5-2014

Biopsychosocial Variables Predict Compensation and Medical Costs of Radiofrequency Neurotomy in Utah Workers' Compensation Patients

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BIOPSYCHOSOCIAL VARIABLES PREDICT COMPENSATION AND MEDICAL COSTS OF RADIOFREQUENCY NEUROTOMY IN UTAH WORKERS' COMPENSATION PATIENTS

by

Amie L. Smith

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF ARTS

in

Psychology

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UTAH STATE UNIVERSITY
Logan, Utah

2014

ABSTRACT

Biopsychosocial Variables Predict Compensation and Medical Costs of Radiofrequency Neurotomy in Utah Workers' Compensation Patients

by

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Back pain is a highly prevalent condition with a lifetime prevalence estimate of up to 85%. Treating back pain is also expensive and has been cited as one of the most expensive medical conditions. Surgical treatments for back pain have been researched and studies have demonstrated escalating costs for these procedures, but less research has been conducted on the costs of less-invasive procedures such as radiofrequency neurotomy. Radiofrequency neurotomy is used to treat facet joint pain and typically offers temporary pain relief by coagulating the affected nerve with radiofrequency waves to block pain messages from reaching the brain.

The present study aimed to fill this gap in the literature by analyzing the compensation and medical costs of a cohort of participants who received neurotomy through the Workers Compensation Fund of Utah (WCFU) between 1998 and 2009. It was hypothesized that presurgical biopsychosocial characteristics of participants would be correlated with costs. Costs and presurgical variables were garnered from a review of participants' medical records and claim data from the WCFU.

Compensation costs had a mean of $28,030.79 (*SD* = $39,351.47) and a median of $13,004.12. Medical costs had a mean of $79,227.89 (*SD* = $89,947.37) and a median of $47,945.04. Furthermore, biopsychosocial characteristics were strongly correlated to cost outcomes in both bivariate correlations and regression models. An increased number of total prior back and neck surgeries and lawyer involvement in the case were both predictive of higher compensation costs. Those variables plus a history of depression were predictive of higher medical costs.

This was the first study to document costs associated with spinal radiofrequency neurotomy. The costs proved to be substantial, variable, and commensurate with costs seen in other types of spine surgeries. The findings also add to the line of research suggesting that a biopsychosocial framework can be used to predict costs in spine care. Discovering participant characteristics that may predict high costs can inform policy-level decisions for payers, and can be used by providers to influence care decisions. More research on the presurgical variables may also lead to interventions at the patient level that can ameliorate high cost outcomes.

(69 pages)

PUBLIC ABSTRACT

Biopsychosocial Variables Predict Compensation and Medical Costs of Radiofrequency Neurotomy in Utah Workers' Compensation Patients

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Back pain is one of the most expensive medical conditions to treat. There has been a great deal of research showing that back pain surgery is expensive, but less is known about the costs of less-invasive spine procedures such as radiofrequency neurotomy. Radiofrequency neurotomy is used to treat facet joint pain and typically offers temporary pain relief by coagulating the affected nerve with radiofrequency waves to block pain messages from reaching the brain. This study aimed to document the costs of radiofrequency neurotomy in a group of participants who received the procedure through the Workers' Compensation Fund of Utah (WCFU). Another goal of the study was to determine if any biopsychosocial variables of participants predicted costs. Biopsychosocial variables include biological (e.g., age), psychological (e.g., depression), and social (e.g., hiring a lawyer) characteristics about participants. Costs and characteristics were collected from participant medical records.

Compensation and medical costs were collected; compensation costs were wage payouts as a result of an on-the-job injury, and medical costs were direct medical costs.

Both compensation and medical costs were substantial and similar to other more invasive procedures. Furthermore, three biopsychosocial characteristics predicted high costs. A high number of prior back and neck surgery and lawyer involvement predicted high compensation costs. Those same variables plus history of depression predicted high medical costs.

This was the first known study to document medical and compensation costs associated with spinal radiofrequency neurotomy. The findings add to the line of research suggesting that a biopsychosocial framework can be used to predict costs in spine care. Discovering participant characteristics that may predict high costs can inform policy-level decisions for insurers, and can be used by medical providers to influence patient care decisions. More research on the presurgical variables may lead to interventions at the patient level that can reduce high cost outcomes which could benefit both patients and payers.

ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. M. Scott DeBerard, for trusting my abilities and knowing when to encourage and when to challenge me. Many friends and colleagues helped push and support me through this process, but I would particularly like to thank mentor and friend Dr. Anthony Wheeler who gave me practical help, advice, and lots of laughs as he modeled how to be a well-balanced scholar.

Finally, I am immensely grateful for my husband, Shane Johnson, who has supported me through the challenge of graduate education with a full heart. I could not have done this without you.

Amie L. Smith

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CHAPTER I

INTRODUCTION

Back pain is highly prevalent with an estimated 54 million Americans or approximately 26% of the population experiencing low back pain at any given time (Deyo, Mizra, & Martin, 2006). Low back pain is the fifth most common reason for all physician office visits in the U.S. and the majority of these visits are to generalists and family physicians (Hart, Deyo, & Cherkin, 1995). The lifetime prevalence for nonspecific back pain is estimated to be between 60-85% (World Health Organization [WHO], 2003). It is estimated that approximately 10% of patients with acute back pain will develop chronic back pain, which is defined as pain lasting longer than 3 months (Freburger et al., 2009). Chronic back pain is typically much more difficult to treat and often results in substantial personal and economic tolls both for the patient and society in general.

Treating back pain is also expensive. One estimate cited in the *Journal of American Medical Association (JAMA)* placed the total societal cost of back pain at $86 billion in 2005 (Martin et al., 2008). Back pain has been cited as one of the costliest medical conditions relative to other conditions (e.g., ischemic heart disease, motor vehicle accidents, and acute respiratory infections; Druss, Marcus, Olfson, & Pincus, 2002). Data from six large U.S. corporations indicated the diagnoses of "mechanical low back disorder" and "back disorder not specified as low back" (thoracic and cervical pathologies) were both in the top 10 costliest conditions (Goetzel, Hawkins, Ozminkowski, & Wang, 2003). A troubling recent finding is that costs of treating back pain are increasing substantially without corresponding improvement in patient outcomes. From 1997 to 2005, spending on spine disorders increased faster than spending for all other medical conditions, yet this increase did not coincide with improvements in health status and quality of life in patients (Martin et al., 2008).

One area of back pain treatment that has received considerable recent attention due to substantially escalating costs is spine surgery. Although there are a variety of spine surgeries, the most common procedure is discectomy. Discectomy involves removing a portion of the interverebral disc that is placing pressure on delicate nerves in the spine. Removing impinging disc material alleviates this pressure and is consequently thought to reduce pain and improve physical functioning (DeBerard, LaCaille, Spielmans, Colledge, & Parlin, 2009). Lumbar fusion is another common procedure that involves stabilizing spinal segments through establishment of a bony fusion between vertebrae (Block, Gatchel, Deardorff, & Guyer, 2003). Both discectomy and fusion rates appear to be increasing. A study using Medicare data reported that discectomy rates increased from 1.7 per 1,000 patients to 2.1 per 1,000 over an 11-year period (Weinstein, Lurie, Olson, Bronner, & Fischer, 2006). This study found that during that same period, fusion rates increased even faster from 0.3 per 1,000 to 1.1 per 1,000. The growing popularity of fusion is also borne out in increasing medical costs. Medical costs increased more than 500% in a Medicare population of patients receiving fusion between 1992 and 2003 (Weinstein et al., 2006). Further, a sample of workers' compensation patients who had spinal fusion found an increase of 174% in the average medical costs per patient across a 12 year span (Wheeler, Gundy, & DeBerard, 2012).

Given the significant and escalating costs associated with spine surgical procedures, both payers and providers have interest in less invasive procedures to control pain. One such procedure is radiofrequency neurotomy (alternately called rhizotomy). Radiofrequency neurotomy is a minimally invasive and localized procedure designed to alleviate back pain (Manchikanti, 2004). Radiofrequency neurotomy is a treatment of choice for facet joint pain, which is estimated to account for 39% of patients with chronic neck pain, 34% of those with chronic thoracic spine pain and 27% with chronic lumbar pain (Manchukonda, Manchikanti, Cash, Pampati, & Manchikanti, 2007). During the procedure, radiofrequency waves are applied directly to the root of the nerve that enervates the joint to coagulate and temporarily block the pain signals from reaching the brain (Bogduk, 2008). Functional outcomes for the procedure can be tepid and mixed. A study of workers' compensation patients found that 40% of patients were totally disabled and over 50% reported poor back/neck functioning and dissatisfaction with their condition at 2-year follow-up (Christensen, 2010).

A study that sampled Medicare patients receiving facet joint interventions estimated that between 1997 and 2006, facet joint interventions (which included intraarticular injections and nerve blocks in addition to neurotomy) increased by 543% (Manchikanti et al., 2010). That same study found that the costs for all facet joint interventions rose 123% from 2002 to 2006; in 2006 total costs were over $511 million. Unfortunately this study did not parse out the cost data for just the radiofrequency neurotomy procedures. Despite the popularity of radiofrequency neurotomy, little is known about the costs associated with the procedure and, more importantly, what characteristics of patients might be associated with higher or lower costs.

One proposed method to predict cost outcomes is to use a biopsychosocial framework. Proponents of the biopsychosocial model maintain that it is the integration of biological, psychological and social factors that best explain illness (Engel, 1977). The model has been well documented as predictive of functional outcomes in back pain (DeBerard et al., 2009). Predictive cost models are beginning to emerge for some of the surgical interventions for spine pain such as discectomy (DeBerard, Wheeler, Gundy, Stein, & Colledge, 2011) and fusion (Wheeler et al., 2012). The outcomes of these studies suggest that certain presurgical characteristics of patients can predict both medical and compensation costs. However, such predictive models have yet to be established for radiofrequency neurotomy. Therefore, more research is needed on the costs of radiofrequency neurotomy and what presurgical patient variables may influence such costs. The purposes of this study were to (a) identify and document the medical and compensation costs of radiofrequency neurotomy; (b) identify and document the presurgical biopsychosocial characteristics of such patients; and (c) determine if presurgical biopsychosocial variables are predictive of cost outcomes.

CHAPTER II

REVIEW OF THE LITERATURE

Prevalence of Back Pain

The high prevalence of back pain is well documented. The ubiquitous nature of back pain is shown in a study that collected results from the National Health Interview Study in 2002 that surveyed adults in the U.S. about pain they had experienced. Low back pain was the most common pain syndrome reported with 26.4% of the population (54 million) endorsing back pain within the past 3 months (Deyo et al., 2006). A recent systematic review investigated the global prevalence of low back pain and found a point prevalence of 11.9% and a 1-month prevalence of 23.2% (Hoy et al., 2012). WHO (2003) issued a report on the global impact of musculoskeletal disorders and estimated the lifetime prevalence rate for nonspecific back pain to be between 60-85%. While most episodes of back pain are resolved quickly, an estimated 10% of patients experience pain that lasts longer than 3 months, which then becomes defined as chronic back pain (Freburger et al., 2009).

It also appears the prevalence of back pain is increasing. The prevalence of chronic low back pain increased by 162% between 1992 and 2006 (Freburger et al., 2009). Another study used the Medical Expenditure Panel Survey (MEPS) to identify trends in spine problems. The MEPS collects utilization rates for outpatient, inpatient, and emergency room visits and prescriptions for different ailments from a nationally representative sample (Martin et al., 2009). The authors found that the total number of visits for spine problems increased from 10.8% to 13.5% for the U.S. population between 1997-2006.

Economics of Back Pain

Treating back pain has become increasingly expensive. Determining the total cost of illness for back pain is difficult as there are inconsistencies in terms of which costs are reported in published studies (Dagenais, Caro, & Haldeman, 2008). These authors performed a systematic review of cost-of-illness studies for low back pain and concluded that attempts to estimate total societal costs for back pain are hampered by a wide variability in the definition of back pain, how costs are measured, and the study methodology. Such wildly different methods make it difficult to compare costs between, or aggregate costs across studies to create total estimates that make sense (Dagenais et al., 2008). Back pain costs can be delineated into direct, indirect and intangible costs (Dagenais et al., 2008). Direct costs include billed medical costs and can include other quantifiable incurred costs such as transportation to and from medical appointments. Indirect costs are economic consequences an individual suffers from lost days at work and lost household productivity, and intangible costs are a reduction in a patient's enjoyment of life. A study in the *JAMA* using MEPS data (a national survey used of health services) estimated the total cost of back pain "expenditures," or direct costs, at $86 billion in 2005 (Martin et al., 2008). Indirect and intangible costs are difficult to quantify and are often not reported in the literature (Dagenais et al., 2008). Despite this, indirect costs should not be overlooked as it is estimated that lost productive time among workers aged 40-65 years costs U.S. employers $7.4 billion per year (Ricci et al., 2006). The authors noted that this lost time often includes absenteeism as well as presenteeism, which is being at work but unproductive due to pain (e.g., being fatigued or distracted).

Back pain has been identified as one of the most costly health conditions relative to other conditions. MEPS data placed it as the sixth most costly condition nationwide after heart disease, motor vehicle accidents, acute respiratory infection, arthropathies, and hypertension (Druss et al., 2002). Another study identified the top 10 most expensive medical conditions for U.S. employers. Two back pain diagnoses made this list: “mechanical low back pain” as well as “back disorder not specified as low back,” which includes all thoracic and cervical pathologies (Goetzel et al., 2003).

Another interesting trend in the literature is that spending on back pain is disproportionally skewed to certain patients. Luo, Pietrobon, Sun, Liu, and Hey (2003) investigated direct costs and found that the 10% most expensive individuals spent more than 50% of the total expenditures; the most expensive 25% of patients spent more than 75% of the costs, and the 50% most expensive individuals spent 90% to 100% of the total costs. A key step in predicting and controlling spending in spine care will be to find ways to identify those patients that will end up accruing the greatest costs.

Finally, spending on spine problems is apparently increasing. The same study that published the $86 billion figure from MEPS data also found that from 1997 to 2005, spending on back disorders increased by 65%, yet this period only saw a small increase in estimates of people suffering from spine problems (Martin et al., 2008). The same research group found similar increases in spending when tracking per user expenses, as opposed to the mean expenditures (Martin et al., 2009). What may be most shocking is that the authors found these increases in spending, yet without any reported health status improvements for those with spine disorders. In fact, self-reports of mental and physical health limitations of people with spine disorders became worse during this time (Martin et al., 2008, 2009). This finding of an increase in spending without health status gains raises questions about medical waste (Martin et al., 2008). It further highlights the need for more research on spine care spending.

Spine surgery is one category experiencing rapidly increased spending. Medicare data revealed that spending on discectomy and fusion rose sharply between 1992 and 2003; by 2003 direct costs were over $1 billion just in Medicare spending (Weinstein et al., 2006). The authors noted that lumbar fusion made up a disproportionate percentage of the costs. Spending on lumbar fusion increased by 500% and furthermore, the $482 million spent on lumbar fusion accounted for 47% of all back surgery spending (Weinstein et al., 2006). Likewise, a study using a sample of workers' compensation patients found a 174% increase in the average medical costs for lumbar fusion between 1995 and 2007 (Wheeler et al., 2012).

With spending on more invasive types of spine surgery skyrocketing, payers and providers have turned their focus toward less invasive pain control techniques. In fact, in the *JAMA* study on spine spending increases, the greatest dollar increase from 1997 to 2005 were due to outpatient visits (Martin et al., 2008). These authors surmise the increases may also be due partly to increased frequency of outpatient spinal interventions including spinal injections. These findings parallel the growing emergence of interventional pain management. Manchikanti (2004) described interventional pain management as a group of procedures designed to manage chronic pain by using minimally invasive techniques that target the pain site directly through use of drugs, ablation and some surgeries (such as spinal cord stimulation). Furthermore, these techniques, particularly the injection interventions, are most commonly done in an outpatient office setting, by any number of different specialists, including rheumatologists, orthopedic surgeons, internists, family practitioners, and pain physicians. Finally, the use of these techniques has increased by 95% from 1998 to 2003 (Manchikanti, 2004).

Facet Joint Interventions

Facet joint interventions are one of the most common injection procedures in interventional pain management (Manchikanti, 2004). The facet joints (alternately called zygapophysial joints) are paired joints on the back of the spine in between vertebra and serve to stabilize the spine and limit extreme motions that would cause injury (Beresford, Kendall, & Willick, 2010). It is estimated that the facet joints are implicated in 39% of patients with chronic neck pain, 34% of those with chronic thoracic pain, and 27% with chronic lumbar pain (Manchukonda et al., 2007).

A comprehensive article by Bogduk (2008) detailed the diagnosis and treatment of facet joint pain. Bogduk stated that there were no clinical features of facet joint pain, and currently the only way to diagnose facet pain is through diagnostic nerve blocks of the joint. During a diagnostic block, a dose of anesthetic is inserted directly to the joint;

any subsequent pain relief indicates facet joint involvement. There are debates about how much reduction in pain is needed to correctly diagnose facet joint pain; 80% is ideal, but in clinical practice a less ideal 50% is often enough for confirmatory diagnosis. Bogduk elaborated that a single diagnostic block had a high false positive rate, so a controlled block is necessary. This can be done with a placebo or with a second block using a different anesthetic.

Radiofrequency Neurotomy

The most common procedure to alleviate facet joint pain once diagnosed is called radiofrequency neurotomy (Bogduk, 2008). The procedure involves applying radiofrequency waves directly to the root of the nerve that enervates the joint to coagulate and temporarily block the pain signals from reaching the brain (Bogduk, 2008). Pain relief varies widely with a recent study reporting more than 50% of participants experienced 50% of pain relief at three months post-procedure (Burnham, Holitski, & Dinu, 2009). The authors also reported that the pain relief remained stable for approximately 6 months after the neurotomy, with pain starting to increase again around 9 months. A known limitation to the procedure is that eventually the nerves will regenerate and pain will return; in that case, repeat procedures can be done (Bogduk, Dreyfuss, & Govind, 2009). Studies on repeat neurotomies have shown that repeat procedures continue to provide relief without any complications (Son, Kim, Kim, Lim, & Park, 2010). Another study demonstrated that repeat neurotomies are effective approximately 85% of the time (Shofferman & Kine, 2004). Finally, radiofrequency neurotomy is becoming increasingly popular. A sample of Medicare patients estimated an increase of 543% for facet joint interventions (which also included intraarticular injections and nerve blocks in addition to neurotomy) between 1997 and 2006 (Manchikanti et al., 2010). Unfortunately the study did not provide a breakdown of just the neurotomies.

Despite being a common procedure, numerous controversies abound in the literature regarding the specific protocols and outcomes of radiofrequency neurotomy (Bogduk, 2008). As a result, the outcome studies of neurotomy are hotly debated. Practice guidelines authored by Manchikanti and colleagues (2003) stated that there is strong evidence for short-term relief and moderate evidence for long-term relief based on one systematic review, two randomized clinical trials, and a handful of prospective and retrospective studies. The authors excluded two systematic reviews for serious methodological flaws. Other authors agree that much of the outcome research literature is problematic and includes errors in technique and patient selection (Bogduk et al., 2009).

Procedure Techniques

There are two different neurotomy techniques. One technique, sometimes called the “Dutch” technique, has the physician insert the electrified probe perpendicular to the pain-provokating nerve (Bogduk, 2008). This is a less-popular technique as it is easy for the physician to miss the nerve altogether and even under the best circumstances the procedure is only mildly effective in terms of short-term pain relief (Bogduk, 2008). Bogduk wrote that the best practice is to insert the probe parallel to the nerve, which provides the most effective and long-term pain results by coagulating a large enough section of the nerve. However, many previous studies still utilized the Dutch technique.

Diagnostic Blocks

Another controversy that has led to debate and possibly flawed outcomes is the proper method to diagnose true facet joint pain. The "gold standard" is to perform two nerve blocks, because the false positive rate for a single block is reportedly as high as 21-41% (Bogduk, 2008). Yet, many studies still use single a single block as their diagnostic critique and, therefore, fail or show small results due to incorrect patient selection (Bogduk et al., 2009). The case could be made that this practice merely mimics clinical practice as many practitioners do not use double blocks (Bogduk, 2008). Furthermore, the author writes that some practitioners and payers contend that double blocks are not cost-effective and therefore they are not performed. A different article by the same author argues that double blocks are cost effective, but the fee reimbursement practices in the U.S. encourage single blocks because the facility fees are substantially larger than either the blocks or neurotomies, which encourage only single blocks (Bogduk & Holmes, 2000).

Cost Outcomes of Radiofrequency Neurotomy

The cost-effectiveness study mentioned above (Bogduk & Holmes, 2000) is noteworthy because it is one of the few studies that addressed costs of radiofrequency neurotomy. Despite the fair number of research studies that have been conducted regarding the clinical outcomes, little has been published regarding the costs of neurotomy. One recent study reported that the total cost of facet joint interventions of

Medicare patients was $511 million in 2006 (Manchikanti et al., 2010). Unfortunately that study did not parse out the costs for just radiofrequency neurotomy, and no study could be located that published the costs of neurotomy alone. There is a clear need for more research studies on the costs of neurotomy, particularly given variable outcomes associated with the procedure. First, there appears to be a proliferation of the procedure; as previously stated, all facet joint interventions increased by 543% over the course of 9 years in a Medicare sample (Manchikanti et al., 2010). Second, many patients have multiple procedures. One study on repeat neurotomies started with 20 patients; of those patients, 20 went on to have a second neurotomy, 16 had a third, and 8 had a fourth procedure (Shofferman & Kine, 2004). At those rates, it is easy to see how costs can quickly skyrocket. Third, considering the controversies in clinical practice identified in the literature, payers should be concerned about the possibility of paying for identifiable failures due to poor patient selection. As was previously written, the "gold standard" to diagnose a medically indicated neurotomy is a controlled (double) diagnostic block, but this is rarely done in actual clinical practice. Therefore, it is likely many recipients of neurotomy are not selected appropriately. It may be that poorly selected patients fare worse following this procedure and may accrue higher medical costs than other appropriately selected patients. Further, there may be other patient characteristics that presage higher costs. There is a clear need for costs to be included in more rhizomotmy research studies.

In summary, what appears to be missing from the literature are more detailed analyses of the costs of specific cohorts of patients, and how those costs are allocated so that researchers can identify how to predict and ultimately possibly control costs associated with this procedure. What is further needed, beyond documenting the costs of radiofrequency neurotomy, are models that can predict and help to explain which patients may incur higher costs. Such prediction tools may prove useful for physicians and payers as they plan for appropriate care. The research has shown that careful patient selection based on medical variables (two blocks for diagnosis) is necessary to produce good functional outcomes (Bogduk, 2008). It is plausible then to imagine other presurgical variables that can predict cost outcomes for neurotomy.

Predicting Cost Outcomes

One proposed method to predict cost outcomes is to use a biopsychosocial lens to identify patient characteristics that may lead to differing cost outcomes. Proponents of the biopsychosocial model depart from the purely medical model of biology as the sole cause of illness and maintain that it is the integration of biological, psychological and social factors that best explain illness and health (Engel, 1977). Using the biopsychosocial model to explain aspects of back pain is now generally accepted. It has been used to understand the well-known results of a study by Jensen and colleagues (1994) that demonstrated a large number of patients who had abnormal MRIs, which would indicate a “biological” problem yet endorsed no back pain. In actual spine care practice, the model is used to predict outcomes of spine procedures as well as to design interventions pre and post-surgery to reduce symptoms, reduce chronicity and improve recovery.

Numerous studies have been done demonstrating that biopsychosocial variables can predict outcomes in spine care. Schultz and colleagues (2002) found that maladaptive cognitions predicted disability as measured by return-to-work rates in acute and chronic low back pain patients. Presurgical variables have also been identified to predict functional outcomes after specific procedures in regression models. Age, income, number of prior low back operations, litigation, and depression have been found to predict outcomes of lumbar fusion (DeBerard, Masters, Colledge, Schleusener, & Schlegel, 2001). In addition, older age, comorbid health conditions, case manager, litigation and time delay from injury to surgery were predictors of poor outcomes of lumbar discectomy (DeBerard et al., 2009). A recent study also found predictive variables for functional outcomes of radiofrequency neurotomy: age, history of depression, and litigation status were found to predict poor outcomes of radiofrequency neurotomy (Christensen, 2010). Outcomes were measured by the Stauffer-Coventory Index, Roland-Morris Disability Questionnaire, Short-Form Health Survey-36, Version 2, as well as telephone interview and medical chart review (Christensen, 2010).

In addition, different interventions have been designed using the biopsychosocial model. Gatchel and colleagues (2003) designed a biopsychosocial intervention package aimed at reducing chronic pain and disability of patients who were deemed “high risk.” In the study, back pain patients who were less than 10 weeks post-surgery were recruited from orthopedic practices to participate in an intervention practice that contained aspects of psychology, physical therapy, occupational therapy, and case management. Components included physical therapy, biofeedback, pain management classes, individual and group exercise, and case manager meetings. Those who participated in the intervention had lower chronic pain and disability compared to patients who had not participated. The authors also found the intervention cost effective; patients who participated in the program had overall lower medical costs per patient even when including the cost of the intervention program.

There is promise that biopsychosocial variables can also be used to predict costs of back pain as well as functional outcomes. A retrospective study found that psychiatric illness was related to higher annualized costs for low back pain (Ritzwoller, Crounse, Shetterly, & Rublee, 2006). Biopsychosocial oriented rehabilitation programs have shown to reduce the costs associated with primary care usage (Soegaard, Christensen, Lauersen, & Bunger, 2006). A recent line of research has found presurgical variables that predict medical and compensation costs in workers' compensated patients using retrospective cohort design studies. Variables predictive of medical and compensations costs have been found for lumbar discectomy, lumbar fusion and interbody cage lumbar fusion. Specifically: gender, number of prior low back operations, time delay from injury to surgery, alcohol use, education, lawyer involvement and assignment to nurse case manager were all predictive of costs for lumbar discectomy (DeBerard et al., 2011). Income and assignment to a nurse case manager were predictive of costs of lumbar fusion (Wheeler et al., 2012). Obesity, lawyer involvement and arthrodesis predicted cost outcomes for intercage lumbar fusion (LaCaille, DeBerard, LaCaille, Masters, & Colledge, 2007). Unfortunately, no studies could be located that identified any patient characteristics that predicted cost outcomes for radiofrequency neurotomy.

Using the biopsychosocial model is not without its critics. Weiner (2008) criticized the biopsychosocial model as it relates to spine care and argued that the model as it is used is not falsifiable. He also wrote “the answers one gets are most tightly linked to the questions one asks” (Weiner, 2008, p. 221) and laments the proliferation of linked variables and outcomes. His criticism can be viewed as a caution to throwing any number of variables at a problem and seeing “what fits.” That practice is clearly not good science. Rather a careful selection of theoretically driven variables should be chosen based on previous literature. Ideally the literature would provide variables that are associated with radiofrequency neurotomy costs, but in the absence of those studies, the net must be cast further out in order to identify variables that may predict costs. A handful of studies have found patient variables to be associated with functional outcomes of radiofrequency neurotomy. These patient characteristics include age (Cohen et al., 2009; LeClaire, Fortin, Lambert, Bergeron, & Rossignol, 2001), degree of pain (Cohen et al., 2009), number of prior back or neck surgeries (Cohen et al., 2007; Silvers, 1990), depression (Streitberger, Müller, Eichenberger, Trelle, & Curatolo, 2011), and lawyer involvement (LeClaire et al., 2001). Because these variables have been found to influence outcomes, it is logical to presume they also may be associated with costs of the procedure.

In addition, four previous studies have shown presurgical variables to be predictive of costs for other spine procedures in worker’s compensation patients (DeBerard, Masters, Colledge, & Holmes, 2003; DeBerard et al., 2011; LaCaille et al., 2007; Wheeler et al., 2012). The variables shown to predict functional outcomes in radiofrequency neurotomy are also predictive of costs in other surgical procedures: age, degree of pain prior to procedure, depression, lawyer involvement, and number of prior back or neck surgeries. This further suggests that the variables are good candidates for a cost model. As a result of these nine studies, the presurgical variables to be investigated are age, degree of pain and number of prior surgeries (biological variables), depression (a psychological variable), and lawyer involvement (a social variable).

Research Purpose and Study Objectives

Given the increasing rates of radiofrequency neurotomy combined with the paucity of cost information in the literature, there is a need for studies that document the costs as well as identify any patient characteristics that may influence those costs. The results of this literature review also suggest that there is promise in using a biopsychosocial framework to predict costs of spine procedures. Identifying possible high cost patients prior to intervention would be a valuable tool for payers and provide important information for patients and providers. For example, if meeting diagnostic criteria for a mental illness predicts higher costs, it is conceivable that addressing the depression ahead of time could not only save money for the payer but also for the patient. It is also possible that post-procedure interventions can be used for high-cost patients to encourage adherence to medical instructions and timely return to work. However, there is a hole in the literature on costs and cost correlates for radiofrequency neurotomy. The purpose of this study was therefore to document the costs of radiofrequency neurotomy, as well as to identify any characteristics of patients that can predict costs.

The goals of this study were; therefore, as follows.

1. Document the medical and compensation costs of radiofrequency neurotomy.

2. Document the presurgical biopsychosocial status of workers undergoing radiofrequency neurotomy in Utah.

3. Identify presurgical biological, psychological, or social variables that predict cost outcomes.

CHAPTER III

PROCEDURES

Population and Sample

The current study used an extant data set of 101 participants who received radiofrequency neurotomy through the Workers' Compensation Fund of Utah (WCFU) between 1998 and 2009. The sample was selected from a previous study's cohort on the functional outcomes of radiofrequency neurotomy (Christensen, 2010). Permission was received by the WCFU. All participants were at least 3 months post-treatment. Participants underwent radiofrequency neurotomy on either cervical, thoracic, lumbar or multiple sites of the spine. There was a variety of how many diagnostic nerve blocks each participant had before undergoing the neurotomy, as well as a variety of providers who performed the procedure (e.g., physicians, anesthesiologists). Nothing in the research literature suggested that the procedure techniques would have changed due to time over the 12-year period; however, as previously written, the insertion angle of the electrode continues to be controversial. In this study, participants received neurotomies from a number of different physicians with presumably different technique preferences, so the procedure may have varied between participants. It is presumed that the results of the study could be generalized to workers' compensation patients in the U.S. who receive radiofrequency neurotomy.

Study Design

The study used a retrospective cohort design whereby participant variables were compared to medical and compensation costs accrued. Participant variables were collected via medical records and claim data via either paper copy or electronic resources at the WCFU. Medical and compensation costs were collected from claims data as well.

Measurement of Data

Patient variables were collected using the Medical Chart Review Instrument (see Appendix A) so that data collection was objective and standardized across patients. This instrument was based on similar tools used by DeBerard and colleagues (2001) and LaCaille and colleagues (2007) to collect common variables for spine patients receiving workers' compensation with good reliability. In a study on functional outcomes of lumbar fusion, a fellow doctoral student reviewed 5% of the files for interrater reliability; the instrument was found to have an interrater reliability of .95. The instrument was changed slightly for this study to address the specifications of a prior study regarding analgesic use, additional procedures after the neurotomy, and imaging. None of these changes affected any of the variables chosen for this study.

The predictor variables age, number of prior back or neck surgeries, history of depression and lawyer involvement in case were obtained by visual inspection of participants' medical records. Degree of pain prior to neurotomy was also collected from participants' medical record via their VAS score. The Visual Analogue Scale (VAS) is a self-report pain measure that asks patients to rate their pain by making a mark on a line to designate their pain. Christensen (2010) noted that the VAS scale is frequently used interchangeably with the Verbal Numeric Rating Scale (VNRS), which is similar but asks patients to rate their pain verbally on a scale from 0 to 10 (0 represents "no pain" and 10 represents "worst pain imaginable"). For the present study, the VAS score is most frequently a VNRS score obtained from physician notes (Christensen, 2010). The VNRS has sound validity, a test-retest reliability of .99, and correlates well (95%) with the VAS (Christensen, 2010). Sixteen participants were missing a VAS score prior to their first neurotomy. A hand-search of the Medical Chart Review Instrument for these cases revealed no notes as to why the data were missing, and also no indication that these values were missing in any systematic way.

Compensation costs included wage replacement payments made from WCFU to participants as well as any disability settlements. Medical costs were defined as all WCFU payments made for direct expenses (e.g., physician visits, surgical costs). Many cost studies have used the date of maximum medical improvement (MMI) as the end date for calculation of costs (DeBerard et al., 2011; Wheeler et al., 2012). MMI is determined by the surgeon and the logic in cost studies is that this date is a consistent time by which most of the compensation and medical costs will have been paid out for an injury. However, due to the acknowledged temporary nature of neurotomy, MMI was not used for this study. Instead, it was determined that all patients must be 3 months post-neurotomy, a time period chosen to represent short-term improvement based on systematic reviews of neurotomy (Christensen, 2010). It should be apparent that it is quite possible that any costs measured in the study were an underestimate as some participants may have gone on to accrue more costs for the same claim after data collection. Of the 101 participant files, 59 were still classified as open cases at the time of data collection.

Cost data were retrieved from printouts from the WCFU database that summed the total paid-to-date costs for compensation and medical costs. All cost data were collected in February and March, 2009. Compensation and medical costs were inflation-adjusted to 2009, which is the most recent year of collected data to allow for appropriate comparisons across the 12-year span. Information on the Consumer Price Index (CPI) was retrieved from the U.S. Department of Labor's Bureau of Labor Statistics website (U.S. Department of Labor Bureau of Labor Statistics, 2013). Multipliers were determined by dividing the average consumer price index (CPI) for 2009 by the average of each year (1998-2008); costs for each year were then multiplied by the year's unique multiplier to adjust all costs to the same year.

There is a separate CPI for medical costs but many researchers recommend against using it. The U.S. Department of Veterans Affairs Health Economics Resource Center (2013) cautioned against it stating that the medical CPI exaggerates increases in medical costs because it is calculated based on costs of a day of an inpatient or outpatient visits which have become more expensive per day yet incidences of illness are requiring fewer days of care; the calculation does not take into account an increase in productivity. Applied economics researchers Berndt and colleagues (2000) cited numerous difficulties in developing an index for medical supplies including the medical CPI (MCPI)'s calculation based on list prices, which are largely discounted for consumers; this results in a disconnect between what consumers demand and what physicians recommend and what payers spend. The authors argued that what is purchased by consumers is not a good indicator as to the value of medical expenses. In addition, they cited other inaccuracies of the MCPI; it is calculated based on out-of-pocket expenses while excluding Medicare and employer payments. Therefore, it is plausible that as a result, use of the MCPI could be particularly inaccurate for workers' compensation data. As such, the general CPI was used to adjust for inflation for these analyses.

Data Analyses

Data collected were analyzed using the Statistical Packages for Social Sciences (SPSS), Version 20.0. Table 1 shows the statistical procedures used to address each research question.

Table 1

Statistical Procedures Used to Address Research Questions

Research information needed	Procedure used
1. To document the medical and compensation costs of radiofrequency neurotomy.	Means, standard deviations and percentages were computed.
2. To document the presurgical biopsychosocial status of workers undergoing radiofrequency neurotomy in Utah.	Means, standard deviations and percentages were computed.
3. To identify presurgical biological, psychological or social variables that predicts cost outcomes.	Pearson coefficients were calculated to investigate the relationships. Two simultaneous-entry multiple regressions were calculated: one for medical costs and one for compensation costs to ascertain the utility of each model.

CHAPTER IV

RESULTS

Descriptive Statistics

The cohort included 101 participants who underwent at least one radiofrequency neurotomy between the years 1998 and 2009. Table 2 describes the biopsychosocial characteristics of the cohort. Males comprised 74.3% of the patients, and the average age of the participants at their first neurotomy was 46.15 (*SD* = 11.74 years). The sample was overwhelmingly Caucasian (91.1%). The preoperative diagnoses for the participants had a wide variability and as such most diagnoses were collapsed or combined. Nearly 50% (48.6%) of the participants had the diagnosis of facet joint syndrome that included the sub diagnoses of lumbar facet joint syndrome (32.7%), cervical facet joint syndrome (14.9%), and thoracic facet joint syndrome (1.0%). Spondylosis was diagnosed in 11.9% of participants that included the sub categories lumbar spondylosis (10.9%) and cervical spondylosis (1.0%). Spinal facet joint arthritis (9.9%) and spinal dorsal arthritis (1.0%) were combined into a spinal arthritis category (10.9%). Facet joint arthopathy (9.9%) included the diagnoses lumbar facet arthropathy (6.9%) and cervical facet joint arthropathy (3.0%). Spinal pain (6.0%) comprised cervicogenic facet pain (1.0%), cervicalgia (1.0%), severe low back pain (1.0%), cervical radicular pain (1.0%), lumbar radicular pain (1.0%), and radiculitis (1.0%). Patients with degenerative disc disease (4.0%) had their own category. Finally, an "other" category (6.0%) included spondylolisthesis (1.0%), s/p lumbar discectomy with residual sacroiliac dysfunction

Table 2

Descriptive Statistics for Biopsychosocial Variables

Biopsychosocial variable	Frequencies	Means or proportions	*SD*
Biological sex			
Male	74	74.3%	
Female	26	25.7%	
Ethnicity			
Caucasian	92	91.1%	
Hispanic	8	7.9%	
Asian	1	1.0%	
Age at time of first neurotomy (years)		46.15	11.74
VAS score prior to first neurotomy		6.81	1.75
Primary diagnosis			
Facet joint syndrome	49	48.6%	
Spondylosis	12	11.9%	
Spinal arthritis	11	10.9%	
Facet joint arthopathy	10	9.9%	
Spinal pain	6	6.0%	
Degenerative disc disease	4	4.0%	
Other	6	6.0%	
Missing data	3	3.0%	
Spine regions of neurotomy			
Cervical	24	23.8%	
Thoracic	1	1.0%	
Lumbar	70	69.3%	
Multiple regions	6	6.0%	
Number of neurotomies			
One	60	59.4%	
Two	27	26.7%	
Three	7	6.9%	
Four or more	7	6.9%	
Prior back or neck surgery			
None	62	61.4%	
One	17	16.8%	
Two	10	9.9%	
Three or more	12	11.9%	
Depression			
Yes	53	52.5%	
No	48	47.5%	
Lawyer involvement			
Yes	32	31.7%	
No	69	68.3%	
Average weekly wage[a]		$591.43	$262.54
Case manager assigned			
Yes	50	49.5%	
No	51	50.5%	

[a]Inflation-adjusted to 2009 U.S. dollars.

(1.0%), arachnoiditis (1.0%), SI joint dysfunction (1.0%), s/p lumbar sacral fusion (1.0%), and disc herniation (1.0%).

The average VAS score before participants' first neurotomy was 6.81 (*SD* = 1.75). Most participants (61.4%) had no prior back or neck surgeries, but 16.8% had one prior surgery, 9.9% had two prior surgeries and 11.9% had underwent more than three prior back or neck surgeries. Lumbar neurotomies were the most common spinal site (69.3%) followed by cervical (23.8%), multiple regions (6.0%) and thoracic (1.0%). The majority (59.4%) of participants underwent only one neurotomy, while 26.7% of participants underwent two, 6.9% three, and 6.9% had four or more neurotomies. For the purposes of this study, if a participant had a second neurotomy on the opposite side of the spine within a three-month period, this was coded as one neurotomy. Finally, 52.5% of the participants had a history of depression, 68.3% had a lawyer involved in their compensation claim, and 50.5% had a nurse case manager assigned to them. After adjusting for inflation, the average weekly wage for patients was $591.43 (*SD* = $262.54) in 2009 U.S. dollars. It should be noted that 14 participants were missing values for weekly wage.

Table 3 presents information about compensation and medical costs. All costs were inflation-adjusted to 2009 U.S. dollars. Compensation costs had a mean of $28,030.79 (*SD* = $39,351.47) and a median of $13,004.12. Medical costs were higher with a mean of $79,227.89 (*SD* = $89,947.37) and a median of $47,945.04.

As is common for cost data, both cost outcome variables were found to be positively skewed when analyzing residuals. Moreover the variances of both cost

Table 3

Descriptive Statistics for Cost Outcome Variables

Cost variable	Mean	*SD*	Median
Compensation costs	$28,030.79	$39,351.47	$13,004.12
Medical Costs*	$79,227.89	$89,947.37	$47,945.04

Note. Inflation-adjusted to 2009 U.S. dollars.

outcomes were not normal across all levels. Compensation and medical costs were therefore transformed to improve the normality and homoscedasticity of the residuals; this process also reduced the number of outliers in the data. Compensation costs were transformed with a square root transformation and medical costs were transformed using a logarithmic transformation. Figures 1 and 2 present residual plots for costs both pre- and post-transformations.

Even after transforming both outcome variables, two outlying cases remained. Examination of the DFBeta values identified an outlying case for medical costs; this case was left in the data set as the amount of influence appeared to be modest. Furthermore, an inspection of the participant's records does not suggest any errors were made and as such it is estimated that while an outlier in the sample, this case is an accurate representation of cases in the population. Through Mahalanobis distance, one case was identified as an outlier on the predictor variable total number of back or neck surgeries. This case was also left in the data set since an investigation of the DFBeta values did not suggest this participant had high influence.

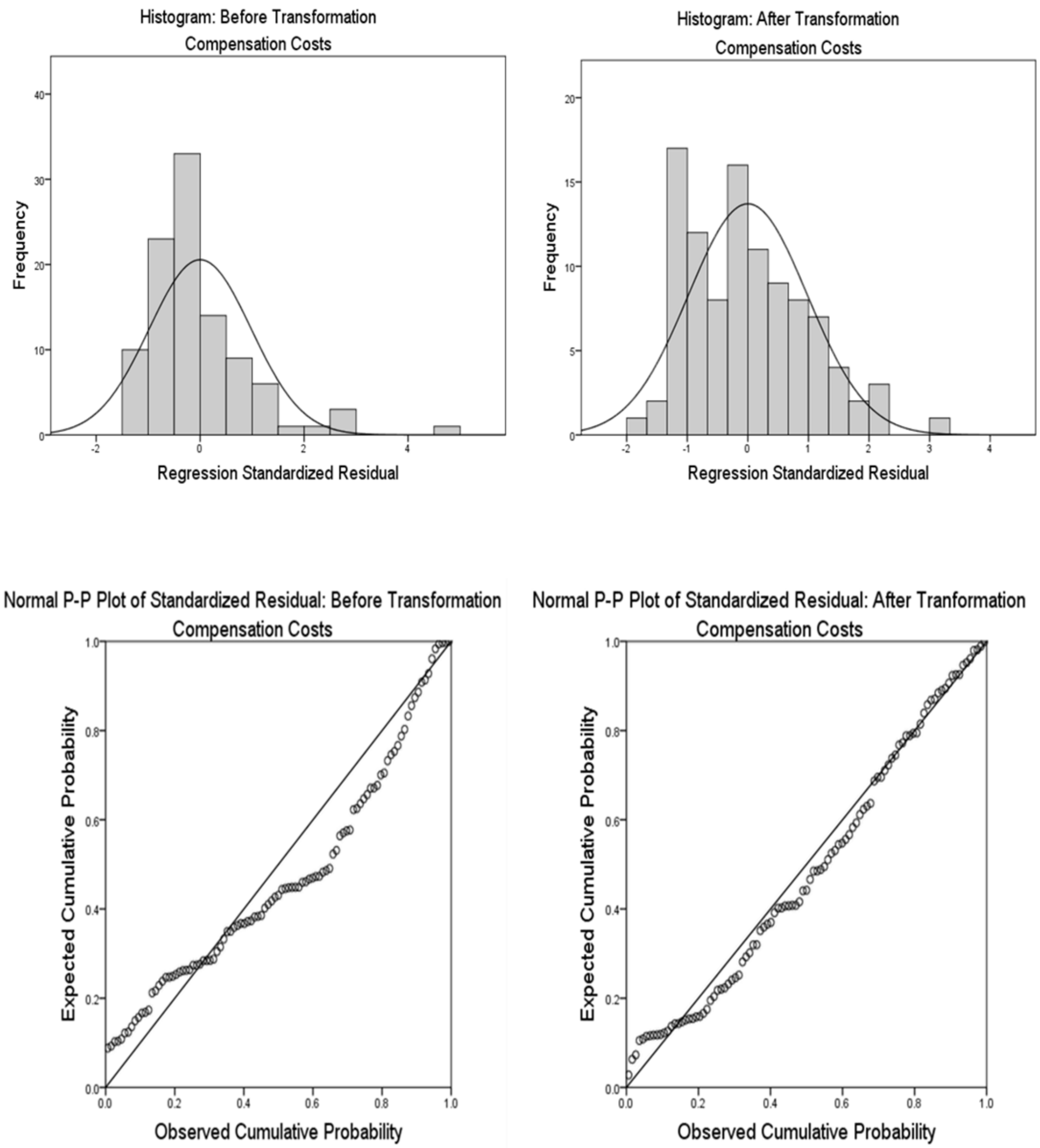

Figure 1. Residual plots of compensation costs before and after data transformation.

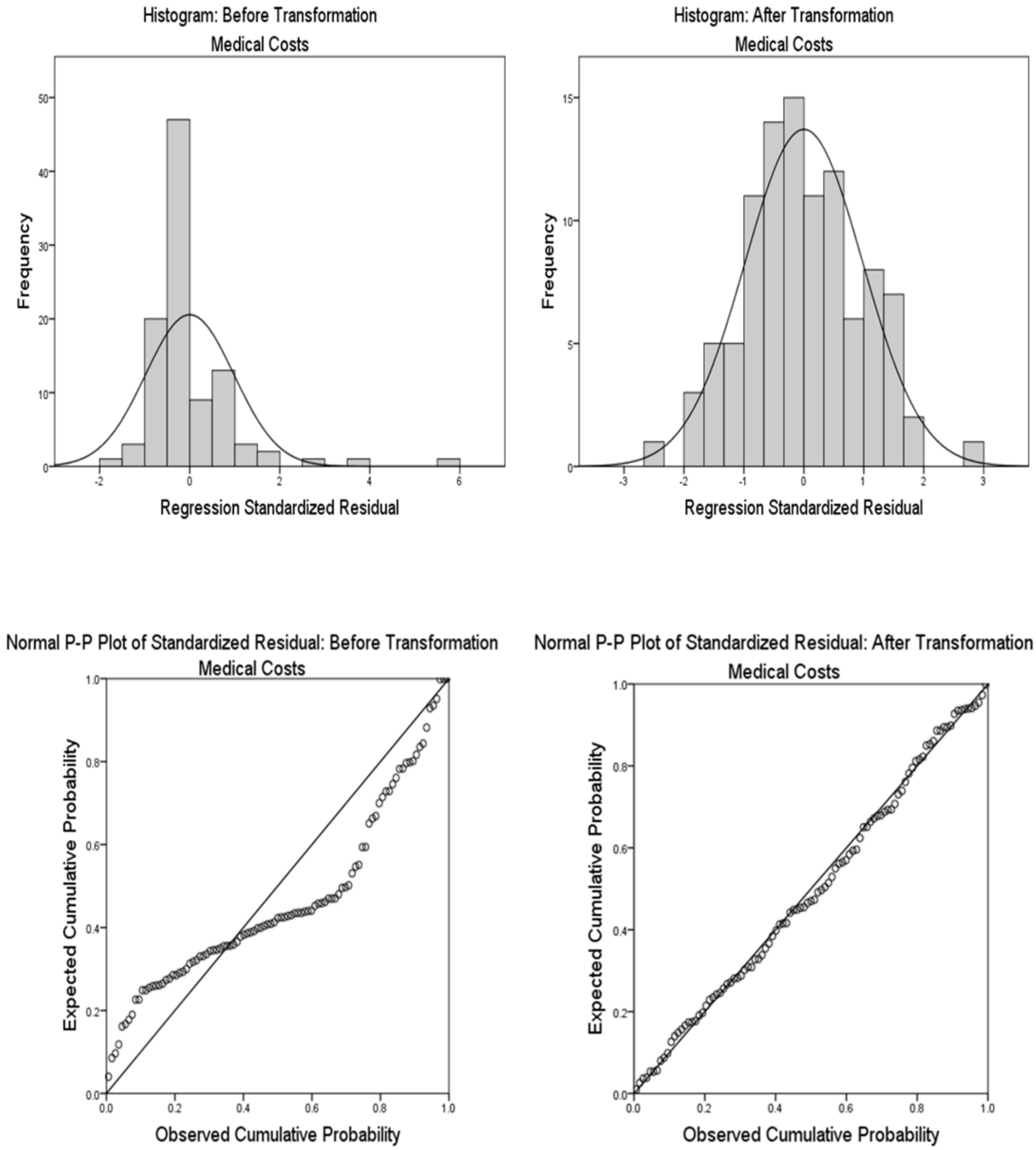

Figure 2. Residual plots of medical costs before and after data transformation.

Correlational Results

Pearson's *r* correlations were run to assess relationships between the presurgical variables and the transformed cost outcome variables. Table 4 presents those relationships. Four of the five preselected variables were positively correlated with cost outcomes; participants' VAS score prior to neurotomy showed no relationship with either compensation or medical costs. On the other hand, number of prior back and neck surgeries and lawyer involvement and were both statistically correlated with compensation and medical costs. Number of prior back or neck surgeries were positively correlated with compensation costs ($r = .266$, $p < .01$) and medical costs ($r = .512$, $p < .01$); an increased number of prior surgeries was related to higher costs. In addition, lawyer involvement in a case was also positively correlated with compensation costs ($r = .395$, $p < .01$) and medical costs ($r = .349$, $p < .01$). This suggests that participants who were involved in possible litigation tended to have more expensive outcomes. The

Table 4

Correlations Between Presurgical Biopsychosocial Variables and Cost Variables

	Outcome variables	
Variables	Total compensation costs	Total medical costs
Age at time of first neurotomy (years)	.160	.247*
VAS score prior to first neurotomy	.013	-.056
Prior back or neck surgery	.266**	.512**
Depression	.092	.377**
Lawyer involvement	.395**	.349**

* = $p < .05$
** = $p < .01$

remaining two variables age and history of depression were related to medical costs only. Age at the time of first neurotomy was positively correlated with medical costs (r = .247, p < .05); older participants tended to incur higher medical costs. Finally, history of depression (r = .377) was also positively correlated with medical costs at the .01 alpha level suggesting that participants with a history of depression tended to have higher medical costs. With the exception of the relationship of age and medical costs which is a small correlation, the rest of the relationships are medium correlations.

Regression Results

Two simultaneous-entry multiple regressions were performed to further assess the relationships between predictor variables and cost outcomes. VAS score was excluded from the regressions since it showed no relationship with either cost outcome. As a result, the resulting variables age, number of back or neck surgeries, depression and lawyer involvement were input as predictor variables with compensation and medical costs as dependent variables. The regression model for compensation costs was statistically significant at the p = .000 alpha level with an F value of 6.172. Regression results for compensation costs are represented in Table 5. An R^2 of .205 was found for the compensation costs, indicating that approximately 20% of the variance in the square root of compensation costs can be accounted for by the four predictors. Both total number of back and neck surgeries (β = .216, p = .046) and lawyer involvement (β = .377, p = .000) had beta weights that were statistically significant. An increased number of prior back or neck surgeries and lawyer involvement in a claim predict higher compensation costs.

Table 5

Simultaneous-Entry Multiple Regression: Predicting Total Compensation Costs With Presurgical Variables As Predictors

Variable	Unstandardized coefficients (*B*)	Standardized coefficient (*SE*)	β	*p* value
Age at time of first neurotomy	.333	.908	.037	.714
Total number of back and/or neck operations	17.544	8.697	.216	.046
Depression	-17.365	21.285	-.082	.417
Lawyer involved in case	85.406	21.543	.377	.000
(constant)	-2.812	48.408		.954

Note. $R = .452$, $R^2 = .205$, $p = .000$.

Table 6 depicts the regression with the four variables age, number of prior back or neck surgeries, depression, and lawyer involvement regressed onto medical costs. An R^2 of .362 was obtained for this model ($F = 13.621$, $p = .000$) indicating that approximately 36% of the variance of medical costs can be accounted for by the predictors. Prior back or neck surgeries (β = .381, $p = .000$), history of depression (β = .185, $p = .043$), and lawyer involvement (β = .228, $p = .009$) were all found to be statistically significant predictors of the log of medical costs. Like was found for compensation costs, increased prior back or neck surgeries and lawyer involvement predicted higher medical costs. In addition, a history of depression predicted higher medical costs.

Table 6

Simultaneous-Entry Multiple Regression: Predicting Total Medical Costs With Presurgical Variables As Predictors

Variable	Unstandardized coefficients (*B*)	Standardized coefficient (*SE*)	β	*p* value
Age at time of first neurotomy	.006	.008	.071	.432
Total number of back and/or neck operations	.299	.075	.381	.000
Depression	.378	.184	.185	.043
Lawyer involved in case	.500	.186	.228	.009
(constant)	9.404	.419		.000

Note. $R = .602$, $R^2 = .362$, $p = .000$.

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CHAPTER V

DISCUSSION

The goals of the present study were to document the compensation and medical costs of radiofrequency neurotomy as well as the presurgical status of patients who underwent the procedure in Utah. A third goal was to identify any presurgical biological, psychological or social variables of the workers that predicted cost outcomes.

Documenting Costs and Participant Characteristics

Costs

As no studies could be located that documented the costs of radiofrequency neurotomy, the results could not be compared to other radiofrequency participants. A similar study was conducted with a cohort of lumbar fusion participants that spanned roughly the same time period, from 1998-2007 (Wheeler et al., 2012). The radiofrequency neurotomy costs were lower than lumbar fusion costs ($8,453 lower compensation costs and $3,107 lower medical costs), which is to be expected; however, considering that radiofrequency is designed to be a minimally invasive procedure as opposed to a major surgical intervention such as a fusion, the radiofrequency costs appear to be surprisingly high. The high costs of the neurotomy participants might be due to participants having repeat procedures. Furthermore, the radiofrequency neurotomy costs were *more* variable than the lumbar fusion costs when comparing standard deviations between the two studies. The current study's compensation cost standard deviation was $13,753 higher than compensation costs in the lumbar fusion study, and a staggering

$37,461 higher when comparing medical costs. Again, this finding might be explained by the tendency for some radiofrequency neurotomy participants to undergo multiple procedures. Wheeler and colleagues (2012) have documented that lumbar fusion rates and costs are rapidly on the rise. More studies on the costs of radiofrequency are needed to determine if spending on radiofrequency neurotomy is keeping pace.

Participant Characteristics

The participants in this cohort where primarily male, overwhelmingly Caucasian and were near middle age (mean age 46 years). A neurotomy on the lumbar region was the most common with more than two thirds of patients receiving a lumbar neurotomy. Participants had a wide variety (22) of presurgical diagnoses, which likely reflects variable patient indications for radiofrequency neurotomy. Roughly 60% of participants had no previous back or neck surgeries. About half of the participant s had a case manager assigned to their case, and 31% had a lawyer involved in their case. Interestingly, 52% of the participants had a history of depression which is higher than similar studies; depression rates for cohorts of discectomy and fusion participants ranged from approximately 11% for discectomy (DeBerard et al., 2003) to 40% for fusion (Wheeler et al., 2012). It is unclear why radiofrequency neurotomy patients might have a higher incidence of depression. It could be that the temporary nature of pain relief in radiofrequency neurotomy leads to greater hopelessness and depression. More research is needed to determine the precise relationship between depression and radiofrequency neurotomy.

Predicting Cost Outcomes

Based on a review of the literature of both functional outcomes for neurotomy and cost outcomes for discectomy and fusion, five variables were predicted to influence cost outcomes. The results partially supported the predictive quality of the five variables. The number of prior back or neck surgeries and lawyer involvement were positively related with both compensation costs and medical costs in bivariate correlations; age and history of depression were positively correlated with medical costs only. Overall the regression model for compensation costs predicted 20% of the variance and the model for medical costs predicted approximately 36% of the variance. These findings are in a similar modest range as other cost outcome studies. A study on discectomy reported approximately 30% of the variance explained for both compensation and medical costs (DeBerard et al., 2011) while a lumbar fusion study reported 17% compensation variance explained and 16% for medical costs (Wheeler et al., 2012). The present findings support a continued utility in using presurgical biopsychosocial variables to predict cost outcomes.

Lawyer involvement in a participant's case was a robust predictor of both compensation and medical costs. This was unsurprising as it has been found to predict costs in other workers' compensation cohorts. Previous authors have suggested insightful possibilities for these findings; being involved in litigation may increase compensation costs as lawyers procure longer wage payouts or larger lump sum payouts for clients (DeBerard et al., 2011). Patients involved in litigation may also have lower motivation to return to work which could increase the length of their wage replacement payouts

(DeBerard et al., 2011). In addition, the authors suggest that litigation may increase the likelihood of ordering second opinions which can increase medical costs.

Total number of prior back or neck surgeries was a statistically significant predictor of both compensation and medical costs. It is plausible to imagine that a participant with a history of prior back or neck surgeries may have a vague or complicated diagnosis that would likely incur higher compensation and medical costs as patients seek additional medical care while searching for pain relief. Moreover, patients with a history of prior surgeries may have increased scarring that could impair their recovery and intensify their pain.

Depression was a statistically significant predictor of medical costs but not compensation costs. Depression has been showed to decrease functional outcomes of radiofrequency neurotomy (Streitberger et al., 2011) as well as increase cost outcomes (DeBerard et al., 2003; Ritzwoller et al., 2006). DeBerard and colleagues elucidated a handful of the reasons for the relationship between depression and cost. They suggested that depression can impact costs by decreasing participant compliance, heighten a participant's experience of pain, interfere with daily functioning, and potentially impact participant malingering. The authors also note that symptoms of depression can be experienced as somatic symptoms. Any one of these possible explanations could account for the positive relationship between depression and costs.

Participants' age was positively related to medical costs in bivariate correlation but not in the four variable regression model. Age was correlated with prior back or neck surgeries and it is hypothesized the shared variance between the two variables was better accounted for by number of prior surgeries in the regression model. Furthermore, participants' VAS score was not correlated with either cost outcome variable in bivariate correlations. Previous studies reported that degree of pain was related to functional and cost outcomes; VAS score was investigated as a possible predictor of cost outcomes with the logic that poor functional outcomes might lead to participant s seeking additional medical care. The inability to find a relationship between pain prior to procedure and costs is an interesting result and one that requires more information about the relationship between reported pain and costs in neurotomy. This finding again highlights the puzzling nature of spine care, in particular patients' subjective report of suffering. As previously written, physical abnormalities are not always predictive of pain; patients with identifiable physical conditions found on MRI that should result in pain do not report experiencing any pain (Jensen et al., 1994). Perhaps it is not surprising that participants' reported degree of pain is not correlated to costs; pain self-reports may introduce large variance as patients' experience of pain may be influenced by a wide variety of factors such as comorbidity, cognitive attribution style, or stress. Furthermore, workers' compensation patients may be motivated to report their degree of pain in different ways. Some may over report their experience of pain in order to seek additional compensation costs and delay their return to work. Alternately, some may underreport their pain to hasten the resumption of their jobs. In summary, self-reports of pain may be multiply influenced by unknown factors and more research is needed to fully understand the relationship between pain and costs.

Implications

With a dearth of previously published research on costs of radiofrequency neurotomy, this study provides researchers with actual cost data for spinal neurotomy. These data are critical to investigate trends in costs, cost-benefit analyses, and to discover relationships between presurgical variables and cost outcomes. The literature on spine care indicates that spine care spending is increasing as a whole, and specifically interventional pain management techniques are increasing as well. As a procedure, radiofrequency neurotomy has a number of clinical issues which may rapidly increase per-patient costs such as improper patient selection and repeat procedures. A careful investigation of costs is needed to determine if repeat neurotomies continue to be cost-effective, and for which patients.

Costs have become a high priority for those outside of the research community as well. In the U.S., the Patient Protection and Affordable Care Act (PPACA) has ushered in an era of financial scrutiny for all stakeholders. Providers and payers are being asked to be accountable for costs; it is hoped that more research on cost data will aid stakeholders in determining policy decisions for payers and proper patient selection for providers. One of the key ways providers and payers can make informed cost decisions is by knowing which patient characteristics may lead to high costs.

It is hoped that the findings can be used beyond just informing actuarial data and can be used to design patient interventions. In a similar study on costs of lumbar fusion, DeBerard and colleagues (2003) noted that a reviewer of their study commented that many of the presurgical variables found to predict costs are not changeable. This is a fair comment and certainly true for some of the biological characteristics such as age or number of prior back or neck surgeries. In the current study, a history of depression was found to predict medical costs and depression is amenable to intervention. Routine presurgical interventions screenings may be able to identify patients with depression before undergoing surgery; interdisciplinary interventions can then be offered before or in conjunction with spine care. Possible treatments can include therapy to treat depression, increasing treatment compliance and psychoeducation on pain management techniques (Wheeler, Smith, Gundy, Sautter, & DeBerard, 2013). Working in an interdisciplinary way offers patients with a good standard of care and has the potential to alleviate depressive symptoms, improve functional spine outcomes and save money for the patient, provider and insurer. In addition, there may be interventions for social variables. In the current study lawyer involvement on a case was related to higher compensation and medical costs. There may be aspects of litigious patients that are also changeable through intervention. For instance, the creation of Accountable Care Organizations (ACOs) have introduced incentivized healthcare (through shared savings) whereby stakeholders are encouraged to work together toward less contentious outcomes (Wheeler et al., 2013). Incentives such as these may also decrease litigation and therefore costs in patients.

Limitations and Future Research

Limitations

It should be noted that the sample used in this study was relatively homogenous (largely Caucasian and male) and as such it is unclear how generalizable the findings would be to a wider population. More research on workers' compensation in other states is needed to yield information for different cohorts in different geographic regions. Furthermore it is unknown how well workers' compensation samples apply to patients with Medicare or private insurance. In addition, the current study used a retrospective design which limits the specificity of data collection and interpretation. In particular, it is unclear how precise "history of depression" was assessed for participants. Coders relied on medical files to gather this information and it is easy to imagine wide variability in how a diagnosis was reached ranging from meeting full DSM-IV-TR criteria to participant self-report. Therefore, although the relationship between depression and costs is an important result of this study, caution should be exercised when generalizing the findings. In a similar vein, there are limited data on which neurotomy technique was used (i.e., the angle of insertion).

Another potential limitation of the study is the way costs were assessed. In other spine cost studies, costs were assessed after a physician deemed participants achieved their maximum medical improvement (MMI). In the current study costs stopped being counted when participants were at least 3 months post-procedure. While there is research to suggest 3 months is an accurate representation of improvement, the date is somewhat arbitrary and it is almost certain that some participants went on to incur more costs after data were collected. Moreover, lumped costs do not provide information about when costs are assessed which is particularly important for patients who have multiple procedures over the course of their treatment. It would be exceedingly useful to know how costs are incurred over the span of an entire case. Specifically, are the costs for subsequent procedures relatively the same? Is there a linear relationship between repeat neurotomies and increasing costs or is there a point of diminishing returns? Considering the finding of this study that participants with a unique set of presurgical variables incur costs differently, the questions about repeat procedures should include “for which patients?”

Future Research

In order to answer the questions raised above, more controlled cost studies are needed to garner the full picture of radiofrequency neurotomy costs. It would be useful to be able to track exactly how costs unfold throughout a patient’s treatment to be able to determine how and when costs are incurred. A total “paid-to-date” sum does not help providers and payers plan for payments as would data at specific time points (first physician visit after injury, first and second diagnostic block appointments, patients hiring a lawyer, first and subsequent neurotomies, follow-up appointments, etc.). It is worthy to recall that only 20% and 36% of the variance is explained for compensation and medical costs respectively, therefore more research is needed to ascertain what other variables predict costs.

Randomized controlled treatment studies of patients with depression who undergo spine treatments may further explain the relationship between depression and spine cost outcomes. Component studies may be able to identify the mechanism to explain the relationship between depression and lower functional outcomes and higher costs for spine care patients. Moreover, if depression is related to higher medical costs, it is possible that other mental health disorders may also be correlated in a similar way. It would behoove the research community to extend this research and investigate how other diagnoses such as anxiety, somatoform, and personality disorders influence cost outcomes for patients. Presurgical mental health screenings are a first step in identifying how many spine patients also have comorbid mental health concerns.

To our knowledge, this is the first study to present raw cost amounts for patients who received radiofrequency neurotomy. In addition, the findings of this study support the utility of a biopsychosocial framework in explaining and predicting cost outcomes for spine surgery. Further research in this area will continue to provide providers and payers with data that can better inform both policy decisions and better patient care.

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APPENDIX

Medical Records Review Instrument

DEMOGRAPHIC/COMPENSATION VARIABLES		
1. Patient Name:	**2. Address:**	**3. Phone Number (home):**
4. Claim Number:	**5. Gender** 0=not reported 1= Male 2= Female	**6. Happened on employer premises:** Y N
7. Study Number:	**8. Date of Birth:**	**9. Date of Injury** **9a. Injury type:** **9b. Date first Tx:** **9c. Prior injury same part of body:** Y N **9d. Date employer notified**
9e. Prior Interventions 1 = Physical Therapy 2 = Injections 3 = Acupuncture 4 = Chiropractic 5 = Narcotics 6 = Bed Rest 7 = Heat 8 = TENS unit 9 = Other	**9g. Modified employment available:** Y N **9h. Previous convictions:** Y N	
9f. Initial complaint ________________________ ________________________ ________________________	**9i. Witness to accident/injury:** Y N	**10. Hire date:**
	13. Validity of claim doubted by employer: Y N	**11. Date RTW:** **12. Months worked for employer prior to injury:**
14. Marital status at time of injury: 0=Not reported 1=Married 2=Divorced 3=Separated 4=In a significant relationship (i.e., boyfriend or girlfriend) 5=Single	**16. Safeguards available at work:** Y N **17. Safeguards used during injury:** Y N	**15. Time interval between injury and surgery? (Days):**
18a. Occupation at time of injury: **18b. Change Jobs:** Y N	**19. Average weekly wage:** 0 = not reported	**20. Hourly wage at time of injury:** **0 = not reported**
21. Date WCFU file created:	**22. Child care responsibility:** 1=No 2=Yes **Total # Dependents**__________	**23. Laweyer involvement in compensation case?** 0=not reported 1=no 2=yes

24. Red Flags			25. Received full day's pay on day of injury:
A. AGE (AG) - Claimant age over 50	1=yes	2=no	Y N
B. ALCOHO (AL) - History of Alcoholism	1=yes	2=no	
C. CREDIB (CR) - Questionable Validity	1=yes	2=no	
D. CUMTRA (CT) - Cumulative Trauma	1=yes	2=no	
E. DISVAL (DI) - Disputed Validity Settlement	1=yes	2=no	
F. DRUG (DR) - History of Drug Abuse	1=yes	2=no	
G. EDUCAT (ED) - Education Level	1=yes	2=no	
H. EMPLOY (EF) - Employment Factors	1=yes	2=no	
I. FNCOVER (FO) - Functional Overlay	1=yes	2=no	**26. Salary con't:**
J. FRAUD (FR) - Fraud	1=yes	2=no	Y N
K. LEGAL (LG) - Claim Involves Litigation	1=yes	2=no	
L. LIEN (LI) - Claim Involves Lienholder	1=yes	2=no	
M. NESPEK (NE) - Language Barriers	1=yes	2=no	
N. OBESE (OB) - Obesity	1=yes	2=no	
O. OFFCR (OF) - Claimant Officer/Partner	1=yes	2=no	
P. OTHER (OT) - Other Factors	1=yes	2=no	
Q. OVRPAY (OP) - Compensation Overpayments	1=yes	2=no	
R. PIREF (PR) - Private Investigator Referred	1=yes	2=no	
S. PREEXI (PR) - Pre-Existing Condition	1=yes	2=no	
T. PRIORS (PS) - Claiman has prior claims	1=yes	2=no	
U. PSYCH (PF) - Psychological Factors	1=yes	2=no	
V. PTSD (PT) - Post-Traumatic Stress Dis	1=yes	2=no	
W. SOCIAL (SF) - Social Factors	1=yes	2=no	
Y. SUBSYM (SS) - CLMT has subjective sympt	1=yes	2=no	
X. SYSDIS (SD) - Systemic Diseases	1=yes	2=no	

WORK/COMPENSATION VARIABLES		
27. Date last worked:	**33. Total Paid Comp**	**43. Total paid to date:**
28. History of prior industrial claim? (Generic) 0=not reported 1=no 2=yes **Total Number_________________** **Specific Code #'s_______________** **Type of Injury_______________** **__________________________**	**34. Total paid temporary comp:** **35. Total paid permanent comp:**	**44. Expected duration** **45. Medical stability date** **% Impairment**
29. History of prior industrial claim? (Low Back Pain) 0=not reported 1=no 2=yes Total Number__________________ Specific Codes #'s______________	**36. Total paid medical:**	**46. Total weeks impaired**
30. Vocational rehabilitation following surgery? 0=not reported 1=no 2=yes	**37. Total paid rehab** **38. Total ALAE**	**47. Time to medical stability from date of surgery (days):**
31. Light duty available? 0=not reported 1=no 2=yes	**39. Total Medical:** **40. Total Rehab:**	**48. RTW date:**
32. Case manager assigned? 0=not reported 1=no 2=yes	**41. Grand total paid out:** **42. Percent physical impairment paid out:**	**49. WCFU Adjustor Name:**

50. Physical exam data

a. Height________

b. Weight________

c. Straight leg raise (30-70 degree raise produces radicular pain below knee)

0=not reported
1=Positive
2=Negative

d. Neck pain with radiation
(circle: Left or Right)

0=not reported
1=Positive
2=Negative

e. Neck pain without radiation
(circle: Left or Right)

0=not reported
1=Positive
2=Negative

f. Back pain with radiation
(circle: Left or Right)

0=not reported
1=Positive
2=Negative

g. Back pain without radiation
(circle: Left or Right)

0=not reported
1=Positive
2=Negative

h. Radicular pain
(circle: Left or Right)

0=Not reported
1= Shoulder
2=arm
3=Face
4=To thigh
5=To knee
6=To foot
7=Groin

i. Motor weakness (asymmetric)

0=Not reported
1= Shoulder
2=arm
3=Face
4=To thigh
5=To knee
6=To foot
7=Groin

j. Any Non-organic signs present?

0=not reported
1=superficial or non-anatomic tenderness
2=Pain with simulated axial loading or rotation
3=Distraction (SLR different sitting v. supine)
4= Regional disturbance (Non-anatomic sensory pr motor deficit)
5=Overreaction

51. Patients primary surgical diagnosis:

0=not reported
1= Disc Herniation
2=Degenerative disc disease (internal disc derangement
3= Degenerative Scoliosis
4= Segmental Instability
5= Pseudoarthrosis
6= Degenerative Spondylolisthesis
7= Spinal Stenosis
8=Failed Back Surgery Syndrome
9=Osteoarthritis
10=Facet Syndrome
11=Other:

____

52. General health problems (list up to 5 conditions)

0=None reported
1=Diabetes
2=Heart Disease
3=Stroke
4=Arthritis
5=Asthma
6=Depression
7=Hypertension
8=Colitis
9=Psoriasis
10=Cancer history
11=Trauma history
12=Infectious history
13=Auto-immune history
14=Steroid usage
15=Other:

53. Imaging studies conducted prior to surgery?

0=none reported
1=X-ray
2=CT
3=MRI
4=CT Myelogram
5=Discography
6=Other:

54. Additional misc. procedures performed?

0=Not reported
1=none

____
____
____
____

55. Number of prior back/neck operations?

0=None
1=One
2=Two
3=Three
4=Four or more

56. Back/Neck surgical history:

Dr:

Procedure:

Dr:

Procedure:

Dr:

Procedure:

Dr:

Procedure:

57. Psychological history additional notes:

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PHYSICAL/HEALTH/PROCEDURAL VARIABLES		
58a. 1ST Nerve Block: 0=Not reported 1= L1 – L2 Left Right Bilateral 2= L2 – L3 Left Right Bilateral 3= L3 – L4 Left Right Bilateral 4= L4 – L5 Left Right Bilateral 5= L5 – S1 Left Right Bilateral 6= C1 – C2 Left Right Bilateral 7= C2 – C3 Left Right Bilateral 8= C3 – C4 Left Right Bilateral 9= C4 – C5 Left Right Bilateral 10= C5 – C6 Left Right Bilateral 11= C6 – C7 Left Right Bilateral 12= C7 – T1 Left Right Bilateral **Date:______________________** **Physician:__________________** **Product:____________________**	**58b. 2nd Nerve Block:** 0=Not reported 1= L1 – L2 Left Right Bilateral 2= L2 – L3 Left Right Bilateral 3= L3 – L4 Left Right Bilateral 4= L4 – L5 Left Right Bilateral 5= L5 – S1 Left Right Bilateral 6= C1 – C2 Left Right Bilateral 7= C2 – C3 Left Right Bilateral 8= C3 – C4 Left Right Bilateral 9= C4 – C5 Left Right Bilateral 10= C5 – C6 Left Right Bilateral 11= C6 – C7 Left Right Bilateral 12= C7 – T1 Left Right Bilateral **Date:______________________** **Physician:__________________** **Product:____________________**	**59a. Levels 1st rhizotomy:** 0=Not reported 1= L1 – L2 Left Right Bilateral 2= L2 – L3 Left Right Bilateral 3= L3 – L4 Left Right Bilateral 4= L4 – L5 Left Right Bilateral 5= L5 – S1 Left Right Bilateral 6= C1 – C2 Left Right Bilateral 7= C2 – C3 Left Right Bilateral 8= C3 – C4 Left Right Bilateral 9= C4 – C5 Left Right Bilateral 10= C5 – C6 Left Right Bilateral 11= C6 – C7 Left Right Bilateral 12= C7 – T1 Left Right Bilateral **Date:______________________** **Physician:__________________** **Product:____________________**
58c. Duration of pain relief following 1st block in hours: ______________________	**58c. Duration of pain relief following 1st block in hours:** ______________________	**59b. Levels 2nd rhizotomy:** 0=Not reported 1= L1 – L2 Left Right Bilateral 2= L2 – L3 Left Right Bilateral 3= L3 – L4 Left Right Bilateral 4= L4 – L5 Left Right Bilateral 5= L5 – S1 Left Right Bilateral 6= C1 – C2 Left Right Bilateral 7= C2 – C3 Left Right Bilateral 8= C3 – C4 Left Right Bilateral 9= C4 – C5 Left Right Bilateral 10= C5 – C6 Left Right Bilateral 11= C6 – C7 Left Right Bilateral 12= C7 – T1 Left Right Bilateral Date:______________________ Physician:__________________ Product:____________________
60a. Number of levels receiving 1st block: 0=Not reported 1=One level 2=Two levels 3=Three or three plus levels	**60b. Number of levels receiving 2nd block:** 0=Not reported 1=One level 2=Two levels 3=Three or three plus levels	**63a. Degree of heat/duration used on 1st rhizotomy:** 0=Not reported
60c. Number of levels operated on 1st rhizotomy: 0=Not reported 1=One level 2=Two levels 3=Three or three plus levels	**60d. Number of levels operated on 2nd rhizotomy:** 0=Not reported 1=One level 2=Two levels 3=Three or three plus levels	**63b. Degree of heat/duration used on 2nd rhizotomy:** 0=Not reported

61a. Total # blocks:
1=1
2=2
3=3
 	
61b. Total # rhizotomies:
1=1
2=2
3=3
	62. Post-operative treatment?
	0=Not reported
	1=Patient education/counseling
	2=physical therapy
	3=Manipulation
	4=Activity restriction
	5=Devices (corsets/casts)
	6=Injections
	7=Functional restoration/rehab programs
		64. Surgical complications:
		0=Not reported
		1=None
		2=Deep infection
		3=Superficial infection
		4=Motor/sensory loss
		5=Afibrilation
		6=Nerve root injury
		7=Operation at wrong level
		8= Increased pain
		9=Percutaneous burn
		10= Other________________

PHYSICAL/HEALTH/SURGICAL VARIABLES		
65. Previous Chiropractic Treatment? 0=not reported 1=no 2=yes	**68. Amount of Pain Before Surgery?** 0=No Pain or Minimal Pain 1=Mild 2=Moderate 3=Severe	**71. Use of Pain Meds Prior to Surgery** 0=not reported 1=no 2=yes
66. Significant testing after surgery? 0=None Reported 1=X-ray 2=CT 3=MRI 4=CT Myelogram 5=Discography 6=Other__________	**69. Smoking at time of Surgery?** 0 = Not reported 1 = No 2 = Yes	**72. Alcohol Use at time of Surgery?** 0=Not reported 1=no 2=yes
67. Ethnicity 0=Not reported 1=White 2=Black of African American 3=Hispanic 4=Asian or Pacific Islander 5=Native American Indian 6=Other (Specify___________)	**70. Education Level** 0=Not reported 1=Less than 12 years 2=12 years (HS Degree) 3=Some College 4=Trade School/AA 5=College Degree 6=Advanced Degree	**73. Lifting restrictions in pounds following surgery:**

PRE/POST PROCEDURAL VARIABLES		
74a. Medications before 1st rhizotomy (list):		
74b. VAS score before 1st rhizotomy (0-10):	**74c. Total # of meds before 1st rhizotomy:**	**74d. Morphine equivalence of narcotics before 1st rhizotomy:**
75a. Medications before 2nd rhizotomy (list):		
75b. VAS score before 2nd rhizotomy (0-10):	**75c. Total # of meds before 2nd rhizotomy:**	**75d. Morphine equivalence of narcotics before 2nd rhizotomy:**
76a. Medications 3 months after 1st rhizotomy (list & date):		**Date:**
76b. VAS score 3 months after 1st rhizotomy (0-10):	**76c. Total # of meds 3 months after 1st rhizotomy:**	**76d. Morphine equivalence of narcotics 3 months after 1st rhizotomy:**
77a. Medications 6 months after 1st rhizotomy (list & date):		**Date:**
77b. VAS score 6 months after 1st rhizotomy (0-10):	**77c. Total # of meds 6 months after 1st rhizotomy:**	**77d. Morphine equivalence of narcotics 6 months after 1st rhizotomy:**
78a. Medications 12 months after 1st rhizotomy (list & date):		**Date:**
78b. VAS score 12 months after 1st rhizotomy (0-10):	**78c. Total # of meds 12 months after 1st rhizotomy:**	**78d. Morphine equivalence of narcotics 12 months after 1st rhizotomy:**
79a. Medications 18 months after 1st rhizotomy (list & date):		**Date:**

79b. VAS score 18 months after 1st rhizotomy (0-10):	**79c. Total # of meds 18 months after 1st rhizotomy:**	**79d. Morphine equivalence of narcotics 18 months after 1st rhizotomy:**

80. Additional back/neck procedures within 2 years following 1st rhizotomy (list & date):

1= Date:

2= Date:

3= Date:

4= Date:

81a. Medications 3 months after 2nd rhizotomy (list & date):	**Date:**

82b. VAS score 3 months after 2nd rhizotomy (0-10):	**82c. Total # of meds 3 months after 2nd rhizotomy:**	**82d. Morphine equivalence of narcotics 3 months after 2nd rhizotomy:**

83a. Medications 6 months after 2nd rhizotomy (list & date):	**Date:**

83b. VAS score 6 months after 2nd rhizotomy (0-10):	**83c. Total # of meds 6 months after 2nd rhizotomy:**	**83d. Morphine equivalence of narcotics 6 months after 2nd rhizotomy:**

84a. Medications 12 months after 2nd rhizotomy (list & date):	**Date:**

84b. VAS score 12 months after 2nd rhizotomy (0-10):	**84c. Total # of meds 12 months after 2nd rhizotomy:**	**84d. Morphine equivalence of narcotics 12 months after 2nd rhizotomy:**

85a. Medications 18 months after 2nd rhizotomy (list & date):	**Date:**

85b. VAS score 18 months after 2nd rhizotomy (0-10):	**85c. Total # of meds 18 months after 2nd rhizotomy:**	**85d. Morphine equivalence of narcotics 18 months after 2nd rhizotomy:**

86. Additional back/neck procedures within 2 years following 2nd rhizotomy (list & date):

1= Date:

2= Date:

3= Date:

4= Date: