5-2013

Anterior Cervical Decompression and Fusion on Neck Range of Motion, Pain and Function: A Prospective Analysis

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ANTERIOR CERVICAL DECOMPRESSION AND FUSION ON NECK RANGE OF MOTION, PAIN AND FUNCTION: A PROSPECTIVE ANALYSIS

By

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A doctoral project submitted in partial fulfillment

of the requirements for the

Doctor of Physical Therapy

Department of Physical Therapy

School of Allied Health Sciences

The Graduate College

University of Nevada, Las Vegas

May 2013

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

THE GRADUATE COLLEGE

We recommend the doctoral project prepared under our supervision by

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Entitled

Anterior Cervical Decompression and Fusion on Neck Range of Motion, Pain and Function: A Prospective Analysis

be accepted in partial fulfillment of the requirements for the degree of

Doctor of Physical Therapy
Department of Physical Therapy

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May 2013

Abstract

Summary of background data: Intractable cervical radiculopathy secondary to stenosis or herniated nucleus pulposus is commonly treated with an anterior cervical decompression and fusion procedure (ACDF). However, there is little evidence in the literature that demonstrates the impact such surgery has on long term range of motion outcomes.

Study Design: Prospective, non-experimental.

Objective: The objective of this study was to compare cervical range of motion and patient reported outcomes in patients before and after a 1, 2 or 3 level ACDF.

Patient Sample: 46 patients.

Methods*:* Patients undergoing an ACDF for cervical radiculopathy had their cervical range of motion measured preoperatively, and also at 3 months and 6 months following the procedure. Neck Disability Index and pain visual analog scale values were also recorded at the same time.

Outcome Measures: The following were measured preoperatively and also at 3 months and 6 months after ACDF: active range of motion (full and painfree) in three planes (i.e., sagittal, coronal and horizontal), pain Visual Analog Scale (VAS), Neck Disability Index (NDI), and headache frequency.

Results: Both painfree and full active range of motion did not change significantly from the preoperative measurement to the 3 month postoperative measurement (ps > .05). However, painfree and full active range of motion did increase significantly in all three

planes of motion from the preoperative measurement to the 6 month postoperative measurement regardless of the number of levels fused (ps ≤ .023). VAS, NDI and headache frequency all improved significantly over time (ps ≤ .017).

Conclusion: Our results suggest that patients who have had an ACDF for cervical radiculopathy will experience improved range of motion in the long term following their procedure. In addition, patients can expect a decrease in pain, an improvement in neck function, and a decrease in headache frequency over the long term.

Keywords: cervical, range of motion, radiculopathy, outcomes

Acknowledgements

Merrill R. Landers, PT, DPT, PhD, OCS
Emilio Puentedura, PT, PhD, DPT, OCS, GDMT, CSMT, FAAOMPT
Michael Daubs, MD, FACS

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Introduction

Disabling Neck pain is a common condition within the adult general population with 12-month prevalence estimates ranging from 2 to 13.5%. Cervical radiculopathy, however, is less common; with a prevalence of 3.3 cases per 1000 people.[1-6] Disabling neck pain and radiculopathy often result in considerable disability, substantial economic hardship and is often treated with surgical intervention. One of the most common surgical treatments for chronic neck pain and radiculopathy is an anterior cervical decompression and fusion (ACDF). It is typically used when conservative management has been unsuccessful.[7, 8] ACDF is thought to relieve pressure on nerve roots through decompression and is purported to help prevent further irritation at the level by fusing the vertebra above and below together.[7, 9]

ACDF has been shown to be a successful treatment for neck and radiating arm pain. [8-15] In a majority of patients that undergo ACDF, pain is lessened or alleviated, even when tested up to six years afterwards.[16] ACDF was also shown to be an effective treatment for improving function at a 10 year follow up.[8] In a study performed by Bohlman et al[13], it was found that 95.1% of patients had complete recovery of all radicular symptoms, including radiating arm pain, sensory deficits, and motor deficits at a 6 year follow up.

Regardless of the clinical success of ACDF in terms of pain relief, there is uncertainty regarding the possible permanent loss of range of motion (ROM) following the procedure. Often the term 'fusion' is equated with a loss of motion because the fused

segment/s will no longer contribute to cervical ROM. Since many people that are experiencing chronic radiculopathy and neck pain already have limited motion, the idea of losing more ROM is disconcerting.[9] When ROM is lost, it affects more than just the ability to turn the neck, it may also impact function and may limit activities of daily living.[15] While it is logical to think that a loss of segmental motion from ACDF will lead to an overall decrease in cervical ROM, it is thought by some that adjacent segments may become more mobile in order to make up for the loss of motion at the fused segments.[17-20] The downstream consequences of ACDF in terms of range of motion and function have not received much attention in the literature;[9] therefore, physicians cannot confidently give evidence-based assurance on whether ROM will actually increase or decrease. The primary purpose of this study was to determine the influence of ACDF on overall cervical ROM measured in the short (3 months post surgery) and long term (6 months post surgery). In addition, a secondary purpose was to determine the outcomes for ACDF in terms of pain, function, and headache frequency.

Methods

Patients

All patients were initially evaluated and treated by fellowship-trained spine surgeons prior to being enrolled in the study. Patients that had failed non-surgical treatment for cervical radiculopathy (home exercise program or formal physical therapy) and were deemed candidates for an ACDF were approached about the study by the surgeon and/or his staff. Following an informational discussion about the study, patients that were willing to be involved in the study were referred to the research team for formal inclusion screening. All acceptable patients for this study were formally consented under institutional review board approval[‡]. Inclusion criteria were patients between the ages of 20 and 65 who were scheduled for an ACDF. If patients possessed any of the following, they were excluded from the study: previous cervical surgeries, C1-C2 fusion, cervical vertebral fractures as the primary reason for fusion, congenital neck abnormalities, history of stroke or spinal cord injury, pregnancy, and other potentially confounding co-morbidities. A total of 49 patients were screened for participation and 46 were enrolled in the study (Figure 1). Of the patients that started the study, 20 had a one-level fusion, 13 had a two-level fusion, and 13 had a three-level fusion (Figure 1). Demographic and descriptive patient data are in Table 1.

Overall study design

[‡] UNLV Biomedical IRB protocol 1103-3750

To assess the change in ROM due to ACDF a time series design was employed wherein all patients were measured before surgery (pre-op) and then twice after surgery (post-op) at the 3 month and 6 month points (Figure 2). At each of the same time points, the following questionnaires were completed: pain visual analog scale (VAS), and Neck Disability Index (NDI). In addition, headache frequency within the last month was recorded. After surgery, formal physical therapy was given as an option for every patient; however, many opted for a home exercise program of ROM exercises instead. All patients were instructed to begin ROM exercises immediately following surgery and to progress the ROM as tolerated. Patients were not given a brace or soft collar.

Outcome measures

Cervical range of motion. The cervical range of motion device (CROM[ψ]) is considered the gold standard for measuring cervical ROM.[21] The CROM utilizes inclinometers and a compass. It demonstrates excellent reliability with intraclass correlation coefficients (ICCs) ranging from 0.88 to 0.96[22] and correlates highly with radiographic measurements of ROM.[22,23] The sagittal plane minimal detectable change (MDC) is 11.6°, the coronal plane MDC is 7.8°, and the horizontal plane MDC is 11.0°.[22] These MDC values were extrapolated by adding together the MDCs for the component motions in each cardinal plane [i.e. sagittal plane (flexion + extension), coronal plane (right sidebending + left sidebending), and horizontal plane (right rotation + left rotation)].

[ψ]Patterson Medical / Sammons Preston Corporate Headquarters, 1000 Remington Blvd., Suite 210, Bolingbrook, IL 60440-5117, Phone: (630)378-6000

Pain visual analog scale. The pain Visual Analog Scale (VAS) is a self-report assessment of subjective pain level. It is marked on a standard 100 mm line, with 0 indicating no pain and 100 indicating severe pain. The reliability of this tool is excellent with an ICC = 0.97.[24] The VAS has been shown to correlate with age, balance score, gait scores, mobility scores and falls in the previous year.[25] The MDC was determined to be 1.8 points.[25,26]

Neck Disability Index. The Neck Disability Index (NDI) is a self-report questionnaire measuring disability due to neck pathology. It is composed of ten items with scores ranging from 0 (low disability) to 50 points (high disability). The reliability of the NDI is excellent with an ICC = .93.[27] In addition, it is correlated with general health outcomes (e.g., Medical Outcomes Study Short Form 36). [27] The MDC for the NDI is 5 points.[28]

Headache. Because headaches are commonly cervicogenic and frequently reported in those with neck pain, patients were asked how many headaches they had experienced in the previous month. Pain referred to the head from the cervical spine is considered cervicogenic and represents 14–18% of all chronic headaches.[29]

Procedures

After completion of the questionnaires, patients performed 3 minutes of light, sub-pain threshold cervical motion (10 times with 5 second holds) prior to measurement in the following planes: flexion, extension, right side-bending, left side-bending, right rotation, and left rotation. AROM was then measured as the patient sat upright in a chair with arms resting in their lap. To minimize the upper thoracic contribution to ROM patients

were asked to sit upright and avoid slumping. A CROM device was used to assess active range of motion (AROM) in sagittal, coronal and horizontal planes (Table 2; Illustration 1). Patients were asked to actively move their neck in the plane being tested and to stop at the point at which they first experienced pain. The measurement of this position was then taken and was defined as painfree active range of motion (pAROM). The patient was then asked to move as far into that same plane as they could tolerate. A second measurement was then taken and this was defined as the total AROM. These measurements were then aggregated into three total measurements for both pAROM and AROM: sagittal plane (flexion + extension), coronal plane (right sidebending + left sidebending), and horizontal plane (right rotation + left rotation).

Data analysis

All data were analyzed using PASW 18.0.[a] Data were analyzed in two ways, a per-protocol-analysis (PPA) and an intent-to-treat analysis (ITT). In the PPA, only those patients who completed all three measurement points were included in the computations. In the ITT, all patients who were lost to follow-up at the 6 month measurement point were included in the analysis using imputation (last observation carried forward method). Patients that only completed the preoperative measurement were not included in the ITT analysis; only those patients that had at least one postoperative measurement were included. A 3 (fusion level: one-level, two-level, three-level) X 3 (time: baseline, 3-month, 6-month) mixed factorial analysis of variance

[a]IBM SPSS North American Headquarters, 233 S. Wacker Drive, 11th Floor, Chicago, IL 60606, Phone: (312)651-3000

(ANOVA) was used to determine the influence of ACDF on the following outcome variables: sagittal pAROM and AROM, coronal pAROM and AROM, horizontal pAROM and AROM, pain VAS, NDI, headache frequency. Exploratory analysis of covariate candidates (gender, age, smoking, secondary gain, [30,31] physical therapy before ACDF, physical therapy after ACDF) found no suitable covariates; therefore, standard factorial ANOVAs were conducted.

Results

No interactions were observed for any of the outcomes (sagittal pAROM, coronal pAROM, horizontal pAROM, sagittal AROM, coronal AROM, horizontal AROM, VAS, NDI, headache frequency); however, several significant main effects were noted (Tables 3,5,7). Means and standard deviations are detailed in tables 2, 4 and 6. Results for the ITT analysis were consistent with the PPA; there were no significant interactions for any of the outcomes.

pAROM

Painfree AROM improved significantly in all three planes of motion over the course of the trial (Tables 2-3, Figure 3-4; ps ≤ .011). In all three planes, there was no change from the preoperative measurement to the 3 month measurement (ps ≥ .155); however, there were significant improvements from 3 months to 6 months (ps ≤ .009). In the short term (3 month measurement), only 11 of 32 increased their sagittal pAROM beyond the MDC; however, at the long term measurement point (6 months), 20 of the 32 patients showed increased sagittal pAROM beyond the MDC. For coronal plane pAROM, 15 improved beyond the MDC in the short term while 20 of 32 did in the long term. For horizontal pAROM, 12 out of 32 improved beyond the MDC in the short term while 16 out of 32 did in the long term.

AROM

Total AROM improved significantly over the course of the trial for sagittal and horizontal AROM (Tables 4-5, Figure 3-4; ps ≤ .023); however, coronal plane AROM did not improve over the course of the trial (ps = .085). In all three planes, there was no change from the preoperative measurement to the 3 month measurement (ps = 1.000); however, there were significant improvements from 3 months to 6 months (ps ≤ .008). For total AROM in the sagittal plane, only 12 out of 32 improved beyond the MDC at the 3 month measurement point, whereas 15 out of 32 did by the 6 month measurement point. For coronal AROM in the short term, 12 improved beyond the MDC at the 3 month measurement point whereas 16 had by 6 months. For horizontal AROM by 3 months, 12 out of 32 had improved (i.e., beyond MDC) and by 6 months 14 had.

Pain

Pain decreased significantly over the duration of the study (Tables 6-7; $p < .001$) with most of the pain decreasing over the first 3 months of the trial ($p < .001$); it did not change over the last 3 months of the trial ($p = .119$). Over the first three months, 21 of the 32 patients showed decreased pain beyond the MDC, and 23 of the 32 patients showed decreased pain beyond the MDC over the entire duration of the study.

NDI

NDI score improved over all time periods of the study regardless of how many levels were fused (ps ≤ .005). Over the first 3 months, 27 of the 32 patients showed improved

function beyond the MDC while one additional patient (28 of the 32) showed improved function beyond the MDC over the entire duration of the study.

Headache frequency

Headache frequency did not improve over the first 3 months of the trial ($p = .806$) or from the 3 month to 6 month measurement points ($p = .475$) but did over the entire 6 month trial ($p = .017$) (Tables 6-7). Over the first 3 months, 12 of the 32 patients reported a decrease in frequency of HA. Two of the patients reported no change in headache frequency, 5 reported an increase, and 13 reported no headaches. Over the entire 6 months of the trial, 14 of the 32 patients reported a decrease in frequency of headache. One of the patients reported no change in headache frequency, 4 reported an increase, and 13 reported no headaches.

Discussion

The primary purpose of our study was to determine the effect of ACDF on overall cervical range of motion through a prospective study. Our results show that patients can expect an increase in total and painfree ROM after ACDF in both the short (3 months) and longer term (6 months). In addition to the improved ROM noted in our study, patients also experienced an improvement in function and a decrease in pain and headaches over time for all levels of fusion.

Increased ROM was seen in all three cardinal planes of cervical motion. In terms of percent improvement, the greatest ROM gained in the long term was seen with those who had a single level fusion (figure 4). That is, patients with a single level fusion improved more than those with two and three level fusions. From a statistical perspective, there was no difference in the total long term AROM for those with one and two level fusions; however, both one and two level fusions had better long term outcomes than three or more levels. The plane that improved the most for AROM was sagittal (flexion/extension) at 14.20% (range: 5.79-18.96%) followed by coronal (sidebending) at 13.42% (range: 7.82-22.16%) and then horizontal (rotation) at 10.50% (range: 6.11-13.67%). Nearly half of the patients who underwent an ACDF regardless of the number of fused levels improved beyond the MDC: 46.9% of patients improved in the sagittal plane, 50.0% improved in the coronal plane, and 43.8% improved in the horizontal plane.

The average cervical AROM for all three planes at the 6 month point fall within the ranges of healthy patients from a study conducted by Youdas et al.[32] The ranges for patients aged 30-79 are as follows: sagittal (77.7-150 degrees), coronal (50.8-90.1 degrees), horizontal (99.7-156 degrees). In our study, the ranges for total AROM at 6 months are: sagittal (82.6-101.1 degrees), coronal (55.8-76.71 degrees), horizontal (99.7-122.7 degrees).

Painfree ROM demonstrated a larger percentage of improvement than total AROM. Again, patients with one and two level fusions had better outcomes than those who had 3 or more levels. Coronal plane movement also demonstrated the greatest improvement in pAROM at 20.54% (11.64-29.13%), followed by sagittal at 20.13% (14.88-25.83%) and horizontal at 14.38% (11.00-16.54%). More than half of the patients undergoing ACDF regardless of the number of fused segments experienced improved pAROM beyond the MDC: 60.5% of patients improved in the sagittal plane, 60.5% improved in the coronal plane, and 50.0% improved in the horizontal plane. These results suggest that pAROM will improve or hold constant for the majority of patients who will have an ACDF procedure.

While improved ROM from an ACDF procedure is certainly a desired outcome for those who have painful and restricted neck motion, it may cause unintended downstream consequences. Segments adjacent to fused segments may experience a higher level of mechanical stress and may develop accelerated disc degeneration.[33-35] Focal segmental

motion at the fused segment is limited with a successful fusion, but as our study results show, overall motion is improved. It is logical that the improved ROM following ACDF is a result of a decrease in pain. Rudolfsson et al[36] showed that neck pain decreased cervical ROM. Our study demonstrated a decrease in pain (71.9%) over time regardless of the number of levels fused (Table 7). Increased ROM may have been due to the general decrease in pain that resulted from a lack of mechanical impingement or irritation of pain-sensitive tissues. The majority of patients (93.8%) exhibited a significant decrease of pain (i.e., beyond MDC) over the long term. Decreased neck pain resulting from mechanical impingement/irritation may also decrease high tone in paraspinal neck musculature. While a significant portion of the ROM improvement may be from pain relief, increased ROM is also a result of increased segmental motion at the levels that remain un-fused and mobile. This effect has been shown to occur in an *in vitro* biomechanical study, and may be a factor following ACDF.[37]

While a small minority of patients experienced an increase in headache frequency after 6 months, a majority (73.7%) of the patients had a decreased frequency. Since a majority of these patients exhibited a decrease in headache frequency, it is logical that these headaches may have been cervicogenic, the primary cause of which is thought to be referred from the C1, C2, or C3 nerve roots.[38] However, in our study, only one patient had a fusion that involved the upper cervical segments of C2-C3; most had fusions in the middle to lower cervical spine and, therefore, would not likely have had any involvement of the upper three cervical nerve roots. Bogduk[38] has suggested that no

nerve root pathology below the level of C3 has been shown to precipitate headache. Since all but 1 patient in our study had middle to lower ACDF procedures, it is logical that C1-C3 nerve root impingement was not a primary cause of the headaches observed in our patients. Instead, it is most likely that these headaches may have originated from pain-generated high tone/tension in the middle to lower cervical paraspinal muscles. The prevalence of tension-type headaches at 42% in a global population study supports the notion that high tone may be a more likely cause of the headaches in our study than typical cervicogenic headaches from C1-C3 nerve root impingement.[39]

The majority of patients (87.5% beyond MDC) had decreased disability as measured by the NDI in the long term. A decrease in disability suggests that patients had improved function.[40, 41] While the NDI is only a self-report of neck disability, it is a significant predictive factor for determining patient outcomes following ACDF.[42] In our population, the decrease in disability was consistent with the improvements in ROM and pain. It is logical that improvements in these impairments are what triggered gains in perceived neck function.

The strengths of our study include the fact that it was prospectively performed and all measurements and outcome data were collected outside of the surgeons' office by unbiased, independent researchers. The limitations include the smaller sample size and the drop-out rate (30%).

Conclusion

The results of this study suggest that patients who have undergone an ACDF will experience improved range of motion in the long term following their procedure. In addition, they will also likely have a decrease in pain and headache frequency, as well as an improvement in overall neck function in the long term.

Appendix

Table 1. Statistical profile for all patients including age, gender, smoker.

	All patients	1-level	2-levels	3 or more levels
Number of patients	46	20	13	13
Mean age with SD	53.3 years (SD = 11.0)	50.4 years (SD = 11.6)	50.7 years (SD = 9.6)	60.6 years (SD = 8.4)
Gender	23 males 23 females	12 males 8 females	6 males 7 females	5 males 8 females
Smoker	Yes = 13	Yes = 3	Yes = 8	Yes = 2
Physical therapy before ACDF	Yes = 21	Yes = 7	Yes = 8	Yes = 6
Physical therapy after ACDF	Yes = 14	Yes = 4	Yes = 1	Yes = 9
Secondary gain (i.e., personal injury case, workers' compensation claim)	Yes = 7	Yes = 4	Yes = 1	Yes = 2
Cause	Traumatic = 15 Arthritic = 7 Unknown = 24	Traumatic = 8 Arthritic = 4 Unknown = 8	Traumatic = 3 Arthritic = 1 Unknown = 9	Traumatic = 4 Arthritic = 2 Unknown = 7

Table 2. Means and standard deviations for painfree active range of motion for the per protocol analysis.

		Pre-op	3 months post-op	6 months post-op
Sagittal	1 level	81.9 28.24	98.9 22.0	103.9 19.7
	2 levels	87.5 21.3	93.2 16.7	101.0 16.0
	3 levels	66.8 29.5	67.0 19.6	80.0 16.5
Coronal	1 level	59.4 15.2	71.9 16.2	77.7 15.9
	2 levels	61.5 27.7	63.0 14.8	74.5 13.9
	3 levels	49.6 27.8	49.8 13.0	55.4 16.1
Horizontal	1 level	107.3 13.2	124.0 20.1	125.2 16.3
	2 levels	110.1 31.1	113.3 23.4	122.5 15.9
	3 levels	85.0 30.5	84.0 24.8	98.1 21.0

Table 3. Interactions and main effects for the per protocol analysis of painfree active range of motion.

	Time by level interaction	Main effect for time	Time pairwise comparisons		Main effect for level	Level pairwise comparisons	
Sagittal	p=.319 (power=.288)	p=.001	Pre-op to 3 months	p=.155	p=.003	1 to 2	p=1.00
			3 months to 6 months	p=.002		2 to 3	p=.024
			Pre-op to 6 months	p=.001		1 to 3	p=.003
Coronal	p=.444 (power=.251)	p=.007	Pre-op to 3 months	p=.808	p=.017	1 to 2	p=1.00
			3 months to 6 months	p=.009		2 to 3	p=.118
			Pre-op to 6 months	p=.011		1 to 3	p=.017
Horizontal	p=.174 (power=.476)	p<.001	Pre-op to 3 months	p=.272	p=.003	1 to 2	p=1.00
			3 months to 6 months	p=.007		2 to 3	p=.024
			Pre-op to 6 months	p=.001		1 to 3	p=.003

Table 4. Means and standard deviations for total active range of motion for the per protocol analysis.

		Pre-op	3 months post-op	6 months post-op
Sagittal	1 level	84.6 24.8	96.9 24.9	101.1 21.5
	2 levels	95.6 17.1	93.5 16.8	101.0 16.0
	3 levels	70.6 27.7	67.8 19.9	82.6 14.6
Coronal	1 level	61.7 12.9	69.0 18.9	76.1 16.3
	2 levels	68.8 20.4	63.0 14.8	74.8 13.9
	3 levels	51.8 27.9	51.2 13.8	55.8 15.8
Horizontal	1 level	107.9 10.4	122.6 23.7	122.7 18.3
	2 levels	115.6 22.0	113.3 23.4	122.5 15.9
	3 levels	90.0 28.3	85.0 24.9	99.7 21.4

Table 5. Interactions and main effects for total active range of motion for the per protocol analysis.

	Time by level interaction	Main effect for time	Time pairwise comparisons		Main effect for level	Level pairwise comparisons	
Sagittal	p=.202 (power=.422)	p=.004	Pre-op to 3 months	p=1.00	p=.020	1 to 2	p=1.00
			3 months to 6 months	p=.003		2 to 3	p=.046
			Pre-op to 6 months	p=.023		1 to 3	p=.040
Coronal	p=.444 (power=.258)	p=.034	Pre-op to 3 months	p=1.00	p=.021	1 to 2	p=1.00
			3 months to 6 months	p=.008		2 to 3	p=.072
			Pre-op to 6 months	p=.085		1 to 3	p=.030
Horizontal	p=.059 (power=.658)	p=.004	Pre-op to 3 months	p=1.00	p=.004	1 to 2	p=1.00
			3 months to 6 months	p=.006		2 to 3	p=.022
			Pre-op to 6 months	p=.015		1 to 3	p=.006

Table 6. Means and standard deviations of the VAS, NDI, and headaches.

		Pre-op	3 months post-op	6 months post-op
VAS	1 level	4.9 3.2	1.4 2.1	1.0 1.5
	2 levels	6.5 3.8	2.4 2.2	.9 1.9
	3 levels	7.4 1.7	3.8 2.2	3.4 2.3
NDI	1 level	14.9 9.1	5.5 7.4	3.6 5.8
	2 levels	20.0 11.9	9.0 6.3	5.6 5.6
	3 levels	28.4 5.7	18.0 9.0	13.1 7.3
Headaches	1 level	17.4 27.8	11.4 24.7	3.1 7.9
	2 levels	13.0 12.0	2.3 4.2	2.1 4.2
	3 levels	7.7 12.4	8.5 11.1	4.5 9.1

Table 7. Interactions and main effects for Visual Analog Scale (VAS), Neck Disability Index (NDI), and headaches for the per protocol analysis.

PPA	Time by level interaction	Main effect for time	Time pairwise comparisons		Main effect for level	Level pairwise comparisons	
VAS	p=.604 (power=.200)	p<.001	Pre-op to 3 months	p<.001	p=.010	1 to 2	p=.855
			3 months to 6 months	p=.119		2 to 3	p=.223
			Pre-op to 6 months	p<.001		1 to 3	p=.008
NDI	p=.716 (power=.159)	p<.001	Pre-op to 3 months	p<.001	p=.001	1 to 2	p=.683
			3 months to 6 months	p=.005		2 to 3	p=.035
			Pre-op to 6 months	p<.001		1 to 3	p<.001
Headaches	p=.555 (power=.178)	p=.043	Pre-op to 3 months	p=.806	p=.575	1 to 2	p=1.00
			3 months to 6 months	p=.475		2 to 3	p=.024
			Pre-op to 6 months	p=.017		1 to 3	p=.003

Figure 1. Schematic for patient eligibility, follow-up, and analysis.

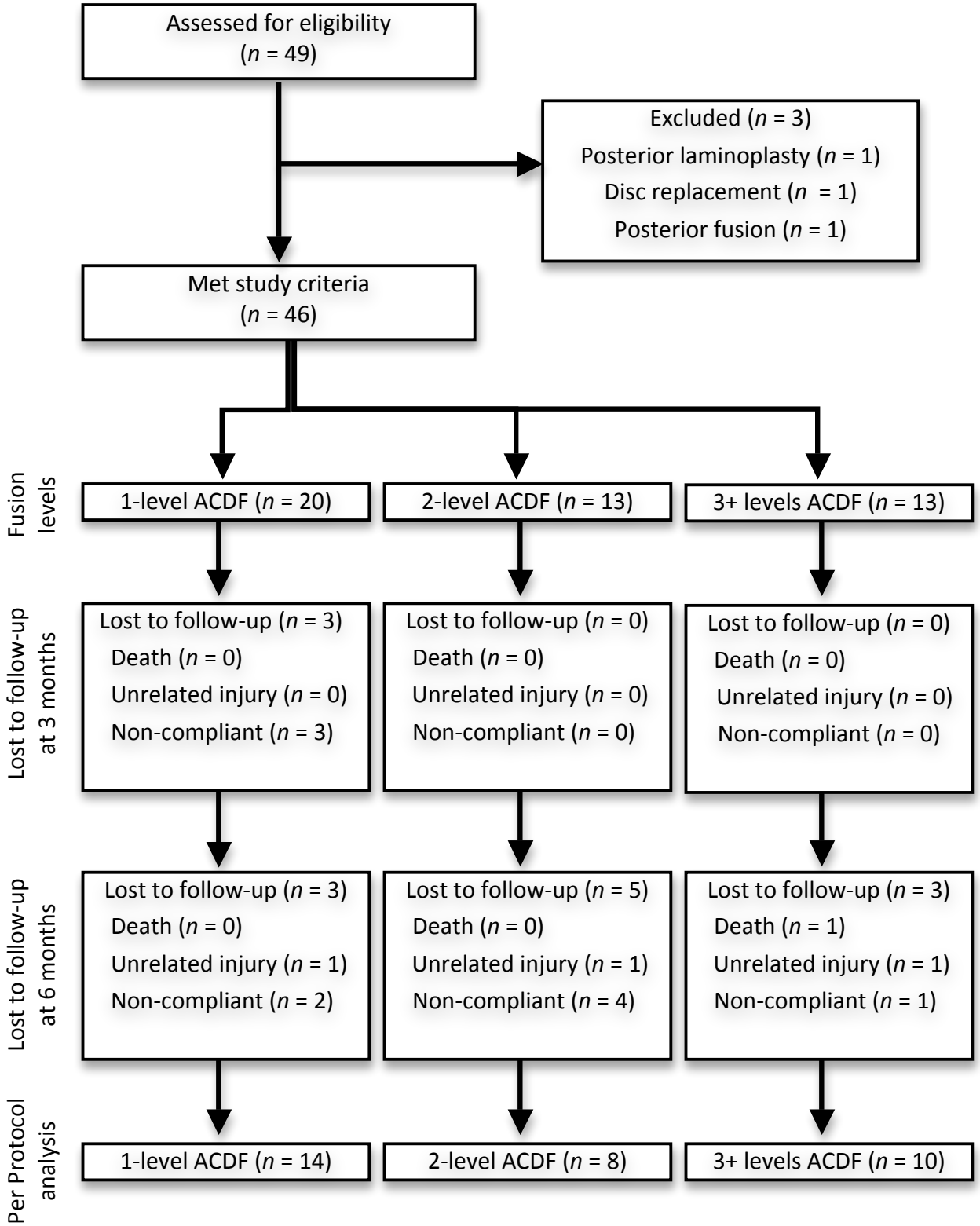


Figure 2. Schematic for study design.

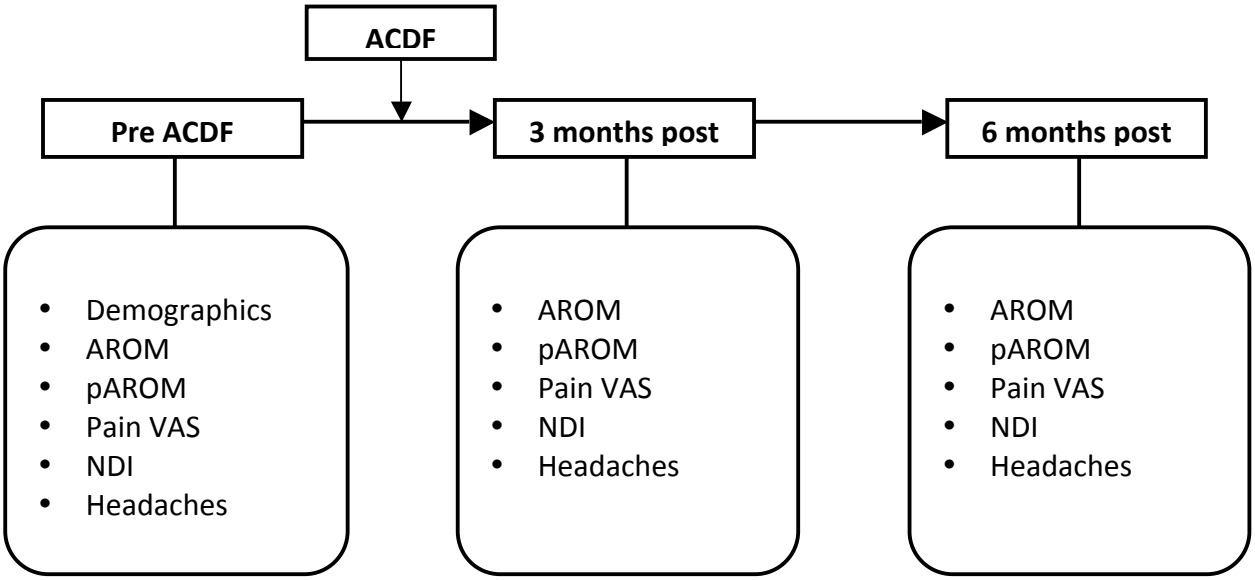


Figure 3. Overall range of motion (sagittal + coronal + horizontal) for active painfree and total range of motion.

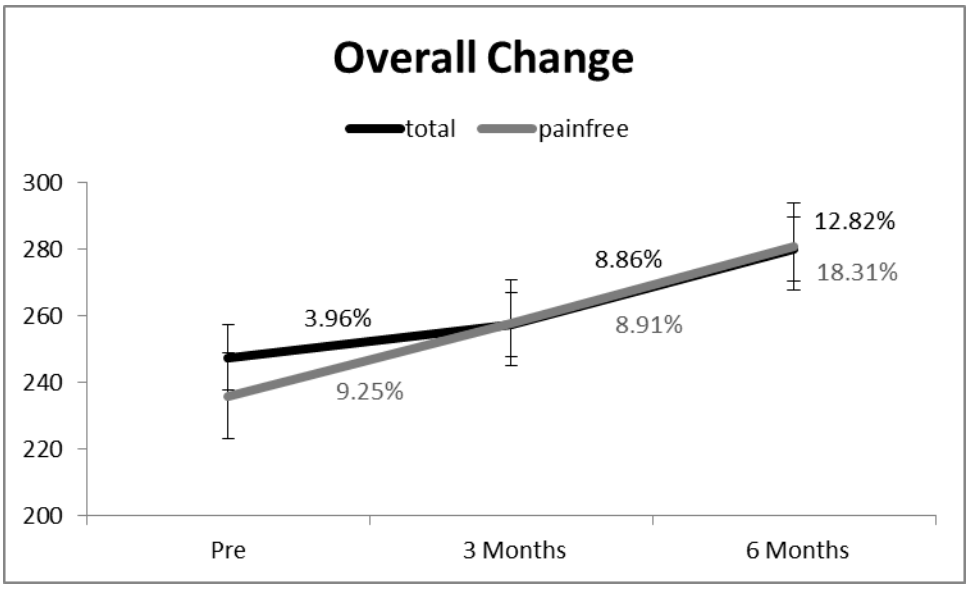


Figure 4. Active painfree and total ROM for each of the 3 planes of motion.

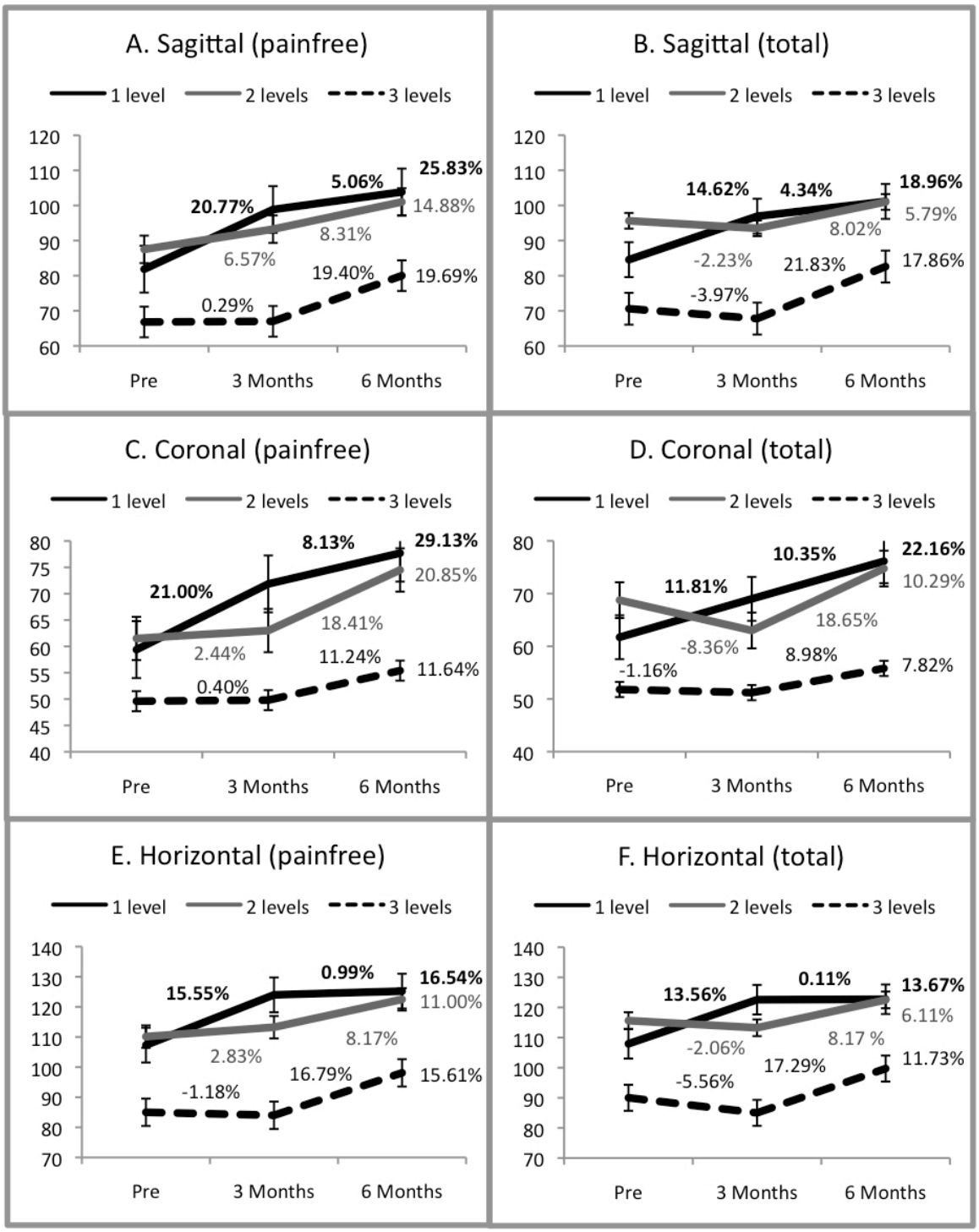
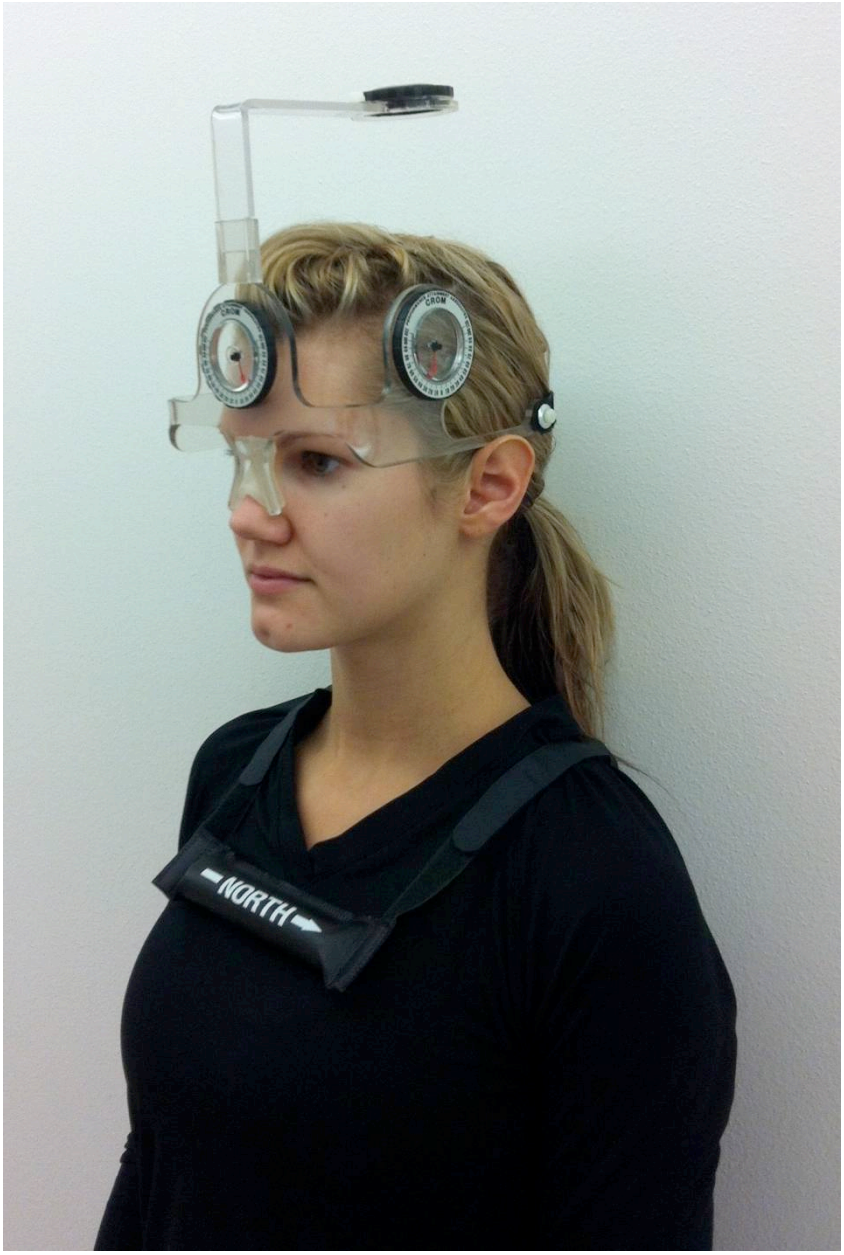


Illustration 1. Patient sitting upright in measurement position with CROM device.



This paper is currently undergoing second review for the Spine Journal.

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Vitas

Kate Addis

Education

- Doctorate of Physical Therapy Las Vegas, NV May 2013
  - The University of Nevada Las Vegas
- Bachelor of Arts in Psychology Portland, OR May 2008
  - Lewis & Clark College

Professional Internships

- **Concentra** Las Vegas, NV January 2013-Arpil 2013
  - Conducted comprehensive evaluations and treatments of patients with acute job related orthopedic conditions: ankle sprains, rotator cuff tears, lumbar strains, cervical strains, internal derangement, and multiple traumas.
- **Health South Rehabilitation** Henderson, NV October 2012-December 2012
  - Evaluated and treated patients in an acute rehabilitation setting with emphasis on complex patients with multiple co-morbidities, total knee replacements, total hip replacements, uremic myopathy, stroke and general debility.
- **Sunrise Hospital** Las Vegas, NV July 2012-September 2012
  - Performed all elements of patient management in the pediatric intensive care unit, general pediatric unit, orthopedic unit, and intensive care unit.
- **Balance Center** Las Vegas, NV June 2011-July 2011
  - Examined patients with vestibular and balance conditions using computerized dynamic posturography, vestibular evoked myogenic potential, dynamic visual acuity testing, and high frequency vestibular reflex testing.
- **Island Dolphin Care** Key Largo, FL June 2007-July 2007
  - Supported therapists with planning, instructing and documenting dolphin assisted therapy sessions designed to enhance motor skills, encourage socialization, and motivate communication in children with special needs.

Work Experience

- **Graduate Assistant** Las Vegas, NV June 2012-July2012
  - Assisted faculty and tutored students in physical therapy graduate courses at the University of Nevada Las Vegas: Gross Anatomy & Physiology, Evidenced Based Practice, Movement Science and Electro-physical Agents.
- **Edwin Suarez Physical Therapy** Las Vegas, NV June 2009-March 2012
  - Provided physical therapist with support during patient treatments in a general orthopedic and pediatric setting.
  - Instructed group fitness classes, designed personal workout programs, and trained clients on an individual basis.

Professional Memberships/Certifications

- **Certified Personal Trainer** October 2009-Present
  - National Strength and Conditioning Association
- **American Physical Therapy Association** July 2010-Present
  - Nevada, Research & Orthopedic sections
  - Attended Combined Sections Meeting 2011 & 2012
- **Health Care Provider CPR and AED Certification** April 2011-Present
  - American Heart Association
- **American Academy of Orthopaedic Manual Physical Therapists** November 2011-Present

JASON LONGHURST

EDUCATION

Brigham Young University
Bachelors in Exercise Science
University of Nevada – Las Vegas
Doctorate of Physical Therapy

CLININCAL EXPERIENCE

Student Physical Therapist
HealthSouth Rehab Hospital
Provo, Utah
Las Vegas, Nevada
April 2010 May 2013
January 2013 – April 2013 Henderson, Nevada
Worked as part of a team to evaluate and treat patients with many different neurologic and orthopedic pathologies. Participated in weekly interdisciplinary team conferences. Developed skills handling neurologically involved patients using Neuro-IFRAH techniques. Experience with autoambulator, bioness, bodyweight supported gait, and interactive metronome.

Student Physical Therapist October 2012 – December 2012
Southern Hills Hospital Las Vegas, Nevada
Evaluated and treated patients in the acute inpatient setting. Participated in wound care evaluations and treatment. Evaluated patients to determine best location for discharge. Developed effective patient education skills. Experience with psychiatric, orthopedics, med surg, IMC, and ICU units.

Student Physical Therapist July 2012 – October 2012 *Concentra Urgent Care* Las Vegas, Nevada
Evaluation and treatment of patients with many acute orthopedic pathologies. Emphasis on manual therapy with experience in soft tissue mobilization, joint mobilization and manipulation techniques. Participated in Human performance evaluations. Actively worked with MDs to determine best and most effective course of treatment in occupational medicine setting. Experience with worker's compensation.

Student Physical Therapist June 2011 – July 2011 *Rehab Authority* Pocatello, Idaho
Evaluated and treated patients with multiple orthopedic impairments, with an emphasis on low back and neck pathologies. Coordinated patient care and billing with support staff. Participated in marketing of outpatient physical therapy services to local physicians and surgeons.

CERTIFICATIONS AND ADDITIONAL SKILLS

CPR and AED certified
Bilingual - Spanish
Mentored Research
American Heart Association
Reading, Writing, Speaking
Currently in peer review
Anterior cervical decompression and fusion on neck range of motion pain and function: a prospective analysis.
Boy Scouts of America Eagle Scout Volunteer Cub Scout Leader!

Bree-lyn vom Steeg

Education

- Doctorate of Physical Therapy
    - University of Nevada Las Vegas, 2013
- Bachelor of Science in General Science
    - University of Oregon, 2007

Professional Experience

- La Pine Physical Therapy, La Pine, OR January-April 2013
    - Evaluated and treated a variety of conditions in an outpatient, orthopedic setting
- Elk's Rehab Hospital, Boise, Idaho Oct-Dec 2012
    - Examined and evaluated pts in a rehab setting
    - Participated in pt planning and family meetings
- Providence Saint Peter's Hospital, Olympia, WA July-Sept 2012
    - Treated a combination of orthopedic, neurological and ICU patients
    - Evaluated and treated pts and participated in discharge planning
- Rehab Services of Nevada, Winnemucca, NV June-July 2011
    - Combination of orthopedic outpatient, acute, and skilled nursing facility
    - Examined, evaluated and treated patients in a variety of different settings

Research Experience

- Mentored Group Research Project Currently under peer review

Student Investigator

- Anterior cervical decompression and fusion on active neck range of motion

Professional Membership/Certifications

- Member of APTA and NV Chapter of APTA since 2010
- Healthcare Provider CPR and AED Certifications since 2007

Continuing Education

- CSM, February 2011
- Understand and Explain Pain with Dr. Lorimer Moseley, August 2010
- Pain Society of Oregon, March 2013