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Recovery from Central Cord Syndrome: A Case Report

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RECOVERY FROM CENTRAL CORD SYNDROME:
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by

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ABSTRACT

BACKGROUND AND PURPOSE : Falls are the second leading cause of spinal cord injury and the average age at time of injury has been increasing over the last several decades. Current estimates suggest that the annual incidence of spinal cord injury (SCI) in the geriatric population (>65 years of age) is 67.9/million. According to the National Institute of Neurologic Disorders and Stroke, the most common form of incomplete spinal cord injury is Central Cord Syndrome (CCS) which typically presents with greater upper versus lower extremity impairment. The primary objective of this case report was to describe interventions and management for a patient with symptoms of Central Cord Syndrome following a suspected hyperextension injury.

CASE DESCRIPTION: The patient was a 76-year-old retired construction worker who developed CCS as a result of a fall from a tractor. He presented with significant weakness, greater in the upper extremities than the lower extremities, and limited knee range of motion (ROM). This individual also displayed activity limitations related to sitting, standing, balance, transfers, stairs, and ambulation. Other pertinent past medical history included arthritis in both knees, spinal degenerative joint disease (DJD), and spondylolysis.

INTERVENTIONS: Treatment interventions consisted of stretching, therapeutic exercises and activities, aerobic conditioning, stair training, transfer training, gait training, patient education and aquatic therapy.

OUTCOMES: By the end of therapy the patient's Berg score had improved by 24% from 21 points to 34. He was able to ambulate approximately 360 feet in 6 minutes; 30% of his age-predicted norm. After 10 weeks (approximately 110 treatments) the patient was discharged home with recommended physical therapy (PT) homecare services. He was independent with bed mobility, required occasional supervision for safety on transfers, and was walking 500 feet using a front wheeled walker, requiring stand-by-assist (SBA).

DISCUSSION: This case report describes a patient's rehabilitation process following a spinal cord injury secondary to a fall with recovery being limited by the orthopedic condition of his knees. Additional randomized control trials to compare physical therapy interventions with other management of CCS would be beneficial in order to determine the effectiveness of physical therapy for this patient population.

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RESEARCH ADVISOR FINAL APPROVAL FORM

The undersigned certify that they have read, and recommended approval of the research project entitled

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submitted by

Katie Jacobson

in partial fulfillment of the requirements for the Doctor of Physical Therapy Program

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CHAPTER I: BACKGROUND AND PURPOSE

According to the National Spinal Cord Injury Statistical Center, falls are the second leading cause of spinal cord injuries behind vehicular accidents.[1] Recent studies suggest that the incidence and prevalence of spinal cord injury (SCI) in the older population is on the rise.[2] In developed nations, the population aged 60 or over is increasing at a rate of 2% annually.[2] Current estimates suggest that the annual incidence of SCI in the geriatric (>65 years of age) population is 67.9 per million with a prevalence as high as 116.3 per million.[2] The true incidence is most likely underestimated as SCI data is collected on patients admitted to the hospital and does not include prehospital deaths or deaths upon arrival.[3] In the geriatric population, incomplete lesions are more common than complete lesions. Central Cord Syndrome (CCS) is the most common form of incomplete spinal cord injury, and those affected who are older than 60 typically have a poorer prognosis in terms of functional recovery.[4, 5, 6, 7, 8] Schneider et al. first described a person with CCS as an individual who experiences significant weakness with greater upper extremity (UE) than lower extremity (LE) involvement, bladder dysfunction, and varying sensory loss below the level of the lesion.[9] Presentation of CCS may be dramatic or quite subtle and easily missed. In the second instance, a potential delay in diagnosis may expose the patient to the risk of increased neurological deficit.[10] Because this condition is sufficiently uncommon (although not rare), many physicians are not aware of it, and this can lead to a delay in diagnosis.[11] As the geriatric population continues to grow, it is important to investigate different physical therapy interventions to determine which may have the greatest potential to assist those with central cord syndrome to

achieve the greatest functional success in the rehabilitation process with the goal of minimizing participation restrictions and maximizing quality of life.

According to Morse, hyperextension injuries are the most common clinical presentation of CCS. Experimental data suggests that when this injury occurs functional changes may result due to compressive stresses that damage the gray matter and most medial portion of the corticospinal tract.[7,10,12,13] Schneider provided further details, stating that this compression decreased the space available for spinal cord function and that symptoms of CCS would often occur following hyperextension of the neck where preexisting disc space collapse, osteophyte development, and ligamentum hypertrophy combined to create degenerative spondylosis of the cervical spine with subsequent stenosis of the canal.[9] Schneider's findings were supported by another study where individuals with congenital shortening of the anteroposterior diameter of the spinal canal or other pathological process that diminished the available space for the spinal cord had greater risk of developing CCS.[11] Neurologic insult due to compression of the spinal cord leads to cell injury and cell death. The body's response to injury sets off a sequence of events including an inflammatory response resulting in edema which can increase the amount of cell death. Over time the edema subsides and some cells are able to recover but not all. Therefore, the amount of neurologic dysfunction and cell death is variable and depends on the severity of injury as well as the degree of the body's response.[10] Initial recovery of motor function follows a definite, predictable pattern beginning with the legs as the LE fibers are most lateral and sustain the least amount of damage; this is followed

by bladder recovery, then arm recovery, and finally a return of finger function if it happens at all.[10]

There are two different mechanisms of hyperextension that can result in symptoms of CCS. The first mechanism involves an individual with an underlying narrowing of their spinal canal (as previously described by Schneider) who experiences hyperextension by one of two differing methods. The first method results from a high-energy incident such as a motor vehicle accident (MVA) with rapid deceleration when an individual strikes his or her head on the windshield or other part of the car. The second method is more subtle and typically involves a low-energy incident which happens in the absence of head injury such as a fall that occurs to the frontal lobe.[11] Elderly individuals with preexisting spondylosis may be predisposed to suffer neurologic injuries from a low-energy mechanism.[4] One study found that 74% of geriatric patients sustained a SCI secondary to a fall while another study found that 77% of SCIs in patients over 60 occurred from falls.[2,4]

In contrast to a hyperextension injury that results from a narrowed spinal canal secondary to osteophyte development, ligamentum flavum hypertrophy, and disc space collapse as seen in the first mechanism, the second mechanism of hyperextension can lead to the development of CCS from buckling of the ligamentum flavum. This occurrence compresses the spinal cord by creating a “pincher” effect between the posterior elements of the vertebral column and the lamina of the vertebra below even without dislocation or fracture.[11] This mechanism requires a significant high-energy force

and would not occur from a subtle fall. Other potential mechanisms associated with the development of CCS include severe cervical compression fracture, fracture-dislocations, a congenitally narrowed spinal canal, or an atraumatic thrombosis or hemorrhage.[10]

Patients who experience symptoms of CCS secondary to acute disc herniations, fractures, and/or instability are usually managed surgically.[15] In contrast, management of patients impacted by CCS secondary to a hyperextension injury in the setting of preexisting cervical stenotic changes without fractures or instability can vary slightly between surgeons.[14] Since 1954, the general trend in the latter instance (i.e., CCS symptoms without fractures or instability) has been reluctance to undertake aggressive treatment and hasty decompression of the spinal cord in an urgent fashion.[6] Surgeons reported spontaneous functional recovery, comorbidities, and risk of intraoperative worsening of neurological condition as reasons for not relieving spinal cord compression as soon as possible.[6] But following a Yamazaki et al. study done in 2005 that reported a direct relationship between outcome and midsagittal diameter of the spinal canal, treatment has recently shifted toward earlier decompression.[16]

A separate study completed by Chen et al. looked at patients who had preexisting spondylosis and presented with symptoms of CCS due to minor hyperextension of the neck and found that those who underwent surgical intervention recovered more quickly.[17] Another study completed by Guest et al. found that timing of surgical intervention was not as critical, but patients who were older than 60 years typically had worse outcomes.[18] Using two different outcome measures, Chen and his colleagues found

that age was the only factor that influenced outcome.[19] A systematic review performed by Dahdaleh also determined that age was the most important prognostic factor in addition to surgical intervention as five out of six studies identified older age as adversely affecting outcome.[15] A 2010 study performed by Yadla determined that early medical and surgical interventions and the severity of the initial injury were factors primarily responsible for neurologic recovery.[8] Despite there being no cure or standard course of treatment for CCS, interventions typically involve drug therapy, surgery, and rest.[20, 21] Physical rehabilitation has traditionally been viewed as an adjunct therapy in the treatment of patients with spinal cord injuries.[8] Recent research focused on recovery after SCI has suggested that activity-dependent plasticity, or repetitive task-specific sensory input may improve motor output. This discovery has led to a greater emphasis on physical rehabilitation therapies as a modality to directly impact neurologic recovery.[8]

Research on physical therapy as a means of intervention for CCS is lacking. Important issues to focus on in physical therapy include: preservation of range of motion (ROM) and enhancement of mobility, strengthening of preserved LE musculature, trunk balance and stabilization, safe transfers, and wheelchair mobility prior to start of gait training. Deficits to the UEs may limit the use of an assistive device (AD) and impact functional quality of ambulation.[20] Referring these patients to occupational therapy (OT) is important to help prevent contractures of the fingers as well as address additional UE limitations that may prevent patients from being able to independently complete activities of daily living (ADLs) .[20] The purpose of this case report is to describe physical therapy interventions and management of a patient with CCS secondary to a fall. Determining the

best approach for treating this patient population is important as the prevalence of this condition continues to increase with a growing elderly population.

CHAPTER II: CASE DESCRIPTION

History

The patient was a 76 year-old Caucasian male referred to physical therapy with a spinal cord injury secondary to a fall from a tractor. The initial injury occurred late in the evening, and the patient spent the night outside on the ground because he was unable to move his extremities after regaining consciousness. He first received medical attention after his brother found him the next morning.

At the hospital the patient underwent computed tomography (CT) scans of his head and spine. The CT of his head was negative, but the CT of his spine showed degeneration of the spine with stenosis at C3-C4 and retrolisthesis at C3-C7. Physicians tried magnetic resonance imaging (MRI) multiple times, but the patient was unable to tolerate the procedure despite medication to promote relaxation. With the imaging that was available, the doctors ruled out an epidural hematoma. Chest x-rays were taken to rule out any rib fractures, and the patient's results were negative for any noticeable spinal or rib fractures. The patient reported a pain level of 5/10 (with 0 being no pain and 10 being the worst pain) and stated that his neck and bilateral shoulders were the areas of his pain. Bilateral weakness greater in the UEs than the LEs was evident as well as weakness in trunk control. Lower extremity strength was assessed at the hospital and reported as 3/5 bilaterally. In a gravity-eliminated position the right deltoid was 4/5, left deltoid 2/5, and bilateral hand grip was 1/5. The patient did not present with any sensory loss or report trouble voiding his bladder. He displayed mild cognitive impairment, and was

unable to answer questions about where he was after being informed. He also presented with impaired ability with personal safety, memory, and attention tasks. He was given a medical diagnosis of spinal cord injury and referred to a neurosurgeon who performed decompressive laminectomies of C3-C7 with posterior instrumentation and fusion for central cord syndrome following a suspected hyperextension injury on his fourth day of hospitalization.

The patient spent a total of 10 days in the acute care hospital before being discharged to the subacute facility. After surgery, he spent five more days at the acute care hospital where he received daily OT and PT which focused on tolerating an upright position, UE use for activities of daily living, bed mobility, transferring supine-to-sit, seated balance, and sit-to-stand in preparation for ambulation. Three days after his operation the patient had trouble voiding and a catheter was placed.

Upon arrival to the subacute facility the patient's main complaints were of pain in his shoulders and back. He denied having any neck pain, but did complain about not being able to use his hands or UEs and had difficulty walking. The patient's only precaution was to wear a cervical collar when being upright. In addition to arthritis in both of his knees, other pertinent past medical history included spinal degenerative joint disease (DJD) and spondylolysis. During the initial interview the patient reported English as his primary language, a high school diploma as his highest level of education, and stated that he was a retired construction worker. The patient reported consuming 2-3 alcoholic drinks every other day, and indicated that he had been drinking prior to his fall.

Although unable to recall how he fell, he did remember hitting his face. The patient stated that he used Ranitidine to treat occasional heartburn and also took some arthritis medications. He was unable to provide further details about his medications. One pre-morbid factor limiting the patient's activity level was arthritis in his knees as he reported multiple occasions of his left knee giving out prior to his fall. He mentioned that he had a single end cane (SEC) which he occasionally used when his left knee got sore. The patient's main goals for therapy were to be independent with bed mobility, increase his distance of ambulation, and decrease his level of assistance needed to transfer, all of which pertained to his overall goal of going home. He wanted to be able to independently transfer to the toilet and be able to drive his tractor and golf cart. He also did not want to be dependent on his wife for completing his ADLs. When the patient was questioned about his home environment he reported that he lived on a farm with 3 stairs to enter the home and a flight of stairs to the basement. He reported having a single rail on the right side going up the 3 steps, and a single rail on the right side going down to the basement. The patient was not very conversant about what he did at home except for mow the lawn on his tractor. It was unclear what his prior roles and responsibilities entailed. He appeared to have family support at home as his brother was the one who found him, and his daughter was present for part of the initial PT evaluation.

Systems Review

A systems review was completed prior to the examination.

Vitals: Vital signs were not assessed at this time because they had been checked by nursing and were considered stable. To screen the patient's cardiovascular system he was asked if he had any trouble breathing, and the patient denied having shortness of breath (SOB).

Cognition: The patient was oriented to person and place, but stated that it was 1906. He also had a difficult time responding to questions about his home environment. The patient could follow some simple two-step commands, but still responded inappropriately at times. He mentioned ringing bells for the attack on the Indian school during the night. It was unclear whether his confusion was a medication side-effect. The patient understood he had fallen, but demonstrated a lack of insight as he did not understand why he could not return home to recover where he would be more comfortable and could use his own bed.

Integumentary: The patient had abrasions on his arm and face secondary to his fall, a surgical incision on the posterior side of his neck, and a wound on the side of his heel. It was suspected that his heel wound was related to lying on the ground for an extended period of time after his fall. All abrasions and wounds were healing well.

Sensation: While in the supine position a sensation screen was performed by simultaneously running a finger along both extremities and asking the patient whether it

felt the same on both sides. The patient did not present with any deficits in upper or lower extremity light touch sensation.

Range of Motion: A LE ROM screen was done in the supine position and the patient was asked to point his toes up and down, bend his knees up and straighten them out, and bring his legs out to the side and back in. It was noted that the patient was lacking in dorsiflexion (DF) ROM bilaterally at his ankles and could only get to neutral. The patient was unable to bring his knees up toward his chest actively, but with assistance from the student physical therapist the patient's hip and knee ROM appeared to be within functional limits (WFL) and only lacking in strength. The patient required min assist of one to bring his legs out to the side and back in (one at a time) when screening for impairments of hip abduction and adduction. The patient's hip abduction and adduction ROM was within normal limits (WNL), but lacking in strength as the patient could not perform the movement without assistance. The patient was asked to lift his arms over his head to screen the UEs. He did not have any active motion at the shoulder and was only able to initiate elbow flexion, lifting his arms approximately 10 degrees at the elbows. The patient was able to move his shoulders through almost full range of motion with assistance from the student physical therapist.

Strength: To screen UE strength the patient was asked to squeeze the student physical therapist's hand. He was unable to make a complete fist and apply any pressure through his fingers. It was noted that the patient had significant weakness in his UEs and very limited arm movement. The patient was also lacking in grip strength. The patient

had weakness in his LEs, though not to the same degree as his UEs. Assessments of the patient's UE ROM and strength impairments were deferred to the OT.

Neurological: The quality of the patient's movement was slow and appeared uncoordinated. No spasticity was present when the student physical therapist moved the patient's LEs quickly through their range of motion.

Examination

Proprioception: A proprioception test was attempted while the patient was supine to determine whether he had any position sense of his lower extremities. The test could not be completed as the patient was confused about the testing procedure.

Coordination: To examine the patient's coordination he was asked to slide his heel upward on the shin of the opposite leg while in the supine position to avoid the impact of gravity. He was unsuccessful and lacked the necessary coordination to complete this task.

Range of Motion: The patient's ROM was more formally addressed during the sixth week to determine how it was impacting the quality of his gait. Despite what appeared to be a normal screen that was WFL at the initial examination, he was observed to have limited knee extension during ambulation. A true passive range of motion measure of knee extension could not be gathered initially as he would not allow the therapist to use any over-pressure. The patient complained of pain and tightness in the back of his thighs when trying to fully straighten his knees, which suggested that the restriction might be due, in part, to tight hamstring muscles. When knee extension

measurements were taken it was noted that he was lacking six degrees on the right and eleven degrees on the left.

Pain: The patient reported having pain with any movement. When asked to rate the severity of his pain on a 0-10 scale the patient was unable to report a number. His only statement regarding his pain was that "it hurts." The patient's pain appeared to play a significant role as during the examination he reported that he was not able to complete certain tasks such as walking because it was too painful.

Strength: In order to complete the assessment of strength we deviated from the regular protocols and opted to assess strength functionally by looking at the patient's ability to perform transfers as well as maintain his balance in both seated and standing positions. Manual muscle testing (MMT) could not be completed due to his complaints of pain and inability to assume the standard testing positions. Complaints of pain invalidate MMT grades as the patient's pain decreases their ability to exert maximum effort against the examiner's resistance leading to potentially inaccurate and meaningless results.[22] At the time of initial examination the patient appeared to have severe weakness in all of his extremities. The patient was unable to generate adequate strength in his LEs to transfer from his bed to the wheelchair; however, once seated in the wheelchair he demonstrated enough leg strength to stretch out his LEs and rest his feet on the edge of bed (EOB), crossing his left leg over the right. This task demonstrated more strength and coordination than previously noted at the beginning of the examination and appeared equal on both sides based on observation. Strength of his UEs was not formally assessed beyond the

initial screen. The patient also demonstrated core strength weakness as he needed assistance to sit up. Once seated upright he was unable to maintain that position on his own without tipping over backwards.

Bed Mobility: In order to assess the patient's mobility in bed he was asked to roll over onto his side in both directions. He required moderate assistance from the student physical therapist for this task and was only able to provide minimal help with his left hand by grabbing the bed rail when rolling toward his right. While assessing the patient's bed mobility it was observed that he was able to independently lift his LEs part way off the bed. From this observation and lifting his feet up to rest them on the EOB, it was assumed he would have enough strength to help complete a stand pivot transfer from the bed to a wheelchair.

Balance: Before a stand pivot transfer was attempted the patient's static seated and standing balance were assessed. With his feet supported firmly on the ground, the patient was unable to sit at EOB independently as he would start to fall backward when not given moderate assistance of 1 to keep his trunk upright. In order to stand the patient required moderate assistance of 1 to block his knees plus tactile cues at the sternum to stand tall. His standing balance was poor as he stood with a wide base of support (BOS). His knees began to buckle under him when the support to block them was removed for more than 10 seconds, and his UEs seemed to pull him forward and down with gravity. The patient experienced no difficulties with midline orientation, perception, or sensation. Thus, we believed that performance deficits were related to impaired strength.

A more formal standing balance assessment was completed early in week 3 when the patient was asked to stand without the use of an assistive device for 30 seconds while keeping his eyes open. He was able to do this successfully with a wide base of support. When asked to put his feet closer together, there was an increase in postural sway front-to-back and the patient could not maintain this position for 30 seconds. Prior to that time the patient was unable to stand without an assistive device or some kind of support for his UEs.

Transfers: To transfer from supine->sit a log roll technique was used to prevent increased strain on his neck and back. The patient required max assist of 2 for this transfer in order to control his trunk. He was unable to provide assistance for this task as he could not push off the bed with his UEs or move his legs over the side of the bed. To determine how much assistance the patient would require for a stand pivot transfer from the bed to a high-backed wheelchair, his ability to weight shift from side-side was assessed. He required moderate assistance of 2 to block his knees and support his UEs as he was able to follow instructions and turn his feet in the proper direction in preparation to sit down. After two minutes of sitting in the wheelchair the patient reported an increase in pain and refused to try any type of ambulation. He was unable to rate his pain or describe its location, but said it had increased with all the activity. The patient appeared tired and required more assistance for the second transfer back to bed. It took a max assist of 2 to transfer back to a seated position at the EOB, and then mod-max assist of 2 to return to a supine position: one to lift his legs up, and another to control his trunk descent down to the pillow.

Endurance: The patient's endurance did not last long as he required more assistance with getting back into bed after sitting in the wheelchair for only a couple of minutes. His lack of muscular endurance was noted as he fatigued quickly during the examination and was too tired to attempt ambulation. He appeared to have a decreased aerobic capacity in addition to poor muscle endurance.

Aerobic Capacity: Despite the patient denying having SOB in the cardiovascular screen, during completion of the examination it was noted that the patient needed frequent rest breaks in order to catch his breath. He appeared short winded as it required extra effort to respond to questions. Neither ambulation nor stairs were tested at the initial assessment due to his levels of fatigue and pain. The examination was continued at a future date as the patient was able.

Ambulation: The following day the patient's ambulation was assessed, and he required use of a platform walker and a therapist on either side to block his knees and hold his hands in place because he could not grip the handles.

Clinical Impression

In addition to his degenerative joint disease (DJD) and spondylolysis, it was hypothesized that the patient's suspected hyperextension injury compressed his spinal cord and created a condition where his limbs became temporarily flaccid, weak, and ineffective due to the insult to the spinal cord. These observations and the patient's consequential difficulties with balance and gait were consistent with his medical diagnosis of CCS. Further assessment of the mild cognitive impairment the patient

displayed was needed to determine whether this was a result of his injury. With minimal strength to complete basic functional movements such as balance and transfers our patient required assistance from others, was unable to live independently, and experienced participation restrictions related to activities such as mowing the lawn and accessing the surrounding community. It was speculated that the pre-morbid arthritis of his knees led to a decrease in physical activity, and that less time spent being active might contribute to a decreased activity tolerance and magnify the impact of fatigue during his recovery. It was anticipated that personal factors including the patient's older age and history of impaired knee joint integrity had the potential to impede his recovery. However, his level of motivation and amount of family support would help minimize the effect of these impairments.

Diagnosis

The patient presented with UE and LE weakness secondary to a SCI. He had difficulty with functional activities including bed mobility, balance, transfers, ambulation, and ADLS secondary to impairments in strength, ROM, and a decreased activity tolerance complicated by confusion. These limitations restricted his ability to drive his tractor or golf cart and interact with others in his surrounding community. The physical therapist working with this patient anticipated that with improvement of his strength and ROM impairments the patient would see improvement of his activity limitations as well as his participation restrictions. With the severity of the patient's UE weakness being much greater than the LE these and the patient's history of spine DJD

and spondylolysis, these findings are consistent with central cord syndrome and are likely associated with a low-impact hyperextension injury.[5, 9, 10, 11, 12, 23, 24] The PT diagnosis was best described by preferred practice patterns 5H: Impaired Motor Function, Peripheral Nerve Integrity, and Sensory Integrity Associated with Nonprogressive Disorders of the Spinal Cord, and 4I: Impaired Joint Mobility, Motor Function, Muscle Performance and Range of Motion Associated with Bony or Soft Tissue Injury listed in the *Guide To Physical Therapist Practice*.[25]

Prognosis

Patients with a diagnosis of spinal cord injury, and central cord syndrome specifically, tend to have varying degrees of functional return. Therefore, our patient's recovery depended on the severity of injury to his spinal cord.[10, 12] He was expected to improve his UE and LE strength impairments thus allowing for decreased activity limitations and participation restrictions. Typically a patient with central cord syndrome will regain function of their LEs first and then their UEs. Hand function is last to return if it happens at all.[10] Since our patient received help within a day of his fall and underwent early surgical intervention, he was expected to have a more complete recovery than someone where surgery was delayed more than 2 weeks according to a 2005 study done by Yamazaki et al.[16]

The literature also suggested that our patient's outcomes might be negatively impacted as patients over the age of 65 tend to have a poorer prognosis following CCS.[4, 5, 6, 7, 8] It was unclear how well the patient ambulated prior to his fall though it appeared

to be fair as he was able to get on a tractor to mow the lawn. The patient's report of his left knee giving out on multiple occasions prior to his spinal cord injury suggested that there was an underlying instability problem that would require future referral to an orthopedic specialist and, until addressed, would likely limit his overall recovery. It was also anticipated that the patient would experience residual functional difficulties as there currently is no cure for CCS.[20] Factors that would help our patient's prognosis included family support and motivation to go home, but because of the patient's age, pre-morbid conditions, and impaired cognitive status, the patient's prognosis was fair for return to independent living at home provided all his goals were met with skilled PT intervention. The plan was for 30 minute PT sessions 2x/day for 2 weeks in order to address his impairments and decrease his activity limitations and participation restrictions before being reevaluated.

CHAPTER III: INTERVENTION

The interventions utilized to progress this patient included therapeutic exercise and activities, aerobic capacity conditioning, balance training (both static and dynamic), assistive device training, gait training, stair training, and aquatic therapy. A sample therapy session during the patient's first week can be seen below in Table 1.

Table 1: Sample Therapy Session

Level of Assistance with Transfers	Balance	Exercises
Max assist of 1 for sit->stand, Mod assist of 2 for bed mobility, Mod assist of 2 for supine->sit	3 trials of static sitting, able to sit 10 seconds unsupported	Supine exercises: heel slides, hip ABD/ADD, SLR, SAQ, ankle pumps, all x10

ABD = Abduction, ADD = Adduction, SLR = Straight leg raise, SAQ = Short arc quad; The patient required assistance with all the exercises except ankle pumps early in the week.

The comprehensive second table viewed below shows the patient's weekly progression of interventions for the duration of his inpatient stay . The purpose of this table is to illustrate the patient's progression from week to week as well as within each week. Everything listed in the week was not completed every single day; however, exercises were done every day if there was time in order to continue to build strength. Stairs and ambulation activities were also scheduled separately for morning and afternoon as completion of one would often tire him out too much to perform the other.

Table 2: Progression of Interventions

Week #	Level of Assistance for Transfers	Time Standing and Distance of Ambulation	Balance	Exercises and Activities
1	Mod assist of 2 supine->sit EOB, Max A of 2 for sit->stand to block knees & support UEs, Pivot transfer Max A of 2, Bed mobility Mod A of 2	Max assist of 2 to stand at platform walker for 1.5 min to block knees initially and place UEs 2x with rest in-between, Mod assist of 1 to weight shift at platform 1.5 min x2 with rest in the middle	30 sec (10s unsupported) sitting at EOB	Supine: heel slides, hip ABD/ADD, SLR, SAQ, ankle pumps 10x
2	Mod assist of 2 with verbal cues for sit->stand & pivot transfer, Mod A of 1 supine->sit	Pt stood 2 min at platform walker(Mod A of 2); Amb 16' with w/ch follow, Mod A of 2; 10' rest 15' with follow – pt's L knee buckled, Stood 30s with FWW Min A of 1 for hand placement	Sat EOB with CGA for 2 min; 5 min CGA	Supine, Seated exercises in chair 15-20x with 1 lb weights bilateral ankles and light green theraband for resistance: HS curls, hip ABD/ADD, flexion, knee extension, ankle pumps; Pedal restorator 2-3 min; PROM/stretching of HS & HC
3	Min A of 2 for sit->stand, Mod A of 1 for sit->stand; Max assist of 2 for roll on ball; Min A of 1 for sit->stand and pivot transfer; Mod A of 1 for sitting on ball and to	20' x2 Min assist of 2 to guide platform walker + w/ch follow with rest in-between; Amb 12' FWW Mod A of 2 + w/ch follow; Amb 110' using platform walker with Min A of 2 +	Sat at edge of mat for 2 min with SBA of 1 and vc	Seated with 2 lb weights bilateral ankles 2 sets of 10 and blue theraband for resistance; Stood at parallel bars CGA of 2 for 2 min; Pedal restorator 10 min; Sat on ball with weight shifts and

	keep balance	w/ch follow and vc		trunk rotations 5x, Rolled on ball into quadruped position – rolled front/back 10x, lift extremities 3x
4	CGA of 1 for sit->stand from w/ch to FWW. Min A of 1 for sit->stand and pivot transfer with vc	Amb 30' x2 FWW with Min A of 1 to guide walker + w/ch follow with rest in-between and vc to keep feet apart before L knee began to buckle; Amb 20' with 2 turns using FWW and Min A of 1 + w/ch follow; Amb 30' with platform walker to increase distance before knees began to buckle; Amb 80' with FWW and Min A of 1	Sat at edge of mat and reached outside BOS in both directions 10x to grab rings and place on a target	Min A of 2 for going up/down (1) 4" step x4; Patient stepped up/down single 4" step 5x leading up with right, and 5x leading up with left; Standing exercises with 4 lbs on bilateral ankles HS curls, hip flexion/extension, toe raises, (sidelying for hip ABD/ADD)
5*	Supine->sit with supervision; CGA for stand-pivot transfer with minimal vc;	Amb 40' x2 with FWW, CGA, rest in-between with left knee buckling when fatigued, vc for wide BOS; Amb 50' with FWW and CGA of 1 + w/ch follow; Amb 70' with FWW and CGA of 1 before left knee gave out; Amb 20' x2 with 4WW for forward/backward and turns	Sat on ball with Mod A of 1, reaching outside BOS with right and left hands for rings to place on a target 2 sets of 20. Asked to hold ball above his head, did not have strength but could with help	Sit<->stand 6x with CGA to SBA; Patient stepped up/down (6) 4" steps with step-to gait pattern and Mod A of 2 for balance and catheter management

6**	SBA of 1 for sit->stand, CGA for pivot transfer	Amb 144' with CGA and FWW before left knee buckled; With new knee brace and FWW amb 165' in 2 min, rest and 175' in 2 min 20s	Sitting in w/ch patient played catch with ball 5x both directions	Completed OPTIMAL outcome measure(Difficulty 48% impaired, Confidence 57% impaired); Berg Balance Scale 21/56 – high fall risk (had to be lowered to mat when left knee gave out); Patient stepped up/down (4) 6" steps x3 CGA and 2 rails, no rest in-between; Knee extension measured: Lacking 6 degrees R, 11 degrees L
7***	Bed mobility – Ind, Sit ->stand with supervision, Bed transfers – supervision	Amb 160' x2 with FWW CGA; Amb 12' using SEC Min A to stabilize the cane; Amb 357' with 2 lbs on bilateral ankles with CGA and few vc to pick up toes in approx. 5-6 min; Amb with SBA approximately 500' using FWW		Partial sit-ups x20 vc to breathe throughout with support to patient's back with pillow; Side stepping in parallel bars, Mini squats x20 rest halfway SBA; (4) 6" steps x4 with 2 rails, supervision, and rest halfway; Aquatic therapy (see table 3)
10(last day)	SBA for amb incase knees give out, especially with longer distances and increased	Amb approximately 500' with FWW and SBA		Berg Balance Scale score 34/56 still high fall risk but improved

	fatigue			

* Catheter removed, weaned off neck brace
** LE Strength/ROM: bilateral DF 4/5 all others 5/5; L knee lacking 11 degrees extension, R knee lacking 6 degrees extension, all other WFL (within functional limits)
*** Aquatic therapy trial, development of wound on knee from extended wear of knee brace
Max A = Maximum assistance, Mod A = Moderate assistance, Min A = Minimal assistance, CGA = Contact guard assist, SBA = Stand by assistance, Ind = independent, EOB =Edge of bed, BOS = Base of Support, PROM = Passive range of motion, FWW = Front wheeled walker, 4WW = Four wheeled walker, w/ch = Wheelchair, SEC = Single end cane, vc = Verbal cues, ABD = Abduction, ADD = Adduction, HS Curls = Hamstring curls, SLR = Straight leg raise, SAQ = Short arc quad, HC = Heel cords, Amb = Ambulation, min = minute(s), lb = pound(s)

Therapeutic Exercise

We selected specific strengthening exercises in order to address the patient's LE strength impairments. These exercises, as described below, were chosen to target the weakened muscles of his extremities and his core. If successful, this intervention was expected to result in improved functional mobility with ambulation and improved balance. Additional indicators of success would include the patient requiring less assistance for exercise completion, and his ability to increase the number of repetitions or resistance of the exercises. This intervention was also designed to improve the patient's quality of movement and address his coordination impairments through the reinforcement of motor pathways, as well as improve his muscular endurance. We adapted the implementation of the intervention, such as increasing or decreasing resistance or repetitions, based on the patient's response along these measures, as described below.

Extremity Strength: At this facility, the occupational therapists focused on the UEs while the physical therapists addressed the LEs. To improve the patient's LE strength seated exercises were performed starting with a set of 10 and progressing to 2 sets of 20 repetitions with increased resistance based on the fatigue level of the patient. Once the

patient was able to do more than 20 repetitions, he changed the position of how he was doing them. Given the time constraints and only having a half hour to complete our intervention session, we elected not to have him do more than 20 repetitions.

At first no resistance was used, but the patient progressed from 1 pound to 2 and then 4 pounds, and the theraband resistance was increased from light green to blue. The patient started with 1 pound as that was the lightest resistance. Clinical judgment and patient observation were used for determining when to increase the resistance. The amount of resistance was intended to be challenging, yet allow the patient to have success in completing a set of 10-12 repetitions. Exercises were initially done supine before doing them in a seated position, and they were eventually done from a standing position. The exercises performed in sitting included hamstring curls and hip abduction with theraband resistance, marching to strengthen the hip flexors with weights on his ankles to increase the challenge, hip adduction with a ball between the knees, and knee extension and toe raises with weights on his ankles. Progression of the resistance applied can be viewed above in Table 2. To challenge the patient further these same exercises were done from a more functional standing position with the exception of hip abduction and adduction which were done from a side lying position to work against gravity.

Core Strength: During the examination we observed that the patient had weak core strength, and that it took moderate assistance to maintain an upright seated position. To strengthen his back muscles we positioned the patient prone on top of a ball, and with his head in a neutral position we asked him to extend each extremity outward using his

available range. To improve the patient's core strength he was instructed to sit on the edge of the mat and lean over onto his elbow in both directions and then use his trunk muscles to right himself. Early on this task was extremely difficult and the patient required min-mod assistance of 1. As the patient improved he was able to do this task independently. The patient would also see how long he could use his core muscles to hold himself upright before he would start to tip over backwards. At the start of therapy the patient was not able to hold himself up, but as he got stronger his time progressed to 30 seconds, a minute, 2 minutes then to 5 minutes etc. until he was able to sit for an extended period of time. His strength had improved enough by the beginning of the 6 th week to switch from a high-backed wheelchair to a regular wheelchair as he was able to sit up and control his trunk movements.

Additional areas of therapeutic exercise performed were flexibility (including assisted stretching exercises) and PROM to address the patient's ROM impairments. Completion of these exercises fulfilled the purpose of maintaining what motion he had and worked to prevent the development of contractures while he lacked the strength to move his extremities through their full range. The patient was able to straighten his knee further with less muscle tension for completing SLRs in the supine and side-lying positions without requiring assistance. Initially the patient required assistance for stretching of his hamstring and heel cord muscles and completion of PROM. Several weeks into his recovery he was able to use a leg lifter to assist with independent stretching. Following patient education about the importance of continuing the flexibility

exercises outside of scheduled therapy sessions, PT assisted PROM was discontinued by the third week.

Aerobic Capacity

The patient spent time on a seated restorator in order to improve his aerobic conditioning. We expected this treatment to result in such improvements as the patient having less SOB, needing fewer and shorter rest breaks between exercises, and having the ability to increase his therapy sessions beyond half an hour. Initially he would tire after 2 minutes, but towards the end of his inpatient stay he wanted to pedal for 10-15 minutes. This intervention was successful as he was able to pedal against increased resistance following completion of other activities such as ambulation, stairs, or other exercises without needing additional time to recover his breath. The resistance level was set using clinical judgment for a level where the patient was challenged but still successful. Time spent on the seated restorator occurred earlier in the patient's rehabilitation when he had limited success with functional activities. The intervention focus shifted toward improving the patient's aerobic capacity through functional activities such as ambulation and stairs after the second week. Time spent on the seated restorator was used more as a reward to motivate the patient to complete other tasks during his therapy session. Therefore, the time on the restorator did not follow a specific protocol and was more patient driven.

Therapeutic Activities

The therapeutic activities we performed consisted of dynamic balance, ambulation, and stairs. Each of these separate activities are described below.

Dynamic Balance: To address limitations in this area the therapist assisted the patient in completing activities that challenged his balance. We planned to assess the efficacy of this treatment by measuring the patient's decreased need for assistance, and his lower risk of falling as evidenced by a Berg balance assessment.[25] With improvement of his balance we also anticipated that the patient would experience improvements in transfers and ambulation. In order to improve dynamic seated balance the patient was seated on a large therapy ball and asked to reach outside his BOS in both directions. This activity required the physical therapist to provide assistance by sitting on a stool behind the patient to prevent the ball from rolling too much in addition to helping the patient maintain his balance by providing verbal and tactile cues. The patient showed improvement by having the ability to reach and grab an object outside his base of support on one side of his body and then rotate to bring that object and place it on the opposite side of his body while he remained seated on a therapy ball, an activity he was unable to do initially.

Standing dynamic balance was addressed by increasing the difficulty of the ambulatory route by having the patient navigate around more turns, and ask him to look in different directions as he walked. The patient completed a Berg balance assessment[26] during the 6th week in order to add an objective measure of balance. This measure

assessed his fall risk by looking at his ability to complete different functional tasks. It was not completed earlier in his rehabilitation due to his low functional status. The patient scored a 21 out of a possible 56 which indicated that he was at a high risk for falling (< 45 = high fall risk).

Assistive Devices and Ambulation: Prior to ambulation the patient stood in the platform walker and was instructed in weight shifting. Instruction on use of different assistive devices was necessary before the initiation of gait activities. Improvements in patient ambulation would be observed by using the least restrictive form of AD, a decrease in the amount of assistance needed for ambulation, appearance of a smoother gait pattern, and the patient's ability to ambulate longer distances. When he first started ambulating, the patient used a platform walker with moderate assistance of 2 to ambulate a short distance before his knees started to buckle. This activity required two people in order to guide the platform walker and help him maintain proper arm placement because he was lacking in grip strength. A third person followed closely behind with the patient's wheelchair in case his knees gave out and he could not go any farther. Details and progression of his ambulation are included in Table 2. The patient demonstrated improvement and showed he was ready to use a FWW by having more endurance and needing less assistance to guide the platform walker, in addition to his improved ability to grip the handles with his hands. It is important to note that during weeks 3 and 4 the patient used both the platform walker and a FWW. Use of two ADs occurred for differing purposes in order to accomplish separate goals. When the platform walker was used it required less work and intervention focused on trying to increase the patient's ambulation

distance. Using a FWW was more functional, required him to work harder, and was used to work on improving his gait pattern and strength. The patient's knees had a tendency to buckle whenever he ambulated for longer distances or became fatigued from completing exercises with his left knee buckling more often than his right knee. Following a visit to an orthopedic specialist at the end of the sixth week, the patient was given a neoprene knee brace to wear for extra support of his knee joint to minimize the frequency of buckling during ambulation. While a SEC was attempted during the seventh week, it was not pursued as he required assistance to stabilize the cane and was unsafe without help. Following the initiation of gait, the patient worked on this task each day. While the patient was unable to improve his distance of ambulation without addressing the orthopedic condition of his knees, he was able to develop a smoother pattern and decrease the level of assistance needed to ambulate.

Stairs: Walking up and down stairs was incorporated as part of the patient's intervention plan because his initial inability to do so was an obstacle to his safe return home. As the patient improved it was expected that he would require less assistance and cuing for safety, need fewer rest breaks, and have the strength to lift his extremities up onto a regulation-sized step. When the patient's ambulation had improved significantly, he was challenged to use the stairs. He started on the smaller 4" steps and would go up and down a single step while needing frequent rest breaks. Progression can be viewed in Table 2 starting at week 4, and soon the patient was climbing up several regulation-sized stairs multiple times without pausing to rest in-between. Two rails and CGA were used each time to maintain patient safety.

Our patient's physical therapy sessions were organized so that he would do the most challenging activity first and then finish with the exercises. This allowed our patient to have better success with the more challenging tasks and not become so discouraged when progress was slow. The patient was motivated to complete his therapy because he wanted to go home. His attitude towards coming to therapy sessions improved as he saw the progress he was making, and he began to ask what challenge we had for him each session. He spent a total of 10 weeks at this rehabilitation facility. There is no data for weeks 8, 9, or 10 except for the last day when the student physical therapist happened to stop by the clinic to say hello.

Aquatic Therapy

We implemented aquatic therapy on the seventh week. This was two weeks following catheter removal to ensure proper bladder and bowel function. Aquatic therapy involved walking on an underwater treadmill with the goal of increasing the patient's ability to ambulate farther without putting the same amount of stress on his knee joints with the hope that it would carry over to land. A sample of exercises performed in the water to help increase his LE strength along with details of ambulation can be seen below in Table 3. Aquatic therapy was discontinued at the end of the 7th week due to a lack of carry-over to land and minimal increases in ambulation speed or distance. In addition to a lack of carry-over, the development of a small wound on his knee from extended wear of the neoprene knee brace (despite recommendations to take it off for periods of time) led to the discontinuation of aquatic therapy after only two sessions.

Table 3: Exercises done in aquatic therapy

- Mini squats x15 with verbal cues
- Stepping in all directions using handrail
- Step-ups
- Single leg balance
- Ambulation: 5 minutes between 0.5 and 1.0 mph

Exercises were tolerated without knee pain with patient lowered in water to just above waist level, mph= miles per hour

Modifications to the interventions were made along the way depending on the patient's status day-to-day, and patient education was provided throughout his course of therapy. Each day the patient was asked to do either a more challenging type of exercise, a few more repetitions, or increase the weight. Ambulation and stair climbing were usually split up into morning and afternoon, but were typically done almost every day as tolerated along with additional exercises to help improve the patient's strength and functional mobility. Continually trying different interventions was used to challenge the patient and find where his limits were in order to show him the progress he had made. The progression of interventions completed by the patient can be viewed in Table 2.

CHAPTER IV: OUTCOMES

One of the outcome measures utilized to show improvements in the patient's balance was the Berg Balance Scale.[25] This measure looks at a patient's ability to complete 14 different tasks (both static and dynamic) of increasing complexity. Tasks vary and include doing a sit-to-stand transfer, retrieving an object from the floor, turning in a circle, and standing on one foot among several others. The patient is given a score of 0-4 for each task with 56 being the best score possible. On the patient's discharge day he scored a 34, which was a 13 point (or 24%) improvement from when his balance was first assessed a month earlier. A baseline Berg could not be completed at the initial examination with such a low functional status as he could not complete any of the functional tasks at that time and would have shown a floor effect. The test-retest reliability for community dwelling elderly was found to be excellent with an intraclass correlation coefficient (ICC) value of 0.91 while the minimal detectable change (MDC) for community dwelling elderly individuals with an initial Berg score of 0-24 is 4.6.[26]

A second measure was the 6 Minute Walk Test (6MWT).[27] This test determines how far a patient is able to walk in six minutes. In this instance there were a couple variations from the standard testing procedure. Typically performance of this test requires the patient to be able to ambulate without assistance; however, in this case assistance was close by and available if necessary as the patient's knee would occasionally buckle without warning. Another difference was that verbal instructions could not be given for completion of this test as the patient would compromise his safety. He would increase his

speed and cross one leg over the other in a scissoring pattern, increasing the frequency of his knees buckling, while trying to ambulate farther. The patient walked approximately 360 feet in 6 minutes. The patient's functional success was limited due to the prior condition of his knees. When the patient's muscles became fatigued his left knee would have a greater tendency to buckle. Similar to the Berg, this test could not be performed initially as another floor effect would have occurred. Other psychometric properties included an MDC value (for spinal cord injuries less than 12 months) of 150 feet or a 22% change, an excellent inter-and intra-rater reliability with ICC values of 0.99, and a better responsiveness for individuals with incomplete SCIs from 1-3 months as the 6MWT was unable to detect any walking improvements after 6 months.[27]

The Outpatient Physical Therapy Improvement Assessment Log, also known as OPTIMAL, which is typically used for outpatients, was selected by the supervising PT as another measure, and completed during the sixth week of his stay. With this tool patients rate their confidence and level of difficulty in completing certain activities such as rolling, supine->sit transfers, sitting, balance, standing, bending, squatting, walking, and climbing stairs among a few others. This measure included two separate scales where a score of zero represented no difficulty completing an activity and one hundred percent confidence in one's ability to complete an activity. The patient had a difficulty score of 48% impairment and a confidence score of 57% impairment. Most of this outcome measure's psychometric properties are not established, and those few that are (criterion and construct validity, as well as responsiveness and ceiling effects) regard musculoskeletal diagnoses rather than spinal cord injuries.[28] For criterion validity the

baseline difficulty scores had a strong correlation (-0.80) with the PF-10 scores (physical function subscale of the SF-36) and a moderate correlation (-0.65) with the Visual Analog Scale (VAS) scores. Baseline confidence scores had strong correlation (-0.72) with PF-10 scores and moderate correlation (-0.60) with VAS scores.[28] Construct validity can be viewed below in Table 4.

Table 4: Construct Validity of the OPTIMAL

Difficulty	2 Weeks	4 Weeks	Confidence	2 Weeks	4 Weeks
Trunk	0.82	0.87	Trunk	0.87	0.87
LE	0.95	0.96	LE	0.95	0.95
UE	0.93	0.94	UE	0.94	0.95

The first 3 columns deal with Cronbach alphas for the subscales of the Difficulty scale while the last 3 columns represent the Cronbach alphas for the subscales of the Confidence scale.

In terms of responsiveness, the four week mark was most sensitive to change as 4 of the 6 subscales had medium effect sizes ranging from 0.21-0.44.[28] There was a small effect size for the UE subscale of the Difficulty scale, and a negative effect size for the UE subscale of the Confidence scale indicating that participants became less confident with mobility over time. Some of the items on the OPTIMAL had minimal to moderate ceiling effects.

With our patient having limited financial resources, once he had exhausted his Medicare coverage it was too much of a financial burden to continue his therapy at this facility. In addition, the patient was no longer making sufficient gains with ambulation without having an orthopedic doctor address the issue of his knee buckling. He was deemed ready for discharge from PT as he was independent with his bed mobility and

only required supervision on occasion for safety during transfers. The duration of the inpatient stay was longer than typical for those with CCS reported in the literature due to his living in a rural location and the difficulty he would have with getting to an outpatient clinic. Therefore, when the patient was discharged it was recommended that he receive homecare services to make sure he had a smooth transition back to his home environment, and that he was capable of everything he needed to do to be successful in that location.

CHAPTER V: DISCUSSION

The purpose of this case report was to show how physical therapy intervention was used to rehabilitate a 76 year-old male following a fall that resulted in a SCI. Physical therapy interventions included therapeutic exercises and activities, aerobic conditioning, balance training, assistive device and gait training, and aquatic therapy. The patient's increase in ambulation distance, decreased level of assistance for ADLs, and improved balance and activity tolerance might have improved from our physical therapy interventions as the patient improved his motor patterns and strength by completing therapeutic activities and exercises. It is also possible the patient's improvements resulted from healing over time. Another possible factor in the patient's improvement was his change in perspective. The patient's ability to follow multiple-step commands and not repeat the same questions multiple times by the end of the second week suggested that his cognition was improving. As his stay became longer he recognized that he was better off than many of the other patients and this provided extra motivation and encouraged him to work harder in order to accomplish his goals and return home. Aquatic therapy was utilized to see if it would allow the patient to increase his activity level and ambulate further distances before his left knee would buckle. The pool had the luxury of the bottom being a treadmill so the patient's speed could be increased as tolerated to improve function; however, the patient did not experience significant gains in either ambulation speed or distance.

Central cord syndrome is one type of incomplete SCI. This syndrome is characterized by greater weakness in the UEs than the LEs, bladder dysfunction, and varying degrees of sensory loss. In our patient's case, clinical observations of significant difficulty using his UEs, poor balance, and weakness in the LEs indicated the existence of this condition.[2, 9] Several studies have suggested that a majority of patients undergoing PT for CCS demonstrate improvement of activity limitations and participation restrictions by addressing impairments of decreased strength, balance, and gait abnormalities.[6, 10, 12] Investigators have found that formal education, comorbidities, age at injury, and development of spasticity were also significant predictors of functional recovery.[8] While still within the 1-4 month time frame of rehabilitation for patients with CCS as reported in the literature, at the time of discharge our patient had a lower level of recovery than other CCS patients as most patients impacted by CCS have greatly improved motor function after rehabilitation.[5] This patient's fair recovery may have been due to the impact of personal factors including his older age and the musculoskeletal condition of his knees. He reported having poor knee function prior to his fall, and it is unlikely that his limitation in ambulation distance would resolve completely until this issue was addressed further.

Although this particular patient remained at a high fall risk, Shumway-Cook, Gruber, Baldwin, and Liao (1997) found a nonlinear relationship between fall risk and Berg score for elderly patients over 65.[29] They reported that while a 1 point drop between 54 and 56 was associated with a 3%-4% increase in fall risk, a 1 point change in score between 46 and 54 was associated with a 6%-8% increase in fall risk.[29] The patient's

final Berg score was 34 (a 13 point improvement) which does not reach the 46 point cut-off for a decreased risk of falling. If this prediction model holds true for older adults with CCS then the patient would have made notable improvement even though he was still at a high risk for falls.

It is important to note that there were several limitations in the completion of this case report. One such limitation is the lack of follow up with this patient after discharge. If this case report would be repeated a more thorough systems review would be documented. A simple neurologic review was completed through observation and it was noted that the patient did not have difficulty with speaking or swallowing. Manual muscle testing was not completed until three-fourths of the way into his stay. It was not completed initially due to invalidation by pain. However, ideally this would have been completed much earlier to have an additional outcome measure to show how the patient had progressed. It may have been helpful to use a different type of measurement as handheld dynamometry has been shown to be more sensitive to change than MMT in patients with SCI.[30] Taking ROM measurements of his hips and ankles in addition to his knees at an earlier time would have been useful to confirm that the flexibility exercises and stretches were working to maintain his motion. Further assessment of hamstring length would have been helpful to determine how it was impacting his ROM and ambulation. While similar interventions would have been used, a stronger emphasis would be placed on functional activities, and greater thought would have gone into determining a specified time and amount of resistance in completing therapeutic exercises. A more detailed assessment of his knee to decide how it was impacting his

ambulation and earlier referral to an orthopedist would have helped determine which interventions the patient should spend the most time completing. Another limitation was the use of the OPTIMAL as an outcome measure as it had a limited value. This measure only showed a snapshot of the patient at a single point in time in his recovery process and was not able to show progress or lack of progress in his recovery. Several activities were not appropriate for this patient at the time such as running and jumping so they were excluded from the calculations. This measure could have been of more value had it been completed twice, once early in his stay and a second time just before discharge in order to show his improvement. Additional outcome measures would have been useful to help quantify improvements in areas such as gait speed, ambulation distance, aerobic fitness, and climbing stairs.

This case report concerns a particular individual and CCS is not a homogenous condition. Thus, results from a single patient case report cannot be generalized to older adults with CCS and even more broadly to a population of individuals with incomplete SCI. Further research is needed to document outcomes of patients with CCS as two separate studies found those who were treated conservatively recovered much slower than patients who underwent surgical intervention.[16,17] Additional randomized control trials to compare physical therapy interventions with other management of CCS would be beneficial in order to determine the effectiveness of physical therapy for this patient population as a case report cannot demonstrate causality or evidence of treatment effectiveness. Future research could involve looking at the effectiveness of aquatic therapy for increasing the return of strength to those affected by CCS. Additional studies

are needed to determine the optimal intensity and duration of therapy in order to improve functional walking outcomes following CCS.

CHAPTER VI: CONCLUSION

Even though our patient was still at a high risk for falls at the time of discharge due to the prior condition of his knees, physical therapy appears to be an effective means for improving strength, balance, and overall functional mobility of patients with CCS secondary to a fall. This case is relevant for physical therapists as the older population continues to grow. With this growth, a greater percentage of individuals seeking physical therapy in the future may present with CSS given that the risk of falling increases with age and falling is a common mechanism associated with this diagnosis in older adults.

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