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Prosthetic Gait Training in Individuals with Pathologic Conditions on the Non-Amputated Side: A Case Series

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Introduction

In general, the functional goal is determined to be lower compared to a case of sound conditions on the non-amputated side by considering the difficulty of supporting weight sufficiently on the non-amputated side, safety of walking, proprioception, and strength. However, previous studies have not reported whether a better outcome could be achieved if the dominant leg was the amputation site. Here in this case series, we present seven complicated amputee cases who had accompanying injuries on the non-amputated legs. We individualized rehabilitation strategies we proceeded. Through this report, we would like to introduce individualized rehabilitation strategies than can be applied to those complicated amputee cases.

Methods and Materials

Among patients who visited our institution between January 2011 and March 2023, seven patients with amputation and pathological conditions on the non-amputation side were enrolled (Table 1). The average age of the patients was 52.4 years (standard deviation 20.2).

Subject	Sex	Age	Diagnosis	Etiology	K level	Concurrent pathologic conditions	Prosthetic components
1	Male	33	Right transfemoral amputation	Trauma	K3	Left. femur shaft fracture Left 1st to 4th metatarsal fracture	Quadrilateral socket Pelvic belt Polycentric pneumatic control knee Dynamic response foot
2	Male	20	Left transfemoral amputation	Trauma	K3	Right fibular fracture Right sciatic nerve injury	Quadrilateral socket Pelvic belt Polycentric hydraulic control knee Dynamic response foot
3	Male	64	Right transfemoral amputation	Trauma	K3	Left tibio-fibular fracture Left femur neck fracture Left common peroneal nerve injury	Quadrilateral socket Pelvic belt Polycentric pneumatic control knee Dynamic response foot
4	Male	41	Left transfemoral amputation	Trauma	K3	Both femur fractures Right tibio-fibular fracture Right sciatic nerve injury	Quadrilateral socket Pelvic belt Polycentric hydraulic control knee Dynamic response foot
5	Male	72	Right transtibial amputation	Trauma	K2	Left proximal tibio-fibular fracture Left femur medial condyle fracture	PTB socket Silicone liner Dynamic SACH foot (flexible keel)
6	Female	71	Left knee disarticulation	Osteosarcoma	K2	Right knee osteoarthritis	End bearing total contact socket Polycentric pneumatic control knee Dynamic SACH foot (flexible keel)
7	Male	59	Right transtibial amputation	Necrotizing fasciitis	K1	Left hemiplegia due to right middle cerebral artery infarction	PTB socket Silicone liner SACH foot

Table 1. Clinical characteristics and prosthetic components of each participant

For each participant, aerobic exercise, manual stretching, strengthening exercises, back extensor strengthening exercise was performed. For participants with peripheral nerve injuries, electrical stimulation therapy was performed to involved muscles. Following fabrication of the prosthesis, standing training was initiated using either parallel bars or a tilt table. Tilt-table standing was initiated to promote safe bone union in case the lower limb fracture had not healed. Upon radiological confirmation of gradual bone union, parallel bars were used for standing training. Gait training using an assistive device was initiated when the gait pattern was sufficiently maintained on the parallel bars and endurance was obtained. Subsequently, advanced gait training was conducted based on the functional goals (Figure 1).

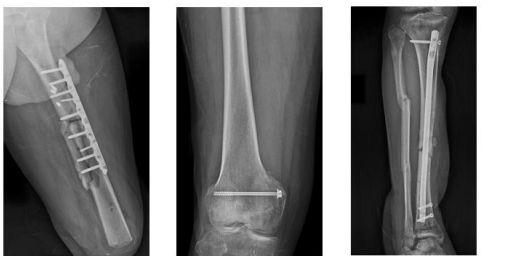
	Pre-gait	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
1		Parallel bar standing		Parallel bar gait	Bilateral crutch		Unilateral crutch	Unilateral cane	Advanced gait
2		Parallel bar standing		Parallel bar gait	Bilateral crutch		Unilateral crutch		Advanced gait
3	Tilt table standing	Parallel bar standing	Parallel bar gait	Bilateral crutch				Advanced gait	
4	Tilt table standing	Parallel bar standing	*Further follow-up is required.*						
5	Tilt table standing	Parallel bar standing		Parallel bar gait		Bilateral crutch		Bilateral cane	Advanced gait
6		Parallel bar standing		Parallel bar gait	Anterior walker	Bilateral cane			
7		Parallel bar standing		Parallel bar gait		Unilateral cane			

Figure 1. Progress of prosthetic gait training of each participant

Case Description

Case 4

The 44-year-old male patient underwent a left transfemoral amputation due to a car accident in May 2022. Internal fixation of both femurs and right tibia were performed. Right sciatic nerve injury was also accompanied after the accident. He stayed in bed ridden status until he was admitted to our center in February 2023. On the admission, the plain films showed complete union of right femur but non-union of left residual femur and right tibia (Figure 2).
To promote early standing and bone union, reoperation was performed to provide stability by replacing the metal plate and inserting an intramedullary nail on the left femur (Figure 3). Further, pin on the right femur was removed in case of breakage while standing by PTB orthosis on the right side. Strengthening exercise and electrical stimulation therapy for right side were also paralleled. After 1 week from the reoperation, tilt-table standing followed by parallel bar standing was initiated. After 1 month, we plan to remove the right orthosis and start gait training, if the bone union is confirmed on the plain films.



(a) (b) (c)

Figure 2. The plain film image showing non-union of left femur fracture, which was taken 10 months after initial injury; (b) The plain film showing union of right femur fracture; (c) The plain film images of right tibia and fibula fractures.

(a) (b)

Figure 3. The plain film image of left femur after revision operation; (b) The plain film image of right femur after screw removal.

Case 5

The 72-year-old male patient underwent a right transtibial amputation due to a crush injury in 2013. Internal fixations were performed for the left proximal tibiofibular and left femoral medial condyle fractures. At the time of admission, fractures of the left femur and tibia were non-union status. (Figure 4) In December 2013, for the purpose of early standing and bone union facilitation through weight bearing, prosthesis was applied to right side and knee-ankle-foot-orthosis with ischial seat was applied to left side. The height of the prosthesis was adjusted such that both legs were of the same length. After 4 months of tilt-table standing exercises, bone union was observed by radiography, and gait training was initiated. The K-level was determined as K2, and the amputated leg was considered as the dominant leg. After 7 weeks of gait training, he was discharged.

(a) (b)

Figure 4. The plain film image of left tibio-fibular fracture and medial condylar fracture after surgery; (b) Bone union is noted on the follow-up plain film image.

Conclusions

Functional outcomes could be achieved in individuals with leg amputation who have pathologic conditions on the non-amputated side by comprehensive and individualized rehabilitation therapy. For patients with multiple problems besides the amputated leg, it is important to establish active treatment goals and appropriate rehabilitation strategies