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**Trunk Control and Standing Tolerance of a Patient with Paraparesis as  
a Result of Transverse Myelitis and Mycotic Aneurysm Rupture:  
A Case Report**

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The patient signed an informed consent allowing the use of medical information and photographs for this case report and received information on the institution’s policies regarding the Health Insurance Portability and Accountability Act.

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24 **Abstract**

25 **Background and Purpose:** Transverse myelitis (TM) is a rare condition in which the spinal  
26 cord becomes inflamed resulting in pain, paraparesis or paraplegia, impaired sensation, and/or  
27 impaired autonomic function. Approximately two-thirds recover with mild to moderate  
28 symptoms, but one-third are left with severe and disabling symptoms. Cerebral mycotic  
29 aneurysm (CMA) rupture is a brain injury due to a burst artery resulting in diminished blood  
30 supply to the brain. There is literature on beneficial physical therapy (PT) intervention  
31 progressions following brain injury, such as bed mobility strategies and pre-gait activities, but  
32 there is little published on PT for impairments as a result of concurrent TM and CMA ruptures.  
33 The purpose of this case report was to describe the PT interventions provided to a patient with  
34 paraparesis as a result of TM and multiple CMA ruptures to progress toward achieving his goals  
35 of standing and ambulating with a standard walker and bilateral knee-ankle-foot-orthoses  
36 (KAFOs).

37 **Case Description:** The 28-year-old male patient had been seen for two years at an outpatient  
38 clinic with an accredited brain injury program. The patient encountered several barriers  
39 throughout his rehabilitation, such as repairs to his KAFOs and low bone mineral density, which  
40 resulted in a decrease in standing tolerance over time.

41 **Outcomes:** The Brain Injury Assessment Tool (BIAT) and manual muscle testing were used to  
42 document changes throughout the patient's period of care. No significant changes were observed.

43 **Discussion:** This patient, despite minimal improvements over a two-year period, may have the  
44 potential to increase his trunk control and standing tolerance if he has an extended period of time  
45 with no barriers to his rehabilitation.

46 **Manuscript Word Count:** 3,453 words

47 **Background and Purpose**

48 Transverse myelitis (TM), also known as pan myelitis, is a condition where a segment of  
49 the spinal cord becomes inflamed and causes a variety of symptoms such as paraplegia,  
50 paraparesis, pain, diminished sensation, and urinary and bowel incontinence below the level of  
51 the inflamed segment.<sup>1</sup> It can occur insidiously, or following a viral or bacterial infection, and  
52 most commonly occurs in the mid-thoracic region in adults.<sup>1,2</sup> The peak incidence, regardless of  
53 gender or race, is 10-19 and 30-39 years old with approximately 1,400 new cases diagnosed in  
54 the United States each year.<sup>1</sup> Though there is currently no cure for TM, it is commonly treated  
55 with steroidal anti-inflammatory medications to decrease the inflammation in the spinal cord.<sup>3</sup>  
56 Only one-third of patients achieve a full recovery, which may take at least two years. Incomplete  
57 recovery, or no recovery, is more likely if there is no improvement within the first three to six  
58 months.<sup>1</sup>

59 A cerebral mycotic aneurysm (CMA), a form of stroke, occurs when a bacterial infection  
60 of a cerebral artery causes it to dilate, forming an aneurysm.<sup>4</sup> This added pressure on the arterial  
61 wall increases the risk that it will rupture, which would create an intracranial bleed and deplete  
62 the brain of oxygen. Mycotic aneurysms can occur in any artery throughout the body and are  
63 very rare, occurring only in 0.7% to 4.0% of people who have a cerebral aneurysm.<sup>5</sup> In those  
64 with a non-mycotic cerebral aneurysm, 46.5% to 76% reported decreased physical capacity.<sup>6,7</sup>  
65 Treatment ranges from intravenous antibiotics for small, intact aneurysms, to surgery and  
66 vascular repair for large or ruptured aneurysms.<sup>5</sup> Recovery and residual deficits range from no  
67 impairments to death and are dependent on the patient, location of the aneurysm, and the  
68 portion(s) of the brain affected.

69           There are many interventions available to help patients with deficits related to stroke.  
70 Schmitz<sup>8</sup> and O’Sullivan<sup>9</sup> describe interventions and progressions to improve trunk control, bed  
71 mobility, and sitting balance in *Improving Functional Outcomes in Physical Rehabilitation*. They  
72 state that these exercises and progressions are appropriate for patients who have spasticity or  
73 rigidity, spinal cord injury, and for those who are recovering from a stroke or traumatic brain  
74 injury to assist in maximizing their independence with activities of daily living and prepare for  
75 more complex skills.<sup>8</sup>

76           This patient was selected as the subject for this case report because of his rare  
77 combination of TM with subsequent multiple CMAs and multiple CMA ruptures. Though there  
78 have been studies published on the medical management of TM<sup>3</sup> and CMAs,<sup>5</sup> little has been  
79 published on the physical therapy (PT) management of the resulting chronic impairments of  
80 these conditions. Thus, the purpose of this case report is to describe the PT management of a  
81 patient with paraparesis secondary to TM and multiple CMAs.

82

### 83 **Case Description: Patient History and Systems Review**

84           The patient signed a consent form to allow this author to participate in his treatment, as  
85 well as a consent form to allow for his medical information and photographs to be used for this  
86 case report. This patient was a 28-year-old male with a history of TM, aseptic meningitis, and  
87 mycotic aneurysms of the right middle cerebral artery, distal left middle cerebral artery,  
88 lenticulostriate artery, right posterior cerebral artery, right superior cerebellar artery affecting the  
89 right caudate head, anterior right putamen and anterior limb, and right internal capsule. The  
90 patient’s co-morbidities included obesity and osteoporosis, theorized to be associated with long-  
91 term prescribed corticosteroid use and prolonged periods of non-weight bearing. The patient had

92 been seen for the previous six years at an outpatient rehabilitation facility and was then referred  
93 to Maine Center for Integrated Rehabilitation (MCIR) to receive services through the Acquired  
94 Brain Injury (ABI) program for continued PT services to improve standing tolerance, increase  
95 strength and range of motion (ROM), and pain management. The patient's chief complaints were  
96 low back pain, right knee pain, and difficulty standing and ambulating with bilateral locking  
97 knee-ankle-foot orthoses\* (KAFOs). The patient's goals were to stand and ambulate with a  
98 standard walker with bilateral locking KAFOs donned. The patient also received speech therapy  
99 (ST), occupational therapy (OT), and recreation therapy (RT) at MCIR. This author first met the  
100 patient approximately a year and a half into his treatment at MCIR. See Appendices 1 and 2 for  
101 information gathered from the patient history and systems review performed at the initial  
102 evaluation and at the final session with this author.

103

#### 104 **Clinical Impression 1**

105 The patient presented eight years post-onset of impairments related to TM and multiple  
106 CMAs and CMA ruptures. There were no other differential diagnoses secondary to the chronicity  
107 of his condition. Following a patient history and systems review by this author, it was expected  
108 that the patient would present with deficits in bilateral lower extremity (BLE) ROM, strength,  
109 coordination, sensation, proprioception, difficulty with transfers and gait, and pain. Additional  
110 tests and measures to assess these areas included goniometric measurements, manual muscle  
111 testing (MMT), coordination assessment, light touch sensation, dynamic sitting balance, the  
112 numeric pain scale, and the Brain Injury Assessment Tool (BIAT).

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\* Townsend Design Custom Knee Ankle Foot Orthoses: Townsend Design, 4615 Shepard St, Bakersfield, CA 93313

113           The patient was a good candidate for this case report because of the paucity of literature  
114 on the PT management of individuals with chronic impairments related to TM and multiple  
115 CMAs.

116

### 117 **Examination: Tests and Measures**

118           Following a thorough patient history, an objective examination was performed as  
119 outlined by White<sup>10</sup> in *Physical Rehabilitation*. See Table 1 for the results of all tests and  
120 measures at admission and at the final session documented in this case report.

121           ROM values were obtained using a universal goniometer and adhering to methods as  
122 described by Norkin and White.<sup>11</sup> The bilateral upper extremities (BUE) were grossly within  
123 functional limits. Measurements were taken for the patient's bilateral passive hip straight leg  
124 raise and bilateral passive ankle dorsiflexion, plantarflexion, inversion, and eversion. Research  
125 has shown that goniometric measurements at the hip and at the ankle have fair to excellent  
126 intrarater and interrater reliability and validity.<sup>12-14</sup>

127           Muscle strength was assessed through MMT as described by Kendall et al<sup>15</sup> with grades  
128 from zero, no movement or muscle contraction, to five, the patient can hold the test position  
129 against strong pressure and against gravity.<sup>15</sup> MMT has been found to have good to excellent  
130 intrarater and interrater reliability as well as good validity.<sup>16</sup>

131           Coordination was assessed via rapid alternating movements (RAMs) of pronation and  
132 supination, and finger to nose coordination, as described by Gutman et al.<sup>17</sup> The coordination of  
133 the lower extremity (LE) was not assessed secondary to paraparesis. Scoring finger to nose  
134 coordination has been reported to have fair intrarater reliability and poor interrater reliability in  
135 the presence of tremor or dysmetria, although it has high reliability when clinicians report the

136 time it takes the patient to complete the test.<sup>18</sup> A study by Dittiger et al<sup>19</sup> found larger amplitude  
137 RAMs to be a reliable and valid measure of coordination. This case report used small amplitude  
138 RAMs of forearm pronation and supination, but the results of Dittiger's study may be applicable  
139 to this case report.

140 Light touch sensation was assessed as described by Schmitz<sup>20</sup> in *Physical Rehabilitation*.  
141 Schmitz states that there is little evidence to support the use of sensory tests in clinical practice  
142 secondary to the inability to correctly measure the test results.<sup>20</sup> Utilizing consistent methods and  
143 having the same skilled clinician perform the assessment each time will improve the reliability  
144 and validity of this assessment tool.<sup>20</sup>

145 Proprioception was examined through assessing the patient's dynamic sitting balance as  
146 described by O'Sullivan<sup>21</sup> in *Physical Rehabilitation*. The patient did not have his bilateral  
147 KAFOs with him on the initial examination, so standing balance was unable to be assessed.  
148 Dynamic sitting balance was assessed with the patient unsupported at the edge of the mat and he  
149 was asked to weight shift and reach outside of his base of support. This author was unable to  
150 locate studies reporting on the reliability and validity of this assessment method.

151 The numeric pain scale, where zero indicates no pain and ten indicates the most severe  
152 pain possible, was used as a means for the patient to quantify his pain from session to session. In  
153 healthy populations, it has been shown to have 100% interrater reliability and excellent  
154 concurrent validity when compared to the numeric pain rating scale (NPRS).<sup>22</sup>

155 The Brain Injury Assessment Tool (BIAT) is the standard outcome measure used for ABI  
156 programs under MaineCare insurance.<sup>23</sup> It is adapted from the Mayo-Portland Adaptability  
157 Inventory-4 (MPAI-4) and has six sections, each with three to ten subsections.<sup>23</sup> Each subsection  
158 is rated on a five point scale where zero indicates no problem and four indicates a severe



159 problem that interferes with activity more than 75% of the time. No research was found on the  
160 reliability or validity of the BIAT.<sup>24</sup> See Table 2 for the patient's BIAT scores at the initial  
161 evaluation and the final session of this case report.

162

## 163 **Clinical Impression 2**

164 The examination revealed decreased BLE active ROM, strength, and impaired light touch  
165 discrimination with left deficits greater than right. This was consistent with the initial impression  
166 of paraparesis secondary to TM with subsequent CMAs and CMA ruptures. The patient  
167 continued to be seen for PT intervention as there was no need for further testing or referral at that  
168 time. The patient continued to be appropriate for this case report as he continued to demonstrate  
169 a need for PT services. The plan for intervention included BLE strengthening, standing and  
170 ambulation within the parallel bars with bilateral locking KAFOs donned, and improving trunk  
171 control, balance, and coordination. The patient was routinely re-evaluated every six months to  
172 assess progress towards goals and achievement of outcomes.

173 The patient's medical diagnoses and associated ICD-9 codes were stroke, 436.0,  
174 idiopathic transverse myelitis, 341.22, and mycotic brain aneurysm, 421.0. The patient's PT  
175 diagnosis was paraplegia, 344.1. The patient's prognosis for improvement with PT was guarded  
176 due to the time since initial injury, co-morbidities, and the mechanism of injury that resulted in  
177 his impairments. The majority of motor recovery occurs up to two years post injury and this  
178 patient was eight years post injury.<sup>1</sup> His obesity was a barrier to the patient achieving his goals  
179 and outcomes secondary to the amount of stress that was placed on his cardiovascular and  
180 pulmonary systems, as well as the additional weight he had to manage when performing

181 transfers, bed mobility, and standing and ambulation tasks. Appropriate short and long term  
182 goals were established (see Appendix 3) and updated every six months.

183

#### 184 **Interventions**

185         The patient received PT, RT, OT, and ST at MCIR where all four disciplines  
186 communicated regularly to address the patient’s impulsivity, safety awareness, and ability to  
187 toilet and transfer independently. The patient communicated with PT in regards to his regular  
188 appointments with his primary care physician to assess his bone mineral density. PT coordinated  
189 with a local wheelchair provider about modifications and repairs the patient needed on his  
190 wheelchair, as well as with the patient’s orthotist about repairs to his KAFOs. Daily therapy  
191 sessions were documented at the end of each day. The patient’s case was reviewed with the  
192 therapy team once a month to reassess progress towards goals and any changes in the patient’s  
193 status. Goals were updated at least every six months.

194         The patient related instruction included verbal instructions from PT regarding his  
195 impulsivity, safety awareness, and written instructions on his home exercise program. Once the  
196 patient received his KAFOs, he was instructed to continue standing at home in his body weight  
197 support system within the parallel bars to improve his standing tolerance.

198         Procedural interventions and a plan of care were developed following a thorough initial  
199 examination. Decisions were based on clinical judgment and evidence-based research to address  
200 his impairments and improve both his activity limitations and participation restrictions.

201 Unfortunately, at the time of his initial evaluation, he was six years post-onset of symptoms and,  
202 at the time of this case report, he was almost eight years post-onset. The chronicity of his  
203 symptoms, in addition to many barriers throughout his rehabilitation at MCIR, proved to be

204 significant in regards to his minimal improvements and subsequent lack of exercise progression  
205 since his start of care (SOC). Tables 3 and 4 describe the exercises he participated in throughout  
206 his PT sessions during this case report period and the description and parameters for each  
207 exercise. Appendix 4 provides the exercises the patient has participated in with PT since his SOC  
208 at MCIR.

209 Schmitz<sup>8</sup> describes different methods and exercises to improve rolling in patients who  
210 have trunk weakness. One of the approaches included having the patient clasp both arms out in  
211 front of him and use the momentum of swinging his arms to either side to initiate a roll. This  
212 method was an effective approach for this patient to achieve more independence with bed  
213 mobility, though he still required occasional minimal assistance with BLE management. Also  
214 discussed were exercises to improve trunk control including prone on elbows and quadruped  
215 progressions. According to Schmitz<sup>8</sup>, the prone on elbows and quadruped exercises are effective  
216 to prepare for sitting and standing through gains in stability and static control of the head, trunk,  
217 shoulders, and hips. These exercises and their progressions, such as rhythmic initiation, unilateral  
218 reaching, and weight shifting, were beneficial to this patient in increasing his trunk control,  
219 upper extremity stability, and control of his bilateral hips.

220 O'Sullivan<sup>9</sup> provides a progression of sitting balance exercises to improve static and  
221 dynamic sitting balance for patients who have impairments in postural control, such as sitting  
222 unsupported at the edge of a mat, reaching outside of the base of support, and altering the sitting  
223 surface. This patient presented with impaired dynamic sitting balance and poor posture in sitting  
224 at the edge of the mat, which indicated that these exercises and their progressions may be  
225 beneficial in improving those impairments.

226           The patient utilized Russian electrical stimulation (e-stim) in order to improve bilateral  
227 quadriceps strength. Vitenzon et al<sup>25</sup> discusses the use of neuromuscular e-stim, which includes  
228 Russian e-stim, with different neurological patient populations to improve muscle strength. The  
229 authors found that the amount of improvement in muscular strength was dependent on the level  
230 of the initial injury. Though the patient populations assessed in this study differ from this  
231 patient’s diagnoses, the clinical implication that there may be limited benefit of using Russian e-  
232 stim due to his level of injury was still applicable. See Figure 1A, which depicts the patient set-  
233 up with Russian e-stim.

234           The WalkAide<sup>†</sup> was utilized to help activate the patient’s tibialis anterior and peroneal  
235 muscle group, as well as to help maintain gastrocnemius and soleus extensibility and ankle  
236 ROM. The WalkAide is typically used in ambulating patients with foot drop, but one study  
237 found that it improved ankle ROM and strength, as well as decreased gastrocnemius spasticity.<sup>26</sup>  
238 Despite this study being performed with ambulatory children with cerebral palsy, the results may  
239 still be applicable for this patient given the shared impairments between the two populations.

240           The patient also performed various core strengthening exercises, such as abdominal curls  
241 in supine with a weighted three-kilogram ball, and quadriceps strengthening exercises, such as  
242 short arc and long arc quads. These exercises were chosen based on clinical judgment and  
243 experience to maintain and improve core and quadriceps strength. Unfortunately, the patient’s  
244 reliance on bilateral KAFOs and BUE support to stand and his impaired dynamic sitting balance,  
245 in addition to the patient’s limited improvement throughout his care at MCIR, were limitations in  
246 progressing his strengthening exercises. See Table 3 for a list of the interventions provided

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<sup>†</sup> WalkAide<sup>®</sup>: 3600 N. Capital of Texas Highway, Suite B150, Austin, TX 78746

247 throughout this case report period and Appendix 4 for a list of the interventions provided since  
248 his SOC at MCIR.

249 The PT or physical therapist assistant (PTA) also performed BLE passive stretching for  
250 the patient's hamstrings, quadriceps, piriformis, adductors, and gastrocnemius at the start of each  
251 session. These stretches were the most feasible with the patient in supine on the therapy mat and  
252 each stretch was held for 30 seconds. These stretches were chosen based on clinical judgment to  
253 preserve ROM, reduce spasticity, and help prevent contracture.

254 The patient was instructed in and given a paper copy of his home exercise program. His  
255 mother assisted him with passive stretching of his BLEs at home. The patient had a body weight  
256 support system and parallel bars at home, which allowed him to improve his standing and  
257 ambulation tolerance while home with his bilateral locking KAFOs donned. Previous treatment  
258 included interferential e-stim, pre-modulated e-stim, cold packs, and moist hot packs to address  
259 the patient's knee and low back pain. These interventions, however, were not necessary during  
260 the duration of this case report due to adequate pain control.

261 The patient encountered many barriers throughout his rehabilitation at MCIR that created  
262 delays in his interventions. He was reliant on locking bilateral KAFOs to stand and ambulate  
263 within the parallel bars. His orthotics broke several times which resulted in a hold on standing  
264 for weeks at a time while they were being repaired. He also fractured his left ankle due to  
265 osteoporosis, which resulted in a hold on weight bearing on BLEs for four months until his  
266 fracture healed and his bone mineral density improved (see Table 5 for full timeline of barriers).  
267 These barriers did not change the plan of care, but required a hold on several interventions  
268 throughout his rehabilitation and delayed his progress towards his standing and ambulation

269 goals. Despite these barriers, the patient was compliant with PT and only canceled appointments  
270 for unexpected hospital stays or when he was ill.

271

## 272 **Outcomes**

273 The patient received approximately 200 PT treatment sessions since his SOC at MCIR  
274 two years prior to this report. He was seen three times a week for one-hour sessions. This case  
275 report highlights approximately 36 of those treatment sessions over a period of 12 weeks. Since  
276 his SOC, his BIAT score had increased by three points, which indicated a slight decrease in  
277 function over time, specifically in the areas of language/cognition and emotional adjustment.  
278 There had been no change in his mobility BIAT score since his SOC, which indicated that there  
279 had been no improvement or regression (see Table 2). There were slight improvements in his  
280 muscle strength (see Table 1), including hip flexion, adduction, and abduction, and knee  
281 extension. With the exception of knee extension, he was unable to move his BLEs against  
282 gravity at the conclusion of this case report. The patient had improvements in ankle eversion and  
283 hip straight leg raise passive ROM, but had decreases in his ankle dorsiflexion passive ROM.

284

## 285 **Discussion**

286 This case report describes the PT management of a patient with paraparesis secondary to  
287 TM and multiple CMAs and CMA ruptures. The patient's progress had been fairly stagnant since  
288 his SOC at MCIR two years prior, secondary to many barriers throughout his rehabilitation. The  
289 patient's obesity was a significant co-morbidity that likely resulted in his bilateral KAFOs  
290 breaking several times. This impaired his ability to improve his standing tolerance since he was  
291 unable to stand in the parallel bars without his orthoses. These periods of extended non-weight

292 bearing and prolonged corticosteroid use likely contributed to decreased bone mineral density.  
293 After his orthoses were repaired and he was able to stand again, he sustained a left ankle fracture  
294 secondary to osteoporosis. His ankle fracture and decreased bone mineral density resulted in a  
295 four month hold on standing until his fracture healed and his bone mineral density improved with  
296 bisphosphonate medications.

297 His obesity also impaired his ability to stand for prolonged periods of time because he  
298 relied heavily on his BUEs to hold himself upright in the parallel bars. The series of  
299 complications related to his obesity diminished his prognosis as his gains in PT were not  
300 consistent and he was subject to regression when he was unable to weight bear and stand. This  
301 postponed his ability to achieve standing and ambulation goals and prolonged his plan of care.  
302 Despite these barriers, the patient's family support as well as his positive attitude and motivation  
303 helped prevent the patient from further regressions, especially during the weeks where he was  
304 non-weight bearing.

305 In the case of this patient, it is unclear and we are unable to definitively determine  
306 whether or not the typical approaches used to address common stroke-related impairments, such  
307 as trunk control and sitting balance activities, are effective to address the impairments related to  
308 TM with subsequent multiple CMAs.<sup>8,9</sup> The chronicity of the patient's condition, as well as the  
309 inconsistent opportunity to build standing and ambulation tolerance with his KAFOs, may also  
310 contribute to his lack of improvements throughout his care at MCIR. Further research is needed  
311 to determine options for effective PT treatment approaches for a patient with impairments related  
312 to TM and multiple CMAs and CMA ruptures.

313

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393

394 **Table 1.** Tests and measures at admission and at the final session for this case report

Test & Measure		Admission		Final Session*	
		Left	Right	Left	Right
Manual Muscle Testing	Hip SLR	1/5	1/5	1/5	1/5
	Hip Flexion	1/5	1/5	2/5	2+/5
	Hip Extension	Not Tested	Not Tested	1/5	1/5
	Hip Adduction	2/5	2/5	2+/5	2+/5
	Hip Abduction	2/5	2/5	2+/5	2+/5
	Knee Flexion	2-/5	2-/5	1/5	1/5
	Knee Extension	2+/5	3-/5	3/5	3/5
	Ankle Dorsiflexion	2/5	2/5	2-/5	2-/5
	Ankle Plantarflexion	2/5	2/5	2-/5	2-/5
	Ankle Inversion	2/5	2/5	2-/5	2-/5
	Ankle Eversion	2/5	2/5	1/5	1/5
Goniometry	Hip SLR	80°	86°	90°	90°
	Ankle Dorsiflexion	5° from neutral	0°	0°	0°
	Ankle Plantarflexion	60°	60°	40°	40°
	Ankle Inversion	WFL	WFL	12°	12°
	Ankle Eversion	0°	5°	14°	14°
Coordination	Rapid alternating movements: pronation & supination	Slow	Slow	Slow	Slow
	Finger to nose	Slow	Slow	Slow	Slow

<b>Sensation</b>	Light touch sensation	Diminished T6 and distally with left deficits greater than right	Diminished T6 and distally	Diminished T6 and distally with left deficits greater than right	Diminished T6 and distally
<b>Proprioception</b>	Dynamic seated balance at edge of mat	Impaired with reaching to each side outside of base of support		Impaired with reaching to each side outside of base of support	

395 SLR = straight leg raise; WFL = within functional limits

396 \*Final session for this case report.

397

398 **Table 2.** Brain Injury Assessment Tool (BIAT) at admission and at the final session for this case  
 399 report.

<b>Brain Injury Assessment Tool (BIAT)</b>	<b>Admission</b>	<b>Final Session*</b>
<b>Physical Function:</b> Mobility, Use of Hands, Dizziness, Vision, Audition	8/20	8/20
<b>Language/Cognition:</b> Attention/Concentration, Motor Speech, Verbal Communication, Nonverbal Communication, Visuospatial Abilities, Memory, Novel Problem-Solving, Executive Function/Prospective Memory, Initiation, Impaired Self-Awareness	21/40	22/40
<b>Emotional Adjustment:</b> Anxiety, Depression, Inappropriate Social Interaction, Irritability/Anger/Aggression, Sensitivity to Mild Symptoms, Psychotic Symptoms, Law Violations, Problem Behaviors, Danger to Self or Others	4/36	7/36
<b>Independence:</b> Self-Care including Eating, Dressing, Bathing, Hygiene, and Toileting; Information Management and Self-Advocacy, Residence, Transportation, Constructive Roles, Managing Money and Finances	26/40	25/40
<b>Medical:</b> Pain and Headache, Fatigue, Sleep Disturbance, Additional Medical/Psychological/Neurological Problems, Medical Self-Care, Medication Management and Compliance	14/24	14/24
<b>Substance Use:</b> Alcohol Use, Drug Use, Nicotine Use	0/12	0/12
<b>TOTAL:</b>	<b>73/172</b>	<b>76/172</b>

400 **Footnote:** Each item within each domain is scored from 0-4 with a score of 0 indicating no  
 401 problem and a score of 4 indicating a severe problem that interferes greater than 75% of the time.  
 402 The total score is the sum of all subsections within each domain.  
 403

404 **Table 3.** Exercises by week for the duration of this case report

405

Weeks	1	2	3	4	5	6	7	8	9	10	11	12
Sessions	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36
Exercise												
Stretching BLEs	X	X	X	X	X	X	X	X	X	X	X	X
Russian e-stim to Quadriceps with Short Arc Quad	X	X		X	X	X		X	X	X	X	X
3-Way Medicine Ball Crunch	X	X	X	X	X	X	X	X	X	X		X
Active Assist ROM	X						X	X		X		
Bed Mobility	X		X			X	X		X	X		
Prone & Quadruped Weight Shifting & Reaching	X	X		X	X				X			
WalkAide Exercise Mode		X								X		
Seated Trunk Stability at EOM		X						X	X	X	X	
Stand and Amb. in Parallel Bars		X	X			X						X

406 BLEs = bilateral lower extremities; e-stim = electrical stimulation; ROM = range of motion; EOM = edge of mat; amb. = ambulation

407

408 **Table 4.** Exercise Descriptions and Parameters

Exercise	Description	Parameters
<b>Stretching bilateral lower extremities</b>	Targeted muscle groups included hamstrings, quadriceps, piriformis, adductors, and gastrocnemius	A stretch to each muscle group was held for 30 seconds, 1-2 times each
<b>Russian electrical stimulation<sup>‡</sup> to bilateral quadriceps with short arc quad</b>	Electrodes <sup>§</sup> were placed on the vastus medialis and rectus femoris of the bilateral quadriceps. The Russian electrical stimulation setting was set to a tolerable intensity that elicited a muscle contraction. The patient contracted his quadriceps and performed a short arc quad exercise over a bolster <sup>**</sup> in conjunction with the electrical stimulation.	<ul style="list-style-type: none"> <li>• 10-15 minute treatment time</li> <li>• Duty cycle: 10 seconds on to 20 seconds off, alternating LEs</li> <li>• Russian electrical stimulation setting on electrical stimulation machine with preset parameters</li> <li>• Intensity between 40mA and 55mA depending on patient tolerance</li> </ul>
<b>3-Way Medicine Ball Crunch</b>	With the patient in supine and a bolster under his knees, the patient held a medicine ball and crunched to the left, center, and right.	<ul style="list-style-type: none"> <li>• 15-20 reps in each direction</li> <li>• 3-5 kg medicine ball</li> </ul>
<b>Active Assist Range of Motion</b>	Active assistance with contraction of quadriceps, hip adductors, and hip abductors.	<ul style="list-style-type: none"> <li>• 3x10 bilaterally</li> </ul>
<b>Bed Mobility</b>	Activities included rolling to each side, and resisted and alternating isometrics in sidelying at the hip and shoulder. The patient required min. assistance for bilateral LE management.	<ul style="list-style-type: none"> <li>• Roll to each side x10</li> <li>• Resisted isometrics at hip and/or shoulder x15 each side</li> <li>• Alternating isometrics at hip and/or shoulder x15 each side</li> </ul>
<b>Prone &amp; Quadruped Weight Shifting &amp; Reaching</b>	Activities in prone included protraction push-ups, maintaining scapular protraction bilaterally and unilaterally when reaching with	<ul style="list-style-type: none"> <li>• Protraction push-ups 3x10</li> <li>• Maintained protraction 3x30 sec</li> </ul>

<sup>‡</sup> Chattanooga Group, Inc Forte 400 Stim Electrical Stimulation Unit: Chattanooga Group, Inc, 827 Intermont Rd, Chattanooga, TN 37415

<sup>§</sup> Performa Reusable and Self-Adhering Stimulating Electrodes: Patterson Medical, 28100 Torch Parkway, Suite 700, Warrenville, IL 60555

<sup>\*\*</sup> Skillbuilders Roll 10’x36’ Fabrication Enterprises Inc, PO Box 1500, White Plains, NY 10602



	contralateral UE, as well as when weight shifting. Activities in quadruped included weight shifting between UEs and LEs and reaching with one UE.	<ul style="list-style-type: none"> <li>• Weight shifting 3x30sec</li> <li>• Reaching 2-3x10 bilaterally</li> </ul>
<b>WalkAide Exercise Mode</b>	The WalkAide was used on exercise mode as a method to help strengthen his ankle dorsiflexors and evertors, as well as to help stretch his gastrocnemius and soleus and maintain ankle ROM while the patient was in supine on the mat.	<ul style="list-style-type: none"> <li>• Exercise mode on device</li> <li>• 3x30 unilaterally or bilaterally</li> </ul>
<b>Seated Trunk Stability at EOM<sup>††</sup></b>	Exercises included using the Body Blade <sup>‡‡</sup> , crunches with a Swiss ball behind the patient, ball catch, balloon tap, posture activities, D1 and D2 flexion and extension UE patterns, and performing various UE motions with a 5-pound dowel.	<ul style="list-style-type: none"> <li>• Body Blade and posture activities performed 2-3x30 sec (bilaterally)</li> <li>• Other activities 2x15</li> <li>• Mirror occasionally used for visual feedback on posture and form</li> <li>• Tactile cues occasionally used for feedback on posture and form</li> </ul>
<b>Stand and Ambulate in Parallel Bars<sup>§§</sup></b>	With bilateral locking KAFOs donned, the patient stood within the parallel bars. The patient required mod. to max. assistance x1 for sit to stand and stand to sit transfers as well as BUE support for transfers and static standing. Min-mod assistance x1 was needed to maintain static standing. Ambulation was done within the parallel bars with BUE support, mod. assistance x1 for weight shifting, and a wheelchair follow.	<ul style="list-style-type: none"> <li>• Static standing time was per patient tolerance. During this case report period, it ranged from 2 minutes to 7 minutes</li> <li>• Ambulation was always 6 feet due to the length of the parallel bars</li> </ul>

<sup>††</sup> Midland Bariatric Mat Platform 5 feet x 7 feet: Patterson Medical, 28100 Torch Parkway, Suite 700, Warrenville, IL 60555

<sup>‡‡</sup> Body Blade<sup>®</sup> Classic Black: Patterson Medical, 28100 Torch Parkway, Suite 700, Warrenville, IL 60555

<sup>§§</sup> Clinton Kangoo Parallel Bars: Clinton Industries, Inc, 1140 Edison St, York, PA 17403

409 mA = milliamps; kg = kilogram; reps = repetitions; min. = minimum; LE = lower extremity; UE  
410 = upper extremity; BUE = bilateral upper extremity; sec = seconds; KAFOs = knee-ankle-foot  
411 orthoses; mod. = moderate; max. = maximum  
412

413 **Table 5.** Timeline of Standing since Start of Care at Maine Center for Integrated Rehabilitation (by month)

414

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
# of sessions	Sessions prior to this author's start of care with the patient.																					2 sessions standing	1 session standing	3 sessions standing
Maximum standing and ambulation tolerance	Stand up to 32 minutes, ambulate 6 feet in parallel bars x5					Stand up to 8 minutes, ambulate 6 feet x1	Stand up to 37 minutes, ambulate 6 feet x3						Stand up to 45 minutes, ambulate 6 feet x4			Stand up to 8 minutes, ambulate 6 feet x2	Stand up to 3 minutes	Stand up to 2 minutes						
Barrier					KAFOs broke and needed repair. Eight weeks without standing.	KAFOs needed adjustment after two sessions. Six weeks without standing.						Consecutive holds on weight bearing due to ankle fracture, low bone density, and multiple syncopal events. Waited to begin weight bearing until 1 month without syncopal event. Total 32 weeks without standing							KAFOs broke, waited to be eligible to receive new KAFOs. 10 weeks without standing	KAFOs needed adjustment. Two weeks without standing.	KAFOs broke after 1 session. Four weeks without standing.			

415 KAFOs = knee-ankle-foot orthoses

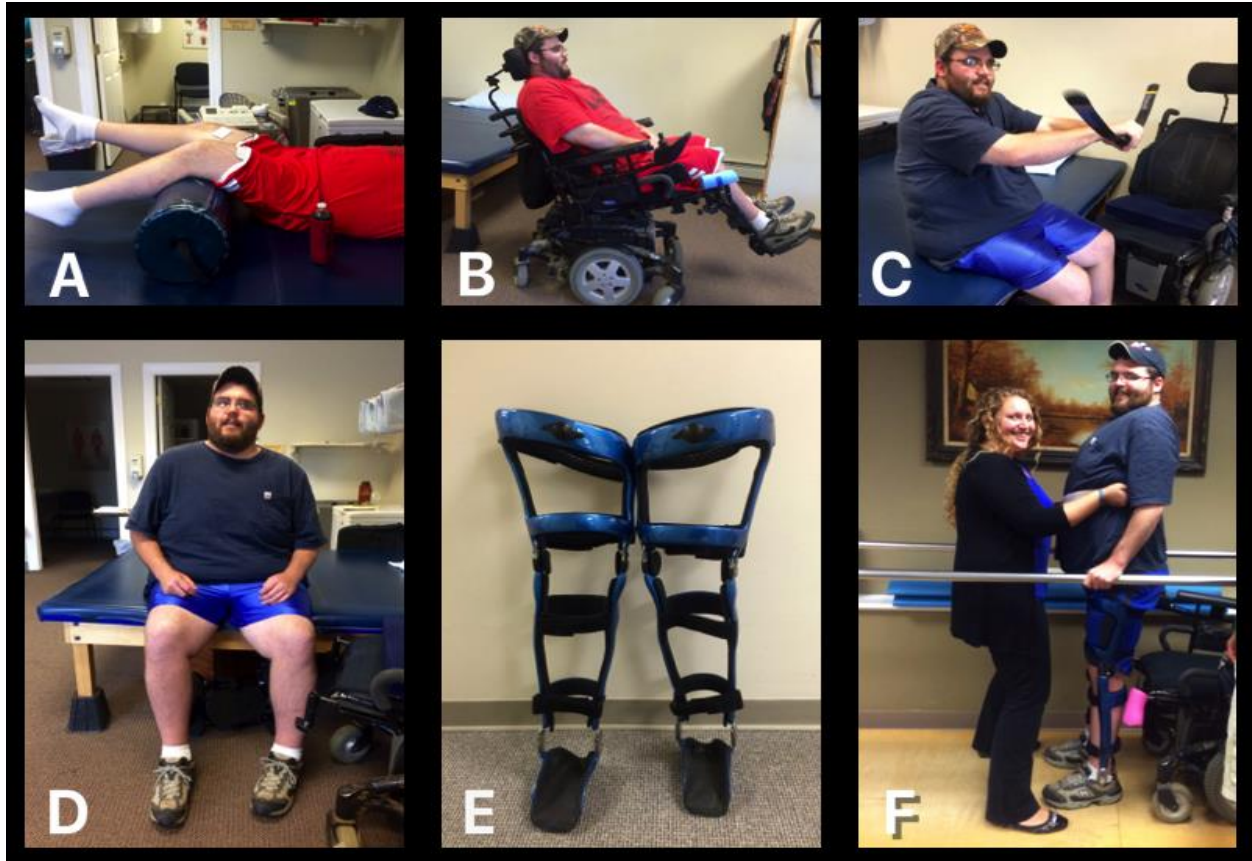
416 **Legend:**

<b>Green</b>	Barriers causing periods of time without standing	<b>Blue</b>	Periods of standing and ambulation
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417

418 **Footnote:** All standing required moderate to maximum assistance of one person to assist the patient from sitting to standing and  
419 minimum to moderate assistance of one person to maintain a standing position. The patient required bilateral upper extremity support  
420 with the parallel bars for all standing and ambulating. The patient required minimum to moderate assistance of one person to assist  
421 with weight shifting when ambulating within the parallel bars and required a second person to perform a wheelchair follow.

422 **Figure 1.** Patient Related Clinical Interventions



**Footnote:**

A. The patient performing a short arc quadriceps exercise with Russian e-stim.

B. The patient in his wheelchair,\*\*\* which is slightly tilted.

C. The patient performing small amplitude shoulders flexion and extension at the edge of the mat with the Body Blade.

D. The patient maintaining a proper upright posture at the edge of the mat.

E. The patient's custom knee-ankle-foot orthoses (KAFOs).

F. The patient standing in the parallel bars with a student physical therapist/manuscript author with bilateral KAFOs donned.

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\*\*\* Invacare TDX SP Power Tilt-In-Space Wheelchair: 1 Invacare Way, Elyria, OH 44035

433 **Appendix 1. Patient History**

<b>Social History</b>	The patient worked as a crane operator at a chip plant until the age of 20 when he experienced an insidious onset of transverse myelitis. The patient was not able to return to work since the initial onset of symptoms. He denied smoking, alcohol consumption, or illicit drug use.
<b>Living Environment</b>	The patient lived with both of his parents in a one-story home with a ramp. The patient had a set of parallel bars with a standing harness in his home.
<b>General Health Status</b>	The patient was obese and was dependent on a power wheelchair for mobility.
<b>Social/Health Habits</b>	The patient had a poor diet and did not comply with diet recommendations. The patient socialized with other clients during his time in MCIR’s ABI day program and was interested in obtaining a job or participating in volunteer work in the future.
<b>Family History</b>	No family history of immune deficiency, prior episodes of transverse myelitis, or aneurysm rupture.
<b>Patient’s Medical/Surgical History</b>	Past surgical history included mediastinal lymph node biopsy, right frontal exploratory craniotomy and open brain biopsy, right-sided ventricular drain placement, video-assisted thoracoscopic surgery (VATS), bronchoscopy, and lumbar puncture.
<b>Clinical Tests</b>	MRI of the whole spine and brain, CT angiogram of the brain, chest CT, and conventional angiography of the head.
<b>Functional Status/Activity Level</b>	The patient was independent in his power wheelchair for mobility. He required min. assistance during sliding board transfers with BLE management. He required min. to mod. assistance for LE management with bed mobility. The patient required mod. to max. assistance times one for sit to stand transfers with bilateral locking KAFOs in the parallel bars. The patient was able to ambulate six feet in the parallel bars with bilateral KAFOs, BUE support, and min. to mod. assistance times one for weight shifting.
<b>Patient Goals</b>	To stand and ambulate with bilateral locking KAFOs and a standard walker. To increase independence with ADLs and IADLs.

434 MCIR = Maine Center for Integrated Rehabilitation; ABI = acquired brain injury; MRI =  
 435 magnetic resonance imaging; CT = computed tomography; min. = minimum; mod. = moderate;  
 436 max. = maximum; BLE = bilateral lower extremity; LE = lower extremity; KAFO = knee-ankle-  
 437 foot orthoses; BUE = bilateral upper extremities; ADLs = activities of daily living; IADLs =  
 438 instrumental activities of daily living  
 439

440 **Appendix 2.** Systems Review

<b>Cardiovascular/Pulmonary System</b>	
Unimpaired	At risk for impairment due to obesity. Respiratory rate, heart rate, and blood pressure within normal limits.
<b>Musculoskeletal System</b>	
Impaired	Weak bilateral lower extremities distal more than proximal. History of left ankle fracture.
<b>Neuromuscular System</b>	
Impaired	Paraparesis left more impaired than right. History of multiple aneurysm ruptures resulting in cerebral vascular accident. Decreased sensation in bilateral lower extremities left more impaired than right.
<b>Integumentary System</b>	
Unimpaired	At risk for skin breakdown due to use of power wheelchair as primary means of mobility.
<b>Communication</b>	
Unimpaired	Able to communicate clearly with physical therapy staff and peers.
<b>Affect, Cognition, Language, Learning Style</b>	
Impaired	Impaired safety awareness.

441

442 **Appendix 3.** Short Term and Long Term Goals

<b>Short Term Goals</b>	<b>Long Term Goals</b>
<b>Within 6 months</b>	<b>Within 1 year</b>
Stand in parallel bars times 15 to 20 minutes with contact guard to minimal assistance times one to two in preparation for gait within six months.	Stand times 10 to 15 minutes in parallel bars and perform sit to stand transfer with standard walker with minimal assistance to increase functional lower extremity mobility within one year.
Demonstrate a decrease in right knee pain to four to five out of ten at worst and five out of ten at worst for low back pain to increase ability to perform transfers when standing within six months.	Demonstrate a decrease in right knee pain to three out of ten at worst to increase ability to sleep at night and perform standing activities within one year.

443

444

445 **Appendix 4. Exercises by Month**

Month	Exercises
1	BLE stretching, stand in parallel bars 1x10 minutes, amb. 6 feet in parallel bars x1, supine BLE exercises x15 each
2	BLE stretching, stand in parallel bars 3x5 minutes, 1x20 minutes 1x32 minutes; amb. 6 feet in parallel bars x3, AAROM for bilateral hip flexion, hip abduction, knee flexion x15 each, supine and seated core exercises
3	BLE stretching, stand x3-4 trials, e-stim IFC right knee times 10 minutes, amb. 6 feet in parallel bars x5
4	BLE stretching, stand in parallel bars 1x13 minutes, 1x7 minutes, IFC R knee, Body Blade seated at edge of mat, e-stim IFC to low back x10 minutes, rolling x10 to each side with min to mod assist for BLE management
5	BLE stretching, quadruped with UE reaching, seated and supine core exercises
6	BLE stretching, stand x8 minutes, amb. in parallel bars x1, e-stim pre-mod to bilateral knees x10 minutes, e-stim IFC to low back x10 minutes, rolling x10 each side, seated and supine core exercises
7	BLE stretching, seated and supine core exercises, rolling x15 to each side, amb. in parallel bars 6 feet x2
8	BLE stretching, seated and supine core exercises, mechanical lumbar traction 60lbs x12 minutes, amb. in parallel bars 6 feet x3, stand in parallel bars x21 minutes, x30 minutes, x37 minutes, e-stim to low back IFC x15 minutes
9	BLE stretching, seated and supine core exercises, short arc quad 2x10 bilaterally, stand in parallel bars up to 8 minutes, amb. 6 feet in parallel bars x4, Russian electrical e-stim to bilateral quadriceps with active knee extension x15 minutes, seated weight-shifting x3 minutes
10	BLE stretching, seated and supine core exercises, amb. 6 feet in parallel bars x2, stand in parallel bars x15 minutes, x10 minutes, Russian e-stim to bilateral quadriceps with active knee extension x10 minutes
11	BLE stretching, seated and supine core exercises, AAROM in supine for hip abduction and adduction 2x10 bilaterally, WalkAide exercise mode x3 in supine to increase right ankle ROM, Russian e-stim to bilateral quadriceps x10 minutes, prone on elbows with UE reach x15 each side
12	BLE stretching, seated and supine core exercises, long arc quadriceps 2x10 bilaterally, rolling x10 each side, bridge 2x15, Russian e-stim bilateral quadriceps x10 minutes, WalkAide exercise mode x3 in supine to increase right ankle ROM
13	BLE stretching, seated and supine core exercises, trunk rotation in sitting x10 bilaterally, WalkAide exercise mode x3 in supine to increase right ankle ROM, long arc quadriceps 2x10 bilaterally, posterior pelvic tilts 2x15, rolling x10 bilaterally



14	BLE stretching, seated and supine core exercises, sidelying pelvic rotation rhythmic initiation with manual resistance 2x10 each side, rolling x10 each side, short arc quadriceps with Russian e-stim bilaterally x10 minutes, isometric contraction for bilateral hamstrings 2x15 and quadriceps 2x15
15	BLE stretching, seated and supine core exercises, pelvic rotation in sidelying 2x15 each side without resistance, 2x15 each side with resistance, Russian e-stim to bilateral quadriceps with short arc quadriceps x15 minutes, isometric contraction for bilateral hamstrings 2x15 and quadriceps 2x15
16	BLE stretching, seated and supine core exercises
17	BLE stretching, seated and supine core exercises, lower trunk rotation x15 each side, bridge 2x15, prone on elbows with reaching, resisted pelvic rotation x15 each side, weight shifting in quadruped, standing in parallel bars x30 minutes, amb. 6 feet in parallel bars x2
18	BLE stretching, seated and supine core exercises, stand x45 minutes, x 23 minutes, x14 minutes in parallel bars, amb. 6 feet in parallel bars x2, resisted pelvic rotation x15 each side, short arc quadriceps 2x10 bilaterally
19	BLE stretching, seated and supine core exercises, rolling x15 each side, stand in parallel bars x20 minutes, amb. 6 feet in parallel bars x1, WalkAide exercise mode x3 in supine to increase right ankle ROM
20	BLE stretching, seated and supine core exercises, Russian e-stim to bilateral quadriceps x10 minutes, pelvic rotations 2x10 bilaterally, quadruped weight shifting and UE reaching x10 bilaterally
21	BLE stretching, seated and supine core exercises, rolling 2x10 each side, quadruped weight shifting 2x10 each side, WalkAide exercise mode x3 in supine to increase right ankle ROM, Russian e-stim to bilateral quadriceps x10 minutes, active hip abduction and adduction in supine x15 bilaterally, prone press up on elbows
22	BLE stretching, seated and supine core exercises, stand in parallel bars x7 minutes, x3 minutes, x8 minutes, amb. 6 feet in parallel bars x2, quadruped weight shifting 2x10 bilaterally, long arc quads x15 bilaterally, wheelchair push-ups x10
23	BLE stretching, seated and supine core exercises, bridge 2x10, Russian e-stim bilateral quadriceps x15 minutes with short arc quadriceps, rolling x10 each side
24	BLE stretching, seated and supine core exercises, stand 2x2 minutes

446 BLE = bilateral lower extremity; UE = upper extremity; AROM = active range of motion; e-stim

447 = electrical stimulation; amb. = ambulation

448 **Footnotes:**

449 • Bilateral lower extremity stretching included hamstrings, quadriceps, piriformis,

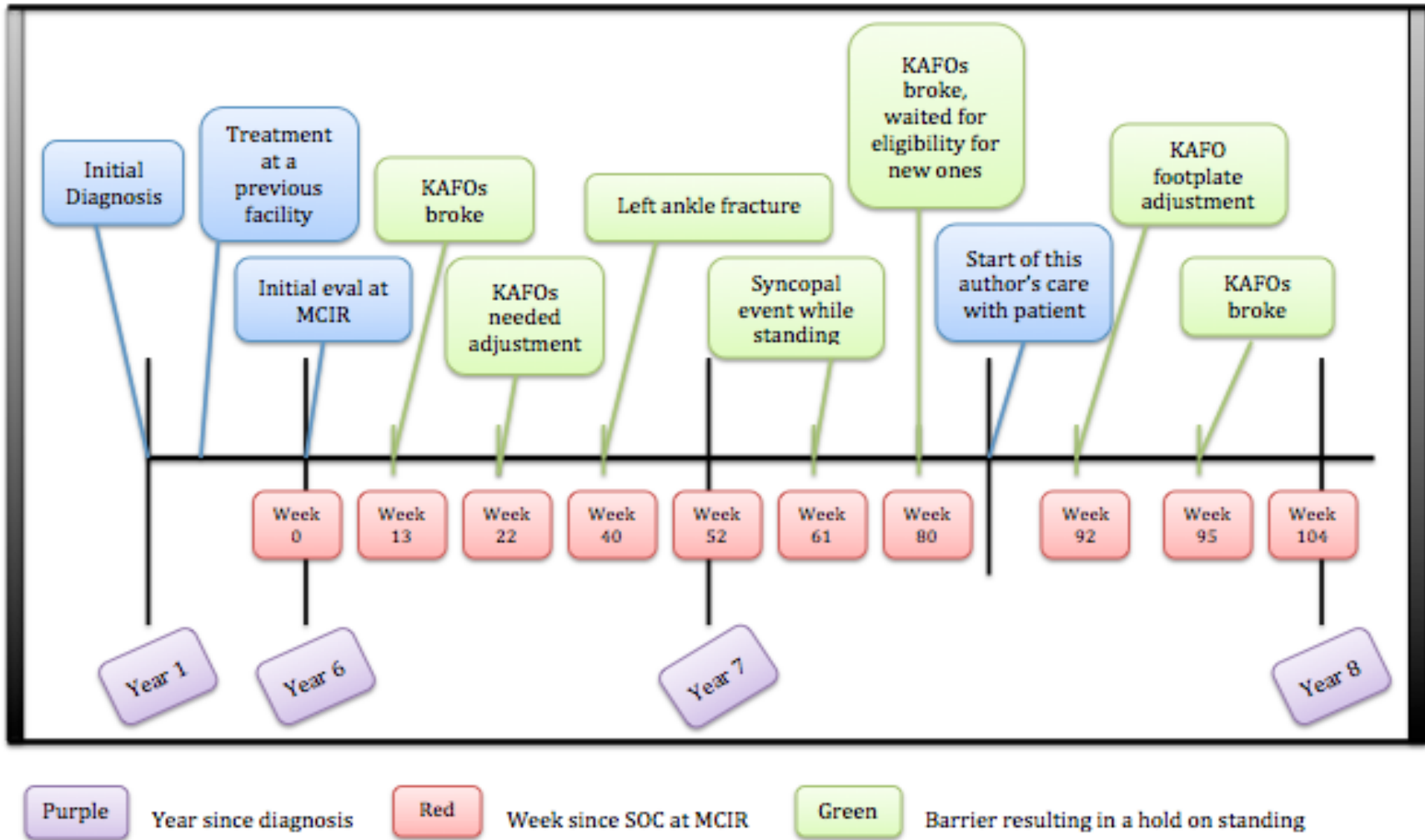
450 adductors, and gastrocnemius. Each stretch was held for 30 seconds.

- 451       • Seated and supine core exercises included supine crunches to the front and each side with  
452       a 3-5 kilogram medicine ball, using a 5 pound dowel in a kayak motion in supine and  
453       sitting, partial sit-up with a Swiss ball behind the patient in sitting, seated balance  
454       exercises at the edge of the mat, such as reaching across the body, ball catch, balloon tap,  
455       and using the Body Blade in D1 and D2 flexion and extension patterns. Each exercise  
456       was performed 2x15 (bilaterally, if applicable).
- 457       • The patient required maximum assistance of one person for sit to stand and stand to sit  
458       transfers in the parallel bars. The patient required minimum to moderate assistance of one  
459       person for weight shifting during ambulation within the parallel bars and second person  
460       for a wheelchair follow.

461

462 **Appendix 5.** Timeline of Barriers to Standing & Ambulating Encountered since Start of Care at MCIR

463



464

465 **Appendix 6. Medications**

Medication	Dose	Frequency	Purpose
Nortriptyline	100 mg	1 tab PM	Depression
Potassium citrate	1080 mg	2 tabs AM & PM	Kidney stones; decrease urine acidity
Multivitamin	N/A	1 tab AM	Prevent vitamin deficiency
Doc-Q-Lace	100 mg	1 tab AM & PM	Stool softener
Senna lax	8.6 mg	2 tabs AM & PM	Stimulant laxative
Azathioprine	50 mg	2 tabs AM & PM	Immunosuppressant
Baclofen	20 mg	1 tab 3x daily	Antispasmodic
Oxybutynin	5 mg	1 tab 3x daily	Decrease overactive bladder
Trazodone HCL	50 mg	1-1.5 tabs PM	Antidepressant
Trimethoprim	100 mg	1 tab PM	Urinary tract infection treatment
Folic acid	1 mg	1 tab AM	Improve folate deficiency, lower homocysteine levels (high levels linked to heart disease & stroke)
Jantoven	6-6.5 mg (alternate)	1 tab PM	Anticoagulant
Oxycontin	20 mg	1 tab AM & PM	Narcotic pain reliever
Oxycodone/Acetaminophen	10/325 mg	As needed	Opioid pain reliever
Prednisone	2 mg	Every other AM, tapering dose every 2 months by 1 mg	Corticosteroid; anti-inflammatory

466 AM = in the morning; PM = in the evening; mg = milligram