular and pulmonary reserve, for ambulation  
**AND**
    3. Adequate cognitive ability to master use and care requirements for the technology
  
  - B. A microprocessor-controlled knee is **not covered** in individuals who do not meet the criteria in II A.

- C. A powered knee may be considered **medically necessary** in individuals with transfemoral amputation who meet **all** of the following requirements:
1. Has a microprocessor-controlled knee (meeting the criteria in II A)  
**AND**
  2. Has K3 functional level only  
(Has the ability or potential for ambulation with variable cadence, typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion [K3])  
**AND**
  3. Has a documented comorbidity of the spine and/or sound limb affecting hip extension and/or quadriceps function that impairs K3 level function with the use of a microprocessor-controlled knee alone  
**AND**
  4. Is able to make use of a product that requires daily charging  
**AND**
  5. Is able to understand and respond to error alerts and alarms indicating problems with the function of the unit
- D. A powered knee is **not covered** in individuals who do not meet the criteria in II C.

### III. **Ankle**

- A. A microprocessor-controlled ankle may be considered **medically necessary** in individuals with tibial amputation who meet **all** of the following requirements:
1. Functional level of K3 or K4:
    - a. Has the ability or potential for ambulation with variable cadence, typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion (K3)  
**OR**
    - b. Has the ability or potential for prosthetic ambulation that exceeds the basic ambulation skills, exhibiting high impact, stress, or energy levels, typical of the prosthetic demands of the child, active adult, or athlete (K4)  
**AND**

2. Physical ability, including adequate cardiovascular and pulmonary reserve, for ambulation  
**AND**
  3. Adequate cognitive ability to master use and care requirements for the technology
- B. A microprocessor-controlled ankle is **not covered** in individuals who do not meet the criteria in III A.

#### IV. **Ankle-Foot**

- A. A microprocessor-controlled ankle foot system may be considered **medically necessary** in individuals with tibial amputation who meet **all** of the following requirements:
1. Functional level of K3 or K4:
    - a. Has the ability or potential for ambulation with variable cadence, typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion (K3)  
**OR**
    - b. Has the ability or potential for prosthetic ambulation that exceeds the basic ambulation skills, exhibiting high impact, stress, or energy levels, typical of the prosthetic demands of the child, active adult, or athlete (K4)  
**AND**
  2. Physical ability, including adequate cardiovascular and pulmonary reserve, for ambulation  
**AND**
  3. Adequate cognitive ability to master use and care requirements for the technology
- B. A microprocessor-controlled ankle-foot system is **not covered** in individuals who do not meet the criteria in IV A.

**Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.**

## **Policy Guidelines**

1. Amputees are evaluated by an independent, qualified professional to determine the most appropriate prosthetic components and control mechanism. A trial period may be indicated to evaluate the tolerability and efficacy of the prosthesis in a real-life setting. Decisions about the potential benefits of microprocessor knees involve multiple factors including activity levels and the patient's physical and cognitive ability. A patient's need for daily ambulation of at least 400 continuous yards, daily and frequent ambulation at variable cadence or on uneven terrain (eg, gravel, grass, curbs), and daily and frequent use of ramps and/or stairs (especially stair descent) should be considered as part of the decision. Typically, daily and frequent need of two or more of these activities would be needed to show benefit.
2. Benefits are not provided for repair or replacement of prosthetic devices due to misuse, malicious damage or gross neglect, or to replace lost or stolen items.
3. Benefits are not provided for implantable prosthetic components and limbs, exoskeleton prosthetic devices or cosmetic components and coverings for prosthetic devices

## **Patient Selection and Identification**

For patients in whom the potential benefits of the microprocessor knees are uncertain, patients may first be fitted with a standard prosthesis to determine their level of function with the standard device.

The following are guidelines from the Veterans Health Administration Prosthetic Clinical Management Program Clinical Practice Recommendations for Microprocessor Knees.<sup>14</sup>

- A. Contraindications for the use of the microprocessor knee should include the following:
  1. Any condition that prevents socket fitting, such as a complicated wound or intractable pain which precludes socket wear
  2. Inability to tolerate the weight of the prosthesis
  3. Medicare level K0-no ability or potential to ambulate or transfer (See Coding section for full modifier definition)
  4. Medicare level K1-limited ability to transfer or ambulate on level ground at fixed cadence (See Coding section for full modifier definition)
  5. Medicare level K2-limited community ambulator who does not have the cardiovascular reserve, strength, and balance to improve stability in stance to permit increased independence, less risk of falls, and potential to advance to a less restrictive walking device (See Coding section for full modifier definition)
  6. Inability to use swing and stance features of the knee unit
  7. Poor balance or ataxia that limits ambulation
  8. Significant hip flexion contracture (>20°)
  9. Significant deformity of remaining limb that would impair the ability to stride
  10. Limited cardiovascular and/or pulmonary reserve or profound weakness
  11. Limited cognitive ability to understand gait sequencing or care requirements
  12. Long distance or competitive running

13. Falls outside of recommended weight or height guidelines of the manufacturer
  14. Specific environmental factors—such as excessive moisture or dust, or inability to charge the prosthesis
  15. Extremely rural conditions where maintenance ability is limited.
- B. Indications for the use of the microprocessor knee should include the following:
1. Adequate cardiovascular and pulmonary reserve to ambulate at variable cadence
  2. Adequate strength and balance in stride to activate the knee unit
  3. Should not exceed the weight or height restrictions of the device
  4. Adequate cognitive ability to master technology and gait requirements of the device
  5. Hemi-pelvectomy through knee-disarticulation level of amputation, including bilateral; lower-extremity amputees are candidates if they meet functional criteria as listed
  6. The patient is an active walker and requires a device that reduces energy consumption to permit longer distances with less fatigue
  7. Daily activities or job tasks that do not permit full focus of concentration on knee control and stability—such as uneven terrain, ramps, curbs, stairs, repetitive lifting, and/or carrying
  8. Medicare level K3—unlimited community ambulator (See Coding section for full modifier definition)
  9. Medicare level K4—active adult, athlete who needs to function as a K3 level in daily activities (See Coding section for full modifier definition)
  10. Potential to lessen back pain by providing more secure stance control, using less muscle control to keep the knee stable
  11. Potential to unload and decrease stress on remaining limb
  12. Potential to return to an active lifestyle.
- C. Physical and Functional Fitting Criteria for New Amputees:
1. New amputees may be considered if they meet certain criteria as outlined above
  2. Premorbid and current functional assessment important determinant
  3. Requires stable wound and ability to fit the socket
  4. Immediate postoperative fit is possible
  5. Must have potential to return to an active lifestyle

## **RATIONALE**

This evidence review has been updated with searches of the MEDLINE database. The most recent literature update was performed through February 24, 2020.

Evidence reviews assess the clinical evidence to determine whether the use of a technology improves the net health outcome. Broadly defined, health outcomes are length of life, quality of life, and ability to function—including benefits and harms. Every clinical condition has specific outcomes that are important to patients and to managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and

whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of a technology, 2 domains are examined: the relevance and the quality and credibility. To be relevant, studies must represent one or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. Randomized controlled trials are rarely large enough or long enough to capture less common adverse events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

### **Clinical Context and Therapy Purpose**

The purpose of powered prostheses in patients who have transfemoral or tibial amputation is to improve activity and function.

The question addressed in this evidence review is: Does powered prostheses improve the net health outcome in individuals with lower-extremity amputations?

The following PICO was used to select literature to inform this review.

### **Patients**

The relevant population(s) of interest are people with transfemoral or tibial amputation.

### **Interventions**

The therapies being considered are microprocessor-controlled or powered lower-limb prostheses.

### ***Microprocessor-Controlled Prosthetic Knees***

Microprocessor-controlled prosthetic knees have been developed, including the Intelligent Prosthesis (Blatchford); the Adaptive (Endolite); the Rheo Knee® (Össur); the C-Leg®, Genium™ Bionic Prosthetic System, and the X2 and X3 prostheses (Otto Bock Orthopedic Industry); and Seattle Power Knees (3 models include Single Axis, 4-bar, and Fusion, from Seattle Systems). These devices are equipped with a sensor that detects when the knee is in full extension and adjusts the swing phase automatically, permitting a more natural walking pattern of varying speeds. The prosthetist can specify several different optimal adjustments that the computer later selects and applies according to the pace of ambulation. Also, these devices (except the Intelligent Prosthesis) use microprocessor control in both the swing and stance phases of gait. (The C-Leg Compact provides only stance control.) By improving stance control, such devices may provide increased safety, stability, and function. For example, the sensors are designed to recognize a stumble and stiffen the knee, thus avoiding a fall. Other potential benefits of microprocessor-controlled knee prostheses are improved ability to navigate stairs, slopes, and uneven terrain and reduction in energy expenditure and concentration required for ambulation. In 1999, the C-Leg was cleared for marketing by the U.S. Food and Drug Administration (FDA) through the 510(k) process (K991590). Next-generation devices such as the Genium Bionic Prosthetic system and the X2 and X3 prostheses use additional environmental



input (eg, gyroscope and accelerometer) and more sophisticated processing that is intended to create more natural movement. One improvement in function is step-over-step stair and ramp ascent. They also allow the user to walk and run forward and backward. The X3 is a more rugged version of the X2 that can be used in water, sand, and mud. The X2 and X3 were developed by Otto Bock as part of the Military Amputee Research Program.

### ***Powered Knee Prostheses***

The Power Knee™ (Össur), which is designed to replace muscle activity of the quadriceps, uses artificial proprioception with sensors similar to the Proprio Foot to anticipate and respond with the appropriate movement required for the next step.

### ***Microprocessor-Controlled Ankle-Foot Prostheses***

Microprocessor-controlled ankle-foot prostheses are being developed for transtibial amputees. These include the Proprio Foot® (Össur), the iPED (developed by Martin Bionics and licensed to College Park Industries), and the Elan Foot (Endolite). With sensors in the feet that determine the direction and speed of the foot's movement, a microprocessor controls the flexion angle of the ankle, allowing the foot to lift during the swing phase and potentially adjust to changes in force, speed, and terrain during the step phase. This technology is designed to make ambulation more efficient and prevent falls in patients ranging from the young, active amputee to the elderly, diabetic patient. The Proprio Foot® and Elan Foot are microprocessor-controlled foot prostheses that are commercially available at this time and are considered class I devices that are exempt from 510(k) marketing clearance. Information on the Össur website indicates the use of the Proprio Foot® for low- to moderate-impact for transtibial amputees who are classified as level K3 (ie, community ambulatory, with the ability or potential for ambulation with variable cadence).

### ***Powered Ankle-Foot Prostheses***

In development are lower-limb prostheses that also replace muscle activity to bend and straighten the prosthetic joint. For example, the PowerFoot BiOM® (developed at the Massachusetts Institute of Technology and licensed to iWalk) is a myoelectric prosthesis for transtibial amputees that uses muscle activity from the remaining limb for the control of ankle movement. This prosthesis is designed to propel the foot forward as it pushes off the ground during the gait cycle, which in addition to improving efficiency, has the potential to reduce hip and back problems arising from an unnatural gait with use of a passive prosthesis. This technology is limited by the size and the weight required for a motor and batteries in the prosthesis.

## **Comparators**

The relevant comparator is prosthesis with a conventional knee or ankle/foot.

## **Outcomes**

Relevant outcomes for microprocessor-controlled lower-limb prostheses may include the patient's perceptions of subjective improvement attributable to the prosthesis and level of activity or function. Also, the energy costs of walking or gait efficiency may be a more objective measure of the clinical benefit of the microprocessor-controlled prosthesis.

### **Microprocessor-Controlled Knee**

In 2000, the Veterans Administration Technology Assessment Program issued a report on computerized lower-limb prosthesis.<sup>24</sup> This report offered the following observations and conclusions:

- Energy requirements of ambulation (vs requirements with conventional prostheses) are decreased at walking speeds slower or faster than the amputee's customary speed but do not differ significantly at customary speeds.
- Results on the potentially improved ability to negotiate uneven terrain, stairs, or inclines are mixed. Such benefits, however, could be particularly important to meeting existing deficits in the reintegration of amputees to normal living, particularly those related to decreased recreational opportunities.
- Users' perceptions of the microprocessor-controlled prosthesis are favorable. Where such decisions are recorded or reported, most study participants choose not to return to their conventional prosthesis or to keep these only as a back-up to acute problems with the computerized one.
- Users' perceptions may be particularly important for evaluating a lower-limb prosthesis, given the magnitude of the loss involved, along with the associated difficulty of designing and collecting objective measures of recovery or rehabilitation. However resilient the human organism or psyche, loss of a limb is unlikely to be fully compensated. A difference between prostheses sufficient to be perceived as distinctly positive to the amputee may represent the difference between coping and a level of function recognizably closer to the preamputation level.

The primary literature consists of small (sample range, 7-28 patients) within-subject comparisons of microprocessor-controlled with non-microprocessor-controlled prostheses in transfemoral amputees. These studies are described in Tables 1 and 2, divided by the Medicare Functional Level. Medicare Functional Level K2 describes a limited community ambulatory who is able to traverse low barriers such as curbs and walk with a fixed cadence. Medicare Functional Level K3 describes a community ambulatory who is able to traverse most barriers at variable cadence and may have activities beyond basic locomotion, and Medicare Functional Level K4 exceeds basic ambulation skills and includes activities with high impact or stress that would be performed by a child, athlete, or active adult. The C-Leg compact provides stance control only and has been tested primarily in the more limited Medicare Functional Level K2 amputees. The C-Leg, which provides both stance and swing control, has been tested in Medicare Functional Level K3 and K4 amputees, in addition to Medicare Functional Level K2 amputees.

About half of the studies first tested participants with their own non-microprocessor prosthesis followed by an acclimation period and testing with the microprocessor-controlled knee (see Table 1). The other studies used an alternating or randomized order, with more than one test session for each type of prosthesis. Most studies compared performance in laboratory activities and about half also included a period of home use.

Table 1. Within-Subject Study Characteristics of the Microprocessor Knee

Study	Study Location	Country	N	Participants	MPK	NMPK	Home Monitoring
<i>K2 ambulators</i>							
Theevenet al (2011, 2012) <sup>3,4.</sup>	Activity at home and lab-simulated ADLs	Netherlands	28	Functional level K2	C-Leg and C-Leg compact 1-wk acclimation	Own NMPK	1 wk for each prosthesis
Burnfield et al (2012) <sup>5.</sup>	Level and ramp walking	U.S.	10	Functional level K2	C-Leg compact 3-mo acclimation	Own NMPK	
<i>K2 to K3 ambulators</i>							
VA (2006) <sup>6,7,8.</sup>	Lab and home	U.S.	8	Functional level K2 to K3	C-Leg	Hydraulic	1 wk
Hafner and Smith (2009) <sup>9.</sup>	A-B-A-(A or B) design in lab and city sidewalk	U.S.	• 8 K2 • 9 K3	Functional level K2 to K3	Retest in lab with preferred prosthesis	Retest in lab with preferred prosthesis	Prior 4 wk from 4-, 8-, and 12-mo tests
Highsmith et al (2013) <sup>10.</sup>	Ramp		21	Independent community ambulator	C-leg with 3-mo acclimation	Own NMPK	
Howard et al (2018) <sup>11.</sup>	4-wk laboratory sessions for each phase (A-B-A or B-A-B)	U.S.	• 1 K2 • 6 K3	Functional level K2 or K3	Rheo Knee	Own NMPK	PROs for 3 wk prior to use
Hafner et al (2007) <sup>12.</sup>	A-B-A-B design in lab and city sidewalk	U.S.	17	Proficient community ambulator		Own mechanical	
Kaufman et al (2018) <sup>13.</sup>	Free living environment	U.S.	5048 K2	Functional level K2 or K3	One of 4 MPK devices	Own NMPK	Functional measures and PROs 10 wks
<i>K3 to K4 ambulators</i>							
Kaufman et al (2007, 2008) <sup>14,15.</sup>	Lab and home	U.S.	15	Functional level K3 or K4	MPK acclimation of 10-39 wk	Own NMPK	10 d
Johansson (2005) <sup>16.</sup>	Laboratory and 0.25-mile indoor track	U.S.	8	Functional level K3 or K4	10-h acclimation if not owned	10-h acclimation if not owned	

ADLs: activities of daily living; MPK: microprocessor knee; NMPK non-microprocessor knee; PROs: patient-reported outcomes; VA: Veterans Administration.

Results of these studies are described in Table 2 and summarized below:

- In K2 ambulators, the C-Leg and C-Leg compact improved performance on simulated activities of daily living that required balance, for walking on level ground and ramps, and led to a faster time to stand up from a seated position and move forward (Timed Up & Go test). In the single study that measured activity levels at home, use of a microprocessor-controlled knee did not increase objectively measured activity.
- In studies that included K2 to K3 ambulators, use of a microprocessor-controlled knee increased balance, mobility, speed, and distance compared with performance using the

participant’s prosthesis. In studies that included independent or proficient community ambulators, the greatest benefit was for the descent of stairs and hills. Normal walking speed was not increased. In a study that primarily included K2 ambulators there was a reduction in falls demonstrated by the change from baseline while using microprocessor knee and an increase in falls with reversion to non-microprocessor knee.

- In studies that included K3 to K4 ambulators, use of a prosthesis with a microprocessor-controlled knee resulted in a more natural gait, and an increase in activity at home. Participants voiced a strong preference for the microprocessor knee.
- Irrespective of the Medicare Functional Level from K2 to K4, all studies reported that participants preferred the C-Leg or C-Leg compact over their non-microprocessor prosthesis.

Table 2. Outcomes With Microprocessor Knee Prosthesis vs a Non-Microprocessor Knee

Study	Performance	Gait Efficiency	Preference (Self-Report or PEQ)	Activity at Home
<i>K2 ambulators</i>				
Theevenet al (2011, 2012) <sup>3,4</sup>	Improved simulated ADLs for activities requiring balance		<ul style="list-style-type: none"> <li>• Subjective benefit on PEQ</li> <li>• No preference for C-leg over C-leg compact</li> </ul>	No difference in objectively measured activity level
Burnfield et al (2012) <sup>5</sup>	Improved walking on level ground, ramps, and faster TUG (17.7 s vs 24.5 s)		<ul style="list-style-type: none"> <li>• PEQ</li> <li>• All wanted to keep the C-Leg compact</li> </ul>	
<i>K2 to K3 ambulators</i>				
VA (2006) <sup>6,7,8</sup>		Marginally improved	7 of 8 participants preferred the MPK	No difference
Hafner and Smith (2009) <sup>9</sup>	Improved mobility and speed			Decrease in self-reported stumbles and falls
Highsmith et al (2013) <sup>10</sup>	Improved hill descent time (6.0 s vs 7.7 s) and HAI			
Howard et al. (2018) <sup>11</sup>	Improved 6MWT, BBS, and AMP, but inconsistent for normal walking speed and L test	Improved Physiological Cost Index	<ul style="list-style-type: none"> <li>• Preference for MPK in 6 of 7 participants</li> <li>• PEQ superior in 5 of 7</li> </ul>	
Hafner et al (2007) <sup>12</sup>	Improved for descent of stairs and hills only		Subjective improvement with MPK	
Kaufman et al (2018) <sup>13</sup>	Reduction in falls			Subjective improvement in PEQ satisfaction with MPK
<i>K3 to K4 ambulators</i>				
Kaufman et al (2007, 2008) <sup>14,15</sup>	More natural gait	No significant difference	Preferred MPK	Increased
Johansson (2005) <sup>16</sup>	More natural gait and decrease in hip work	Oxygen consumption reduced for Rheo but not C-Leg	Preferred MPK	

ADL: activity of daily living; AMP: amputee mobility predictor; BBS: Berg Balance Scale; HAI: Hill Assessment Index; MPK: microprocessor knee; NMPK non-microprocessor knee; PEQ: Prosthesis Evaluation Questionnaire; 6MWT: 6-minute walk test; TUG: Timed Up & Go; VA: Veterans Administration.

### **Section Summary: Microprocessor-Controlled Knee**

The literature consists of a number of small within-subject comparisons of microprocessor-controlled knees with non-microprocessor-controlled knee joints. Studies of prostheses with microprocessor knees in Medicare Functional Level K3 and K4 amputees have shown objective improvements in function on some outcome measures and strong patient preference for the microprocessor-controlled prosthetic knees. Only 1 biomechanical study of the next-generation Genium prosthesis was identified. One small study found little difference in performance between the Rheo Knee II and the user's own non-microprocessor-controlled knee.

### **Powered Knee Prostheses**

We did not identify any literature on powered knee prostheses.

### **Microprocessor-Controlled Ankle-Foot Prostheses**

A Cochrane review by Hofstad et al (2004), which evaluated ankle-foot prostheses, concluded that there was insufficient evidence from high-quality comparative studies for an overall superiority of any individual type of prosthetic ankle-foot mechanism.<sup>17</sup> Also, reviewers noted that most clinical studies on human walking have used standardized gait assessment protocols (eg, treadmills) with limited "ecological validity," and recommended that for future research, functional outcomes be assessed for various aspects of mobility such as making transfers, maintaining balance, level walking, stair climbing, negotiating ramps and obstacles, and changes in walking speed.

### **Proprio Foot**

Gait analysis with the Proprio Foot was evaluated in 16 transtibial K3-K4 amputees during stair and ramp ascent and descent.<sup>18,19</sup> Results with the adaptive ankle (allowing 4° of dorsiflexion) were compared with tests conducted with the same prosthesis but at a fixed neutral angle (similar to other prostheses) and with results from 16 healthy controls. Adaptive dorsiflexion was found to increase during the gait analysis; however, this had a modest impact on other measures of gait for either the involved or uninvolved limb, with only a "tendency" to be closer to the controls, and the patient's speed was not improved by the adapted ankle. The authors noted that an adaptation angle of 4° in the stair mode is small compared with physiologic ankle angles, and the lack of power generation with this quasi-passive design may also limit its clinical benefit. For walking up and down a ramp, the adapted mode resulted in a more normal gait during ramp ascent, but not during ramp descent. Some patients reported feeling safer with the plantar flexed ankle (adaptive mode) during ramp descent. Another small within-subject study (2014; n=6) found no benefit of an active Proprio Foot compared with the same prosthesis turned off with level walking or with slope ascent or descent.<sup>20</sup>

Self-reported and objective performance outcomes for 4 types of prosthetic feet, including the Proprio Foot, were evaluated in a randomized within-subject crossover study reported by Gailey et al (2012).<sup>21</sup> Ten patients with transtibial amputation were initially tested with their prosthesis and tested again following training and a 2-week acclimation period with the SACH (solid ankle cushion heel), SAFE (stationary attachment flexible endoskeletal), Talux, and Proprio Foot in a randomized order. No differences between prostheses were detected by the self-reported Prosthesis Evaluation Questionnaire and Locomotor Capabilities Index, or for the objective 6-minute walk test. Steps per day and hours of daily activity between testing sessions did not differ by type of prosthesis.

In another study by Delussu et al (2013) found a lower energy cost of floor walking with the Proprio Foot compared with a dynamic carbon fiber foot in 10 transtibial amputees.<sup>22</sup> However, the study found no significant benefit for walking stairs or ramps, for the Timed Up & Go test, or for perceived mobility or walking ability.

### **Section Summary: Microprocessor-Controlled Ankle-Foot Prostheses**

Several small studies have been reported with microprocessor-controlled prostheses for transtibial amputees. Larger, higher quality studies are needed to determine the impact of these devices on health outcomes with greater certainty.

### **Powered Ankle-Foot Prostheses**

#### ***PowerFoot BiOM***

Au et al (2008) reported on the design and development of the powered ankle-foot prosthesis (PowerFoot BiOM); however, clinical evaluation of the prototype was performed in a single patient.<sup>23</sup>

Ferris et al (2012) reported on a pre-post comparison of the PowerFoot BiOM with the patient's own energy-storing and energy returning foot in 11 patients with transtibial amputation. Results for both prostheses were also compared with 11 matched controls who had intact limbs.<sup>24</sup> In addition to altering biomechanical measures, the powered ankle-foot increased walking velocity compared with the energy-storing and energy returning prosthesis and increased step length compared with the intact limb. There appeared to be an increase in compensatory strategies at proximal joints with the PowerFoot; the authors noted that normalization of gait kinematics and kinetics might not be possible with a uniarticular device. Physical performance measures did not differ significantly between the prostheses, and there were no significant differences between conditions on the Prosthesis Evaluation Questionnaire. Seven patients preferred the PowerFoot and 4 preferred the energy-storing and energy returning. Compared with controls with intact limbs, the PowerFoot had reduced range of motion but provided greater ankle peak power.

In another similar, small pre-post study (7 amputees, 7 controls), Herr and Grabowski (2012) found gross metabolic cost and preferred walking speed to be more similar to nonamputee controls with the PowerFoot BiOM than with the patient's own energy-storing and energy returning.<sup>25</sup>

In a conference proceeding, Mancinelli et al (2011) described a comparison of a passive-elastic foot and the PowerFoot BiOM in 5 transtibial amputees.<sup>26</sup> The study was supported by the U.S. Department of Defense, and, at the time of testing, the powered prosthesis was a prototype and subjects' exposure to the prosthesis was limited to the laboratory. Laboratory assessment of gait biomechanics showed an average increase of 54% in the peak ankle power generation during late stance. Metabolic cost, measured by oxygen consumption while walking on an indoor track, was reduced by an average of 8.4% ( $p=0.06$ ).

### **Section Summary: Powered Ankle-Foot Prostheses**

Several small studies have been reported with powered ankle-foot prostheses for transtibial amputees.

**Practice Guidelines and Position Statements**

The Veteran’s Affairs Prosthetic and Sensory Aids Strategic Healthcare Group established a Prosthetic Clinical Management Program to coordinate the development of clinical practice recommendations for prosthetic prescriptive practices.<sup>1</sup> A subgroup of the Pre-Post National Amputation Workgroup met in 2004 to define the patient selection and identification criteria for microprocessor prosthetic knees. Their proposal was based on recommendations arising from the 2003 Microprocessor Prosthetic Knee Forum.

**Veterans Affairs/Department of Defense Clinical Practice Guideline for Rehabilitation of Individuals with Lower Limb Amputation**

In 2019, the Veterans Affairs/Department of Defense Clinical Practice Guideline for Rehabilitation of Individuals with Lower Limb Amputation made the following recommendations:<sup>27</sup>

"We suggest offering microprocessor knee units over non-microprocessor knee units for ambulation to reduce risk of falls and maximize patient satisfaction. There is insufficient evidence to recommend for or against any particular socket design, prosthetic foot categories, and suspensions and interfaces. (From Table 3. Clinical practice guideline evidence-based recommendations and evidence strength)."

**U.S. Preventive Services Task Force Recommendations**

Not applicable.

**Ongoing and Unpublished Clinical Trials**

Some currently unpublished trials that might influence this review are listed in Table 3.

Table 3. Summary of Key Trials

<b>NCT No.</b>	<b>Trial Name</b>	<b>Planned Enrollment</b>	<b>Completion Date</b>
<i>Ongoing</i>			
NCT03204513	Impact of Powered Knee-Ankle Prosthesis Leg on Everyday Community Mobility and Social Interaction	15	Apr 2021
<i>Unpublished</i>			
NCT02864693	Comparative Effectiveness of Microprocessor Controlled and Carbon Fiber Energy Storing and Returning Prosthetic Feet in Persons With Unilateral Transtibial Amputation	30	Apr 2018 (Results submitted, pending quality control review)

NCT: national clinical trial.

## **CODING**

**The following codes for treatment and procedures applicable to this policy are included below for informational purposes. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.**

### CPT/HCPCS

- K1014 Addition, endoskeletal knee-shin system, 4 bar linkage or multiaxial, fluid swing and stance phase control
- L5856 Addition to lower extremity prosthesis, endoskeletal knee-shin system, microprocessor control feature, swing and stance phase, includes electronic sensor(s), any type
- L5857 Addition to lower extremity prosthesis, endoskeletal knee-shin system, microprocessor control feature, swing phase only, includes electronic sensor(s), any type
- L5858 Addition to lower extremity prosthesis, endoskeletal knee skin system, microprocessor control feature, stance phase only, includes electronic sensor(s), any type.
- L5859 Addition to lower extremity prosthesis, endoskeletal knee-shin system, powered and programmable flexion/extension assist control, includes any type motor(s)
- L5969 Addition, endoskeletal ankle-foot or ankle system, power assist, includes any type motor(s)
- L5973 Endoskeletal ankle foot system, microprocessor controlled feature, dorsiflexion and/or plantar flexion control, includes power source.

### MODIFIERS

- K0 Lower extremity prosthesis functional level 0 - does not have the ability or potential to ambulate or transfer safely with or without assistance and a prosthesis does not enhance their quality of life or mobility
- K1 Lower extremity prosthesis functional level 1 - has the ability or potential to use a prosthesis for transfers or ambulation on level surfaces at fixed cadence. typical of the limited and unlimited household ambulator
- K2 Lower extremity prosthesis functional level 2 - has the ability or potential for ambulation with the ability to traverse low level environmental barriers such as curbs, stairs or uneven surfaces. typical of the limited community ambulator
- K3 Lower extremity prosthesis functional level 3 - has the ability or potential for ambulation with variable cadence, typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion
- K4 Lower extremity prosthesis functional level 4 - has the ability or potential for prosthetic ambulation that exceeds the basic ambulation skills, exhibiting high impact, stress, or energy levels, typical of the prosthetic demands of the child, active adult, or athlete



**ICD-10 Diagnoses**

- S78.011A Complete traumatic amputation at right hip joint, initial encounter
- S78.011D Complete traumatic amputation at right hip joint, subsequent encounter
- S78.011S Complete traumatic amputation at right hip joint, sequela
- S78.012A Complete traumatic amputation at left hip joint, initial encounter
- S78.012D Complete traumatic amputation at left hip joint, subsequent encounter
- S78.012S Complete traumatic amputation at left hip joint, sequela
- S78.111A Complete traumatic amputation at level between right hip and knee, initial encounter
- S78.111D Complete traumatic amputation at level between right hip and knee, subsequent encounter
- S78.111S Complete traumatic amputation at level between right hip and knee, sequela
- S78.112A Complete traumatic amputation at level between left hip and knee, initial encounter
- S78.112D Complete traumatic amputation at level between left hip and knee, subsequent encounter
- S78.112S Complete traumatic amputation at level between left hip and knee, sequela
- S88.011A Complete traumatic amputation at knee level, right lower leg, initial encounter
- S88.011D Complete traumatic amputation at knee level, right lower leg, subsequent encounter
- S88.011S Complete traumatic amputation at knee level, right lower leg, sequela
- S88.012A Complete traumatic amputation at knee level, left lower leg, initial encounter
- S88.012D Complete traumatic amputation at knee level, left lower leg, subsequent encounter
- S88.012S Complete traumatic amputation at knee level, left lower leg, sequela
- S98.011A Complete traumatic amputation of right foot at ankle level, initial encounter
- S98.011D Complete traumatic amputation of right foot at ankle level, subsequent encounter
- S98.011S Complete traumatic amputation of right foot at ankle level, sequela
- S98.012A Complete traumatic amputation of left foot at ankle level, initial encounter
- S98.012D Complete traumatic amputation of left foot at ankle level, subsequent encounter
- S98.012S Complete traumatic amputation of left foot at ankle level, sequela

**REVISIONS**

01-01-2021	Policy published 11-03-2020. Policy effective 01-01-2021.
04-01-2021	Added HCPCS code K1014

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