AN EVALUATION OF PRESURGICAL PSYCHOLOGICAL SCREENING AS A PREDICTOR OF OUTCOME FOR TOTAL DISC REPLACEMENT

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DEDICATION

For my father

AN EVALUATION OF PRESURGICAL PSYCHOLOGICAL SCREENING AS A PREDICTOR OF OUTCOME FOR TOTAL DISC REPLACEMENT

by

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A long-term follow-up study was conducted to evaluate the efficacy of presurgical psychological screening (PPS) in predicting the response to treatment by patients undergoing Total Disc Replacement (TDR). Subjects participated in a psychological screening prior to surgery and were given a prognosis that was then used to determine whether they were fit to proceed with surgery. All participants in this study had a prognosis of Good (G), Fair-Good (FG), or Fair (F). Subjects were followed for one year and reported on measures of pain and functional disability at baseline, 6 months, and 12 months. G subjects showed significantly greater improvement in both pain and

restoration of function than F subjects. G subjects also had significantly greater pain reduction than FG subjects. SCL-90 response patterns were detected in data but were not found to be predictive of outcome on either pain reduction or functional restoration measures. PAIRS scores were shown to correlate with baseline measures of functional disability but analyses were not able to determine whether these scores could predict treatment outcome. These findings suggest that PPS is an effective tool in predicting a patient's response to TDR.

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LIST OF ABBREVIATIONS

ADR: Artificial Disc Replacement; also known as TDR, or Total Disc Replacement

BDI: Beck Depression Inventory

CES-D: Center for Epidemiological Studies-Depression Scale

CSQ: Coping Skills Questionnaire

CT Scans: Computated Tomography Scanning

EMG: Electromyelogram

FDA: Food and Drug Administration

FN: Non-follow-up Subjects

FY: Follow-up Subjects

GCT: Gate Control Theory

H-PAIRS: High PAIRS score, >75

L-PAIRS: Low PAIRS score, ≤ 75

LBP: Low Back Pain

MCMI: Millon Clinical Multiaxial Inventory

MMPI: Minnesota Multiphasic Personality Inventory

D: Depression scale of the MMPI

Hs: Hysteria scale of the MMPI

Hy: Hypochondriasis scale of the MMPI

Pd: Psychopathic Deviate scale of the MMPI

Pt: Psychasthenia scale of the MMPI

Sc: Schizophrenia scale of the MMPI

MRI: Magnetic Resonance Image

ODI: Oswestry Disability Index

PAIRS: Pain and Impairment Rating Scale

Prognosis:

F: Fair Prognosis

FG: Fair-Good Prognosis

FP: Fair-Poor Prognosis

G: Good Prognosis

P: Poor Prognosis

PPS: Presurgical Psychological Screening

SCL-90-R: Symptom Checklist-90 Revised

DEP: Depression scale of the SCL-90-R

SOM: Somatization scale of the SCL-90-R

SCL-90-R Cluster:

HD: Highly Distressed

MD: Moderately Distressed

N: Normal, or Normally Distressed

SCS: Spinal Cord Stimulator

SF-36: Short-Form 36

SF-36 MCS: Short-Form 36 Mental Component Score

TENS: Transcutaneous Electrical Nerve Stimulation

TDR: Total Disc Replacement; also known as ADR, or Artificial Disc Replacement

TMD: Temporomandibular Joint Dysfunction

VAS: Visual Analog Scale

ZDS: Zung Depression Scale

CHAPTER ONE
Introduction

Millions of Americans struggle every year to live with pain. While most find some relief when the healing process takes it natural course, others find themselves struggling with pain that seems to have no cure. Chronic pain is a problem of epidemic proportions in the United States. More than 76 million Americans over the age of twenty report experiencing problems with chronic pain. Among adults over twenty who report pain, only 32% achieved relief in less than a month and 42% were still suffering after one year (National Center for Health Statistics, 2006).

The complications arising from the experience of chronic pain are plentiful and varied. It has significant ramifications for a person's overall health and wellbeing. A decrease in general activity and exercise is a common response used to minimize physical distress. Pain and discomfort disrupts the sleep of an estimated 20% of American adults two or more nights a week (National Center for Health Statistics, 2006). Pain may also cause difficulties with memory and concentration. In an effort to self-medicate, people may adopt negative lifestyle changes such as overeating, smoking, and excessive alcohol consumption. Ironically, these changes may further exacerbate an existing pain condition. Pain may compel someone to take drastic steps such as taking disability leave, changing jobs, soliciting help for the activities of daily living, or moving to a residence that is easier to manage.

Pain has a significant economic impact, as well. Each year it costs billions of dollars in health expenses, lost income, and lost productivity. An estimated $61.2 billion dollars in productive time is lost every year due to common pain conditions such as back aches, severe headaches, neck aches, and facial pain. While pain is the second leading cause of absenteeism, 76% of the lost productivity time comes in the form of underperformance rather than absence from the workplace (Stewart, Ricci, Chee, & Morganstein, 2003). The most commonly reported type of pain in the United States is low back pain (LBP) . It is the leading cause of disability among Americans under the age of forty-five and it affects more than twenty-six million Americans on a frequent basis (National Center for Health Statistics, 2006). In 2005, the nation's annual costs associated with low back pain reached $85.9 billion (Martin, et al., 2008). Generally, adults with LBP are in poorer physical heath than those reporting no LBP. In addition, they are more the four times as likely to experience serious psychological distress. Seventy-seven percent of LBP patients report feeling depressed, 70% report concentration problems, 74% indicate an impact on their energy levels, and 86% report sleep disturbances (National Center for Health Statistics, 2006).

The cause of back pain is as difficult to treat as it is to diagnose. When noninvasive interventions fail to alleviate pain, doctors and patients may choose to take a chance on an invasive surgery. Surgery does not guarantee relief, though. One study found no significant difference between patients of a similar diagnosis treated surgically and non-surgically for back pain (Deyo & Mirza, 2006). Given the high risks and financial costs associated with the back surgery, it is important that the decision be as informed as possible. The current study aims to build upon the existing knowledge of presurgical psychological screening to identify predictors of pain reduction and functional restoration in response to total disc replacement surgery.

CHAPTER TWO
Review of the Literature

SPINAL PHYSIOLOGY

The spine is a series of bony structures, or vertebra, muscles, and surrounding tissues which extend from the base of the skull into the pelvis (Gray & Clemente, 1985). The primary purposes of the spine are to provide support to the upper body and to allow for a variety of movements. An adult has twenty-six vertebra which can be separated into five sections. The uppermost section consists of the seven cervical vertebra that extend roughly from the upper neck to the shoulders. The twelve thoracic vertebra anchor the rib cage and are larger than the cervical vertebra. The five lumbar vertebra comprise the lower spine and support most of the body's weight. The majority of spinal injuries and pain originate in the lumbar area. Thus low back pain is the most commonly reported cause of pain reported by Americans (National Center for Health Statistics, 2006). The sacrum which forms the back wall of the pelvic girdle is made up of four or five separate bones that become fused in early adulthood. Similarly, the coccyx or tailbone at the bottom of the spine is fused together in adulthood from three to five separate vertebra. Vertebral bodies are connected to each other by lateral facets, bony structures which extend off the lateral posterior sections of the vertebral bone. These facets form joints and bear some of the load placed on the spine.

A vertebral bone has a hollow in the posterior sections which, when lined up with other vertebra, forms a canal that runs down the length of the spine. Through this canal passes the spinal cord, a thick bundle of nerves that stretches to the upper lumbar area.

Below that point, nerve roots called the cauda equina exit out of the spinal canal through foraminal openings and branch out into the body.

Weight which is not assumed by the facet joints is borne by the vertebral discs. A disc is an ovoid structure that rests between the anterior dorsal and anterior ventral plates of two vertebra. The outside of the disc, the annulus, is made up of layered, cartilaginous tissue which encapsulates the central nucleus. Inside the nucleus is a caustic, gel-like substance whose high water content allows it to compress and expand under pressure. Discs act as cushions between the bones and allow the spine to flex and extend in different directions, giving motion to the trunk of the body.

Over time, natural wear and tear takes place in the disc, sometimes resulting in tears in the cartilage lining, dehydration of the nuclear body, or positional shifts of the disc within the disc space. Because the discs are avascular and lack a direct blood supply, it is difficult if not impossible for discs to repair themselves.

THE ORIGINS OF PAIN

Pain takes many forms and should be evaluated along several dimensions. Pain can be acute or chronic; it may be felt continuously or only occasionally. It may assume different qualities, variously described as aching, burning, piercing, throbbing, tingling, or shooting. In back patients, pain can be located in the lumbar, thoracic, or cervical regions. Damage to spinal structures and the surrounding nerves may cause pain that radiates into the limbs and extremities.

Damage to any of the structures comprising or surrounding the spine including the muscles, bone structures, discs, or nerves can produce back pain. For example, misalignment of the vertebra can cause pain in the facet joints, a narrowing of the spinal canal, and compression of the spinal cord. Bone fractures caused by acute trauma or stress may weaken the spine's integrity. Scar tissue from back surgery can compress nerves. Damage or disease can result in a number of conditions including spinal stenosis, arthritis, fibromyalgia, osteoporosis, sciatica, spondylolysis, spondylolisthesis, or failed back surgery syndrome.

Disc-related back pain in particular has three basic causes: damage to the disc tissue, compression of nerves by disc tissue, and the contact of neurotoxins from the nucleus with nerve endings. Early assumptions held that vertebral discs were not innervated so pain could not be caused solely by tissue damage. However, recent studies have identified the presence of nociceptors, or damage-detecting nerve fibers, in the outer rim of the disc (Coppes, Marani, Thomeer, & Groen, 1997; Freemont, et al., 1997).

It was believed at one time that pinched nerves in the spine were the result of tumorous growths, but it has been shown that a compromised disc can intrude into the nerve space (Mixter & Barr, 1934). A bulged disc is one in which the fibers surrounding the nucleus remain intact but the ovoid structure compresses or shifts so that it extrudes out of the intervertebral space and into the channel housing the nerve fibers. When a disc is herniated, the nucleus has ruptured. The annular fibers are torn and pieces of the cartilaginous tissue can shift or migrate into the nerve space. In either case, the disc tissue crowds or compresses nerve endings, producing pain that might remain focused at the site of the compression or might generate radicular pain in the limbs and down into the extremities.

When a nucleus ruptures into the disc's fibers, the caustic contents within may spill outwards into the annular fibers. If the rupture extends all the way through the annulus, the neurotoxins may spill out into the spinal canal, irritating the nerve roots there and causing further pain.

DIAGNOSING BACK PAIN

When a doctor evaluates a patient's report of back pain, he or she will try to determine what the pain generator is. A strong diagnosis requires the identification of specific tissue pathology and a determination that the tissue damage is the sole source of the pain. Tissue pathology does not always result in the generation of pain. In some cases, observable tissue damage, such as a bulging disc, goes unnoticed by a patient because no pain sensation is produced. The injury may heal over time without intervention and without the patient ever having been aware of it. On the other hand, the sensation of pain cannot always be linked to observable tissue damage or to a sole point of origin. In some cases, there are multiple potential pain generators and it is necessary to identify which should be targeted for intervention in order to provide relief to the patient. It is also possible for patients to have distorted experiences of pain which are inconsistent with the tissue pathology. The discrepancies may be attributable to a variety of reasons which will be explored further in this paper. Therefore, the identification of both the pain generator and any possible magnifiers is important so that the doctors can select appropriate interventions and avoid ones which are less likely to eliminate the pain or that might further complicate the patient's injury.

There are many procedures that can be used to locate the origin of back pain. While some assessment measures try to elicit, diminish, or alter the perception of pain in order to identify the pain generator, others have a more passive or static approach.

Tissue damage is most often located by static procedures. X-rays can identify narrowed disc space, facet joint dysfunction, and a narrowing of the spinal canal. CT Scans, or Computated Tomography Scanning, use a computer to generate a three dimensional x-ray that goes a step beyond a traditional x-ray by indicating the state of soft tissue structures as well as bony ones. An MRI, or Magnetic Resonance Image, is more effective at displaying soft tissue than a CT Scan but offers less information about the bony structures. A bone scan can illuminate areas of rapid cell growth around bones which may indicate the presence of fractures or infections. An electromyelogram, or EMG, measures the transmission of nerve impulses to identify nerve damage that might be caused by impingement on the spinal cord.

Pain modification procedures are used to establish the link between the perception of pain and observable tissue pathology. Pain modification tests fall into two categories: clinical and nonclinical. The former are aimed at establishing that tissue damage is the sole pain generator while the latter attempt to gauge the relationship between the tissue damage and the pain sensation. The most common type of clinical pain modification test used to assess disc-related damage is discography. This procedure use painful stimulation applied to the vertebral discs to establish which is responsible for the production of pain. The patient is kept conscious while radiographic contrast material is injected into the disc nucleus. Injections are made into both damaged and non-damaged discs so that comparisons can be made between the patient's reports of pain at different sites. An x-ray or CT scan is used to assess whether the disc's nucleus remains intact. The radiographic material acts an irritant and produces a pain sensation which the patient is asked to describe. The test's administrators monitor for inconsistencies in the patient's reports in order to establish the existence and location of a pain generator. It is expected that the resultant pain will be qualitatively consistent with the patient's normally occurring clinical pain. When a clear correlation cannot be established between the production of pain and observable tissue damage, alternative explanations for the patient's pain experiences should be considered (Block, 1996; Block, Gatchel, Deardorff, & Guyer, 2003).

Nonclinical pain modification tests include symptom magnification assessments. The Waddel's Tests of Nonorganic Signs in Low Back Pain evaluates the relationship between the patient's symptom report and the known tissue damage. Patients are exposed to physical stimuli and asked to report on their pain experiences. Sometimes patients will report sensations that are physically impossible to produce under the specified conditions. Patients may also report sensations that are out of proportion to the stimuli or may be inconsistent under slightly different conditions, such as when a distraction is introduced.

ACUTE VERSUS CHRONIC PAIN

The duration of pain is a critical factor in describing, understanding, and treating pain. Acute pain is usually a normal response to tissue injury, inflammation, or disease. When acute pain persists past the expected healing period associated with the observed tissue damage or pain generator, it becomes chronic pain.

The development and maintenance of chronic pain is more strongly related to psychological factors than is acute pain. It has long been demonstrated that, compared to the general population, patients who present with chronic pain are more likely to exhibit some form of psychopathology such as depression, substance abuse or dependence, or somatization (Dersh, Polatin, & Gatchel, 2002). What is not clear is whether there is a causal relationship or if there are other factors at play in this comorbidity. Gatchel proposes a three-stage model which attempts to shed light on the phenomenon and describe the transition from acute to chronic pain (Robert J. Gatchel, 2004).

In Stage 1, or the *acute phase*, the person's perception of pain leads to subsequent development of normal, adaptive emotions such as fear or anger. Stage 2 begins when the pain persists beyond the normal healing phase which, for most pain syndromes, takes two to four months. Within the second stage, psychological and behavioral symptoms become more exacerbated. The manifestations of symptoms such as learned helplessness, distress, anger, and somatization, is influenced by the person's pre-existing personality structure as well as factors in their environment including financial and social stressors. Stage 3 represents the chronic phase in which the long-term nature of the pain and its associated stressors result in the patient's adoption of a "sick role" where their entire lives revolve around attending to the pain. Patients adapt to avoiding tasks which exacerbate the pain which may included necessary tasks of daily living, interaction with family and friends, and responsibilities at work or home (Robert J. Gatchel, 2004).

One recent study investigated a different model that describes the mechanism(s) through which acute pain of less than six-weeks duration transitions into chronic pain. The model hypothesizes relationships between the direct and indirect effects of cumulative trauma exposure, acute pain sensitivity and disability, baseline depressive symptomology, and baseline pain beliefs on chronic pain severity and disability. This model was able to account for 26% of the variance in chronic pain and 58% of the variance in chronic disability. Baseline depressive symptomology was the strongest independent, positive predictor of both pain and disability, indicating that screening and treating acute pain patients for depression may be important in preventing the development of chronic pain (Young Casey, Greenberg, Nicassio, Harpin, & Hubbard, 2008).

Interventions aimed at treating chronic pain are developed with an eye towards interceding at multiple levels. Once pain has devolved to a chronic state, it is no longer enough to treat only the injury site. Once chronic, it becomes necessary to address the pain's emergent behavioral and emotional features.

INTERVENTION

When tissue damage occurs in the back, there are several possible outcomes. The majority of people recover from back pain over time without intervention. Roughly fifty percent of patients experience relief within two weeks while 90% experience relief within three months (Hochschuler, 2008). However, when time is insufficient to alleviate pain, the patient may choose to seek out corrective intervention. Recovery is possible, but not guaranteed, with invasive and noninvasive treatments.

Physicians prefer to try nonsurgical interventions before resorting to invasive procedures. Both active and passive methods are used to treat back pain. Heat packs reduce muscle spasms while ice packs reduce inflammation and swelling.

Transcutaneous electrical stimulation administered through electrodes attempts to override pain signals, preventing them from reaching the brain. Iontophoresis first introduces anti-inflammatory steroids through the skin and then applies electrical current to deliver the steroids to the pain site. Physical therapy aims to correct weaknesses that cause or exacerbate pain, and to improve overall physical conditioning which helps the body recover from injury. Exercise can address deficits that accompany back injuries, such as reduced range of motion, increased pressure on the spine, and reduced flow of oxygen and nutrients to spinal anatomy. Chiropractic treatments address the alignment of the spine and seek to correct dysfunction that can cause pain, particularly at the joints. Massage therapy can improve blood circulation which allows the body to repair damage. It can also increase a patient's endorphins, serotonin, and dopamine levels, as well as improve the patient's sleep (Hernandez-Reif, Field, Krasnegor, & Theakston, 2001). All of these are important parts of the biopsychosocial model of pain. Nutrition and lifestyle changes can have beneficial effects. Weight loss removes strain from the back and calcium intake plays an important role in osteoporosis. Proper hydration nourishes the overall body as well as the spinal discs, allowing them to maintain a proper cushion between the vertebral bodies. Smoking cessation protects vascular structures and improves overall health, as well.

Invasive procedures are ideally a last resort. Surgery is expensive, comes with risks from complications, and offers no guarantees. When a surgical procedure destroys tissue in order to reach and treat the pain generation site, the spine is destabilized. Iatrogenic problems may arise which may require additional intervention. For example, one study looked at adjacent disc degeneration in patients who underwent fusion of the vertebra versus patients who were treated with exercise. Fused patients experienced a 38% frequency of increased adjacent disc degeneration compared with no increase in degeneration among patients treated conservatively (Ekman, Moller, Shalabi, Yu, & Hedlund, 2009). In addition, the likelihood of correcting a problem and providing relief decreases exponentially with each successive surgery (Ciol, Deyo, Kreuter, & Bigos, 1994; Pheasant, Gilbert, Goldfarb, & Herron, 1979; Turner, et al., 1992; Waddell, 1987).

That being said, when other methods have failed, surgery may be a patient's best option. Epidural steroid injections, a minimally invasive procedure, alleviate pain temporarily but both the efficacy and the duration of relief vary greatly. A discectomy entails the removal of part or all of a disc that is impinging on a nerve. Similarly, a laminectomy might remove part of the vertebral bone as well as disc material to alleviate pressure on a nerve. Foraminectomy and foramintomy procedures correct pain caused by a narrowing of the spinal canal. These procedures remove bone and tissue that intrude into the nerve space. A rhizotomy prevents pain signals from reaching the brain by severing nerve roots above the pain generator. Spinal cord stimulators use electrical stimulation to treat chronic pain. These implanted devices are programmable and can be adjusted by the patient to provide electrical stimulation to the nerves in order to override pain signals.

Spinal Fusion

Fusion is a common procedure that freezes the motion of the spine at a level which has been identified as the origin of pain. A single level, also referred to as a segment or joint, is the combination of structures that work together to provide motion to the spine. For example, the L4-L5 level consists of the fourth and fifth lumbar vertebra and the disc which separates the two bones. When pain originates from a segment in the spine, the immobilization of the structures can provide relief to the patient. To fuse a segment, the surgeon applies a bone graft to the vertebral segment in order to encourage the bones to grow together into a single body. The spine may be approached through the patient's back or abdomen, depending in part on the type of fusion being performed. In a posterolateral fusion, the bone graft is placed on the outside of the spinal segment. An interbody fusion places the bone graft between the endplates of the vertebral bodies, making it necessary to remove the disc in its entirety before inserting the graft tissue. A 360° fusion is one in which grafts are placed on both the sides and in between the vertebrae. The bone grafts are frequently fixed in place using screws, rods, plates or other hardware which increases the stability of the joint. While fusion at one level may result in little noticeable reduction in the patient's range of motion, the fusion of multiple adjacent segments causes far more rigidity of the spine. A multilevel fusion also places greater strain on non-fused segments of the spine which can increase the risk of damage or deterioration at those levels.

Total Disc Replacement

Total disc replacement, or TDR, is an alternative to spinal fusion designed to mimic the natural motion of a spinal segment. The insertion of an artificial disc can restore intervertebrate height, prevent or delay adjacent segment deterioration, and maintain range of motion.

In 1955, David Cleveland was the first to propose the insertion of a material other than bone into the intervertebral space. He suggested that the surgeon remove a majority of the disc material, leaving the anterior and lateral segments of the annulus intact, followed by the injection of a liquid that would polymerize within the disc space. Subsequently, surgeons experimented with inserting metal spheres and silicone prostheses to mimic the effects of a disc. While early attempts focused on nucleus replacement, Drs. Karon Büttner-Janz and Kurt Schellnack introduced first total disc replacement, the Charité prosthesis, in September 1984 (Guyer & Zigler, 2005).

The Charité Artificial Disc

The Charité Artificial Disc underwent several major revisions before achieving its present design. In its current permutation, the disc has three separate components. A biconvex polyethylene sliding core sits securely between two oval metal endplates. Small metal teeth extrude from each endplate to secure it to the face of the vertebra. The horizontal torque is unconstrained, allowing for an increased range of motion. The Charité has been in use in Europe for more than seventeen years. After extensive clinical trials, it was approved for use in the United States by the FDA in October 2004. Clinicians report good outcomes from total disc replacement using the Charité in 62 to 79% of patients (Guyer & Zigler, 2005).

The ProDisc

In contrast to the Charité, the ProDisc is a semi-constrained artificial disc. The superior and inferior endplates are connected by a hinge on the posterior section of the disc. This hinge decreases the range of naturalistic moment of the segment. The core which lies between the endplates is convex on the superior side and flat on the inferior side. It rests in an indentation on the inferior endplate. Upon implantation, channels must be chiseled into the vertebra to make room for the keels, vertical extensions that protrude from the endplates to secure them to the vertebral bodies. The FDA approved the ProDisc for lumbar replacement in August 2006 and for cervical replacement in December 2007. Early studies of ProDisc treatment results report good outcomes in 77 to 82% of patients (Siepe, Mayer, Wiechert, & Korge, 2006; Zigler, et al., 2007).

Other Artificial Disc Prostheses

Researchers continue to seek out total disc replacement alternatives that will address the shortcomings of the devices currently available. The Maverick is a semi-constrained, metal-on-metal device with a midline keels extruding from the endplates. Its use is being evaluated in ongoing FDA clinical trials. The Freedom Disc is also undergoing evaluation in clinical trials. Unlike other devices which used a ball-and-socket design, the Freedom Disc's metal endplates are bonded to an elastomeric core to create a fused structure.

TDR Treatment Considerations

Artificial discs are used to relieve pain caused by the degeneration of an intervertebral disc. They are not intended to address bone fractures and should not be used when the vertebrae of the painful segment lack structural integrity. TDR does not address the narrowing of the spinal canal caused by spinal stenosis and may in fact exacerbate that condition. Similarly, pain caused by facet joint dysfunction is not best corrected with TDR because of possible increase in the load forced by an artificial disc onto the facet joints.

Other contraindications for TDR surgery include previous abdominal surgery which may impede access to the spine and pose a risk of significant vascular injury. Patients who are pregnant, have allergies to the material used in the artificial disc, or have an active infection should not undergo TDR. Autoimmune diseases such as rheumatoid arthritis increase the risk of vessel injury with TDR. Morbid obesity places an excessive load on the painful segment and increases the chance of artificial disc failure. As with other types of spine surgery, previous surgical interventions decrease the probability of a positive outcome. Clinical outcomes also diminish in proportion to the number of levels operated upon.

Beyond these medical considerations, there are factors which may predispose patients to a more or less favorable outcome from TDR surgery. The next section will explore how these indirect psychosocial influences have an effect on pain recovery.

HEALTH PSYCHOLOGY

The oldest medical traditions held that there were connections between the body and the mind. The Greek philosopher Hippocrates was the first to posit a systematic explanation of the mind-body connection in his humoral theory. This school of thought proposed that a homeostasis of the four substances in the body was essential for a healthy mind and body. An overabundance of black bile, for example, could be responsible for both physical ailments as well as the development of melancholia. The Scientific

Revolution of the 17th century brought new attention and thought to medical philosophy, calling into question the connection between mind and body. Descartes expanded upon the concept of dualism and proposed that the mind which was responsible for one's doubts, beliefs, hopes, and thoughts was immaterial and existed independent of the body. This immediately sparked challenges which demanded explanations of observable phenomena that seemed to illustrate the interaction between physical and mental phenomena. A chasm slowly formed between the studies of each domain, and soon medicine and philosophy advanced independent of each other with little focus placed on the interactions between the two disciplines. The recent advent of neurology and the growing body of empirically based psychological research have begun to knit back together the two disciplines and there is a growing acceptance of psychological phenomena as a significant factor in physical health.

PSYCHOLOGICAL PERSPECTIVES ON PAIN

Just as there is no unified consensus on how the mind works, no single theoretical perspective explains how the mind and body interact. Theorists from the major psychological perspectives have attempted to explain how the mind influences and is influenced by pain, and their hypotheses have informed both the understanding of and the treatment methods for pain.

Psychodynamic Theory

Ideas from the psychodynamic community date back to its founder. Freud, as a neurologist himself, believed that pain was a subjective experience rather than an objective one. If pain could not be explained wholly by physiological factors, then it was a consequence or expression of an unconscious conflict which, having been repressed, seeks an alternative path into awareness. This conversion of pain relieved the patient's emotional distress but allowed the pain symptoms to linger long after any associated physical cause had mended (Breuer & Freud, 1895). More recent psychodynamic thinkers describe pain as an adaptive defense or coping mechanism. One might feel more free to seek treatment and relief for a physical ailment than for a mental one. Engle (1959) suggested that the expression of physical pain could be more acceptable within a person's family system and might therefore be substituted for psychic pain when one lacked an outlet or the vocabulary to express oneself. Psychodynamic thought has a weaker empirical body of research in comparison to other orientations and evidence to support these theories is primarily anecdotal.

Behaviorism & Learning Theory

Whereas psychodynamic theory subscribes to the existence and influence of internal states, behaviorism rejects such phenomena and insists that all behavior can be described with reference to external, observable phenomena. Under this perspective, the definition of behavior is expanded to included thoughts and feelings as well as observable actions. In many respects, behaviorism echoes medical models in its heavy emphasis on causal relationships and empiricism. However, it breaks from those models by allowing for the influence of stimuli other than organic tissue damage on pain perception. Fordyce postulated that when a painful stimulus is introduced to the body, the patient's first response is caused by nociception. Overt response behaviors might include verbalizations of pain, rubbing the skin, or guarding the injury. These initial behaviors might then be reinforced by environmental phenomena such as positive attention from friends and family, medication, financial rewards, social incentives, and so on. Subsequent pain behaviors may be related more strongly to these reinforcers than to the pain progenitor (Fordyce, 1976, 1978). The observation of modeled behavior can also affect one’s response to painful stimuli. The reactions of someone who has seen pain behaviors rewarded may be very different than those of a patient who has watched pain behaviors be punished or ignored. Treatment outcome studies, particularly those which use behavioral components as chronic pain interventions, lend credence to the behavioral perspective of pain (A. R. Block, E. F. Kremer, & M. Gaylor, 1980b; Cairns & Pasino, 1977; Flor, Fydrich, & Turk, 1992).

Cognitive and Cognitive-Behavioral

Cognitive perspectives on pain also have a strong empirical basis, but unlike behavioral theory, cognitive models accept the existence and influence of mental states such as belief and desire. The basic premise of cognitive theory maintains there exist in the mind underlying structures and rules that guide the formation and action of mental processes. The sensory, affective, motivational, and evaluative aspects of pain are interpreted through the lens of the patient's existing pain-related belief structures, or *schemas*.

Take as an example two patients. Patient A was born with a condition that caused him pain on a daily basis. He was encouraged by his parents, teachers, doctors, and friends to cope with the pain while experiencing as much of the positive aspects of life as possible. He grew up to be very successful in his chosen field, had rewarding relationships, and was generally happy with his life. Through these experiences, Patient A developed an underlying belief system that pain is a manageable part of life that he could live with while still being content. Patient B, on the other hand, had a normal childhood until he was ten years old. At ten, his father was injured in an accident at work. Patient B's father developed chronic low back pain and became bedridden. He lost the job that had been the family's sole source of income. Patient B's parents eventually divorced. Patient B learned that pain was a crippling, destructive influence that had ramifications across all aspects of his life. He is terrified of pain. If both Patient A and Patient B were exposed to the same pain-generating event, their different pain-related schemas would influence their perceptions of the event, the pain, and the consequences in quite dissimilar ways.

Cognitive theory might explain how a person experiences and evaluates pain, but it is necessary to integrate an additional component to complete the picture. The combination of cognitive and behavioral theory allows the philosopher to encompass the person's response to pain perception, as well. In the cognitive-behavioral model, thoughts, feelings, and behaviors are both multideterministic and interactive. Behaviors can be conditioned by reinforcers in the environment as well by internal cognitions. Thus, the person's response might be influenced by their expectations of the consequences, their fear of the pain experience, and the congruence of their self-image with the proposed behavior.

Gate Control Theory

In contrast to the theories described above, the gate control theory (GCT) has a stronger physiological basis and was developed to explain phenomena that were not covered by other pain models. A basic tenet of other theories is that pain is a direct response to a stimulus. There are occasions, however, when painful stimulus fails to evoke a pain response, or when pain is perceived despite the absence of a trigger. Phantom limb pain is an excellent example of the latter. GCT rationalizes that pain signals pass through a figurative "gateway" which can be opened to allow the signals to pass through or shut to prevent them from reaching the brain (Melzack & Wall, 1965).

At the neural level, pain sensation is the product of the activation of nociceptors and the moderation by nonnociceptive fibers. Nonnociceptive fibers interact with the nerve impulses from pain neurons to either enhance or inhibit the pain sensation. A transcutaneous electrical nerve stimulation (TENS) unit attempts to provide relief by taking advantage of this principle. It selectively stimulates nonnociceptive fibers so they will decrease or block the transmission of pain signals to the brain. Melzack and Dennis (1978) hypothesized that nonnociceptor modulation could be invoked not only by simple physical stimulation but by psychological phenomena as well. Thus affect and cognition have a role in adjusting pain perception.

Biopsychosocial Model

Each of the theories discussed above has its merits and drawbacks, but none are able to account completely for the nonorganic influence on pain. By incorporating these perspectives together, a more flexible and comprehensive model of pain sensation can be reached. The biopsychosocial model holds that pain is influenced by physiological, environmental, and psychological factors which interact with each other in a continuous feedback loop.

Biology

The biological features associated with the production of back pain have been discussed in detail above. Organic factors have the most obvious and direct influence on pain perception. When presented with a report of pain, the first thing doctors check for are infection, tissue damage, and inflammation at the site of the pain. Degenerative factors such as arthritis and osteoporosis may influence severity of the pain sensation secondary to a primary cause such as tears in the muscle fibers. Once these biological factors are accounted for, psychological and environmental influences should then be examined to determine whether they account for unexplained aspects of the patient's pain phenomenon.

Psychology

The legitimate impact of psychological factors on the perception of pain has been amply documented in the literature (Block, 1996; Grahek, 2007; Linton, 2005). Though the distinctions are rather artificial, we can divide the psychological variables into the categories of personality traits, emotion, and cognitions.

Some personality traits predispose the patient to experience and report pain in a particular way. A chronically anxious or obsessive person might focus on the pain, carefully noting the quality, duration, and location. Distraction normally provides some relief from the awareness of pain, so conversely, fixation on the sensation may intensify it. Somatization is the tendency to commute and express emotional distress as physical sensations. A person with somatic tendencies would likely identify more frequent and severe pain sensations than a non-somatic person, particularly in the presence of psychosocial stressors (Dersh, et al., 2002).

Emotional states also affect pain sensation. Negative emotions such as fear, anger, depression, and anxiety tend to exacerbate pain perception while positive emotions may ease it. The GCT provides a neurological explanation for how such interference may take place. Depressed patients, for example, have lower pain thresholds than non-depressed patients(Merskey, 1965). They also tend to focus on the negative rather than the positive (Seligman, 1975). This loss of perspective can skew the patient's perception and affect their assessment of pain sensation.

Cognitive beliefs about pain, the body, and how things “should be” shape a person’s responses to pain sensations. A belief that pain is normal and natural may allow patients to cope more calmly with pain but could convince the patient not to seek help. Alternatively, a conviction that pain is inescapable, crippling, and devastating might keep the patient from putting effort into achieving a greater quality life of life while coping with pain. Self-efficacy, or the belief in one's own ability to cope with or solve a problem, plays an important role in pain sensation. Not only can the sense of self-reliance affect the patient's approach to dealing with pain, the success or failure of their efforts to cope can likewise alter the patient's self-efficacy beliefs. Self-efficacy may be adversely affected when efforts on the patient’s part fail to result in relief from the pain. Conversely, a patient may develop a greater sense of self-efficacy by successfully seeking out and following through on treatment interventions which provide relief.

Common thinking errors can modulate pain perception and coping ability. For example, a thought like, “Pain is keeping me from doing anything” can be tremendously detrimental to the patient’s sense of self-worth, self-efficacy, and motivation to seek help. However, it may also prevent the patient from overdoing it, thus risking additional injury. A thinking error like, “I can do anything I used to regardless of the pain I’m in,” may be seen as a positive in terms of mental health but puts the patient at risk for overreaching their limitations and reinjuring himself.

Environment

The third set of influences in the biopsychosocial model are environmental factors. Many aspects of daily life affect how patients experience and cope with pain. Interactions within the environment mold their actions such as their willingness to disclose details about their pain experiences, their treatment-seeking behaviors, and their activity level. The reception – or rejection – of the patients’ experiences also affects their emotional state and self-image.

The reactions of the support system, including family, friends, coworkers, employees, treatment team, and insurance providers are important. Oversolicitousness by the spouse may serve as a reinforcer for pain behaviors if the patient derives secondary gains from it such as welcomed attention, a reprieve from responsibilities, and affection. Negative treatment from support members such as ignoring, dismissal, or condescension can adversely impact the patient’s emotional well-being and result in poorer coping behaviors. To minimize undesirable effects from the support network, a balance must be struck between being oversolicitous and penalizing the patient because of their condition.

Finances often have an impact on the pain phenomenon. Employers and insurance companies can pressure patients to return to work before the body has healed. They might be motivated to try to reduce the patient's financial claims by sending the patient to a company doctor or by forcing the patient to go to extraordinary measures to receive compensation. The strain placed on the family's finances can negatively affect the patient's home life and mood. On the other hand, the promise of reparations though the legal system might deter a patient from seeking to reduce the pain if the benefits outweigh the consequences.

Cultural values and beliefs about pain may help the frame the patient's experiences by shaping the patient's expectations of pain and appropriate reactions to it. The behaviors and perceptions of a patient who lives in a society where stoicism is valued may be very different from one whose society is receptive and responsive to the patient's needs.

Because of the reciprocal nature of the relationships between the biological, psychological, and environmental factors affecting pain perception, multiple points are accessible for intervention. In this study, physicians intervened at the biological level and sought to correct damage by replacing a disc in the spine. The outcome of the intervention was not solely influenced by the intervention method, though, and the biopsychosocial model helps explain the variance in response among patients. By administering a psychological screen based on this model before the surgery took place, physicians were afforded additional information about how psychosocial variables would affect the patient's prognosis. The next section delves into the prescreening rationale, the methods, and the literature supporting its utility in predicting and tailoring pain interventions.

PRESURGICAL PSYCHOLOGICAL SCREENING

Traditionally, pain interventions were chosen based on the doctor's knowledge of the injury and the available medical techniques that might repair the damage. Demographic information such as age, weight, smoking history, and general health would also have been taken into account. The biopsychosocial model introduced the idea that sequelae not directly related to physical condition could have an impact on the patient's health and recovery. Slowly, as health psychology has become integrated into pain management practices, practitioners have begun to factor in issues known to affect pain perception and recovery such as depression, financial hardship, grief, and other stressors. They have also begun to assess the significance of substance abuse issues and the prospect of secondary gain when determining how best to help patients. As the biopsychosocial model becomes more widely accepted, systematic methods of assessing these factors are being introduced across a variety of health domains. Because of the high risks associated with invasive procedures, the ability to predict response to treatment is especially valuable in that arena.

Non-Back-Related Surgery

A variety of psychological factors assessed by presurgical psychological screening have been linked to treatment outcomes of different medical conditions.

Patients with temporomandibular joint dysfunction (TMD), a set of chronic conditions involving the muscles, tissues and bony structures around the temporomandibular joint, report pain and respond to treatment differently based on their psychological profiles. In one study, higher scores on the Somatization scale of the SCL-90 were positively correlated with reports of pain-related interference in daily activities (Dworkin, et al., 1994). In comparing patients who had undergone conservative treatment for TMD, Schwartz, Greene, and Laskin (1979) found that unresponsive patients had higher scores on the Hy, Hs, D, Pd, Pt, and Sc scales of the MMPI.

In studying outcomes among bariatric surgery patients, a study found that a neurotic personality predisposition, a higher order construct of negative affectivity related to self-esteem, neuroticism, sense of control, and a fear of intimacy, has a demonstrable effect on the weight loss outcome via its influence on emotional eating behaviors (Canetti, Berry, & Elizur, 2009). The development of psychiatric diagnoses among post-operative laproscopic adjustable gastric banding patients was related to poor outcomes in a five-year follow-up study (Scholtz, et al., 2007).

Pre-operative good emotional health as measured by the Short-Form 36 Mental Component Score (SF-36 MCS) was associated in regression models with greater improvement and physical functioning among patients who underwent total knee replacement surgery (Ayers, Franklin, Ploutz-Snyder, & Boisvert, 2005). Untreated depression or depressive symptoms are a strong risk factor for both reduced long-term function and continued pain in total knee replacement surgery (Brander, Gondek, Martin, & Stulberg, 2007). Another group looked closely at pre-operative anxiety/depression as a predictor for total hip replacement surgery. They found that a higher rating on the anxiety/depression dimension was related to reduced pain relief and patient satisfaction (ANCOVA, $p < 0.001$). Furthermore, patients whose anxiety/depression was persistent from the pre-operative to the post-operative period were even more likely to have a poor outcome (Rolfson, Dahlberg, Nilsson, Malchau, & Garellick, 2009).

Spinal Surgery

Presurgical psychological screening has proven useful in predicting treatment outcomes for all major spinal interventions except the newest technique, TDR. Better emotional health as measured by the SF-36 MCS was associated with better physical function after lumbar fusion in multiple trials (Derby, et al., 2005; Trief, Ploutz-Snyder, & Fredrickson, 2006). A recent meta-analysis of studies involving presurgical screening and lumbar laminectomy, discectomy, fusion, decompression or spinal cord stimulator implantation found psychological factors to be predictive of outcome in twenty-three of the twenty-five studies analyzed. Presurgical somatization, depression, anxiety, and poor coping were most frequently associated with poor outcome in the studies reviewed (Celestin, Edwards, & Jamison, 2009).

Psychological variables and other pain-related factors have complex interactions. For example, a longitudinal study of discectomy patients indicated that while psychological distress played little or no role in affecting outcome when pain relief was achieved quickly, it had a more significant role once pain or disability had persisted for three or more months. When surgical intervention was delayed, depressive and somatic pain symptoms assessed in the Distress and Risk Assessment Method were more strongly correlated with poor outcomes including workman's compensation claims ($p < .001$)

(Carragee, 2001). The complicated relationships between variable affecting pain are best reviewed through the lens of the biopsychosocial model. These relationships will be explored further in presenting the rationale behind the PPS method used in this study which is based on the biopsychosocial model.

Commonly Used Assessment Tools

In conducting presurgical screenings, assessors may many different instruments to help generate treatment outcome predictions. Generally, the psychological measures used tend to fall into three categories: those that evaluate personality variables, those that quantify psychological symptoms, and those that measure coping factors. Of the available personality measures, the Minnesota Multiphasic Personality Inventory (MMPI-2) is the most widely used despite – or perhaps because of – its length and complexity (Celestin, et al., 2009). The Short Form-36 (SF-36) is also popular and generates both physical and mental health summary scores using only 36 items. Another alternative is the SCL-90 which was used in this study. The scales of the SCL-90 have been shown to have "adequate" correlations with the MMPI-2 scales. However, while chronic low back pain patients showed significant elevations on the Hy, D, and Hs scales of the MMPI, they did not show similar peaks on any single scale of the SCL-90. The SCL-90 may therefore be a better measure of a single construct of psychological distress (Kinney, Gatchel, & Mayer, 1991).

Symptom measures focus on diagnostic criteria, such as mood or sleep patterns. For example, depression inventories like the Beck Depression Inventory (BDI) or the Zung Depression Scale (ZDS) are often used in presurgical assessment batteries. The

ZDS was specifically created for back pain populations. The Short-Form McGill Pain Questionnaire, which was developed by Melzack and is based on his Gate Control Theory, tries to tease out the difference between pain sensation caused by tissue damage and pain influenced by nonnociceptor fibers, or the more psychological aspects of pain. Measures of coping are quite abundant and quantify a patient's coping methods, pain-related beliefs, locus of control, self-efficacy, cognitive errors, and avoidant tendencies. The Coping Skills Questionnaire identifies and quantifies six different types of coping styles including as distraction, cognitive statements, and catastrophizing. The Pain Coping Inventory has also shown significant predictive value for lumbar surgeries and spinal cord stimulator implantations (Celestin, et al., 2009).

It should be noted that the "outcome" in any pain intervention is a multidimensional phenomenon, and any single measure of "success" would be inadequate. Success could mean reduction in pain, return of function, return to work, decrease in the doctor visits, decrease in medication, lowered cost of care, or the patient's satisfaction. In this study, we use a self-report measure of function, the Oswestry Disability Index, and a subjective pain report, the Visual Analog Scale, as our outcome measures.

The PPS Method

The screening method used in this study is based on an algorithm developed by Dr. Andrew Block to predict a patient's response to back pain treatment (Block, 1996; Block, et al., 2003).

The goal of the screening is to accumulate information about a wide number of factors that are known to have a potential impact on a patient's response to treatment and use it to generate a prognosis. The algorithm incorporates variables from both the physiological and psychosocial domains, and the information is gathered from the patient's medical records, a semi-structured interview, and a short battery of psychological instruments. Once the information is gathered, the assessor uses the algorithm to generate a treatment prognosis of Good, Fair, or Poor.

The physiological risk factors incorporated into the PPS model include:

1. Chronicity of the pain condition
2. Previous spine surgeries
3. Destructiveness of the surgery
4. Nonorganic, or symptom magnification, signs
5. A history of heavy, non-spine-related medical treatment
6. Smoking
7. Obesity (Block, 1996)

Each of these has been shown in the medical literature to increase the patient's risk of having a poor surgical outcome (Block, et al., 2003). The psychosocial risk factors used in Dr. Block's PPS model fall into the categories of Personality and Emotion, Cognition, Historical Background, and Reinforcers for Injury. The rationale supporting the inclusion of these issues in the PPS model is explored below.

Personality and Emotion

While there are a number of psychological factors that can play a role in pain recovery, some have a persistent. habitual quality while others are more transient, reflecting the patient's current situation. How and whether a characterological or emotional factor plays a role in recovery relies on other variables, such as the type of injury, its impact on the patient, the duration of the pain, and the treatment proposed. Therefore, there are many different instruments used to capture the complicated interactions between personality, emotion, and the pain phenomenon.

Personality characteristics that can affect outcome are usually assessed using inventories such as the MMPI, the SF-36, the SCL-90, or the MCMI. Oversensitivity to pain is a strong risk factor for poor surgical outcome. Elevations on the Hs and Hy scales of the MMPI have been associated with both elevated pain sensitivity (Block, Vanharanta, Ohnmeiss, & Guyer, 1996) and poor treatment outcome (Dvorak, Valach, Fuhrimann, & Heim, 1988; Kleinke & Spangler, 1988) for back pain. Gatchel, Polatin, and Meyer (R. J. Gatchel, Polatin, & Mayer, 1995) found the Hy scale to be an excellent predictor of returning to work, second only to self-reported pain and disability ratings. Chronic pain patients frequently show elevations on the D scale (Lindsay & Wyckoff, 1981), and such elevations have also been linked to poor outcome in a number of studies (Block, 1996). Some connections have also been shown between the MMPI's Pt scale and treatment outcome. The Pt scale picks up on agitation and anxious symptomology, particularly obsessive-compulsive traits (Block, 1996). In an outpatient multimodal trial of chronic spinal pain treatment, Vendrig, Derksen, and de Mey (1999) showed a correlation of -.25 ($p < .006$) between patients' Pt scales and the post-treatment VAS scores. Pd scale elevations on the MMPI are associated with anger, hostility, and resentment of authority figures. Patients with Pd scores over 70 tend to respond more poorly to treatment though the links are not as strong as those between Hs/Hy elevations and unfavorable outcome (Block, 1996).

In some cases, psychological factors are an independent risk factor for the onset of pain. Carroll, Cassidy, and Cote (2004) used the Center for Epidemiological Studies-Depression Scale (CES-D) to show that depressed patients, or those who had a CES-D score above 16, were 25% more likely to develop a pain syndrome. Patients who fell into the highest quartile on depression scores were four times as likely to develop pain than those falling into the lowest quartile.

Pincus, Burton, Vogul, and Field (2002) looked at studies which investigated the transition from acute to chronic low back pain in order to determine whether common predictive factors could be identified. They were not able to differentiate satisfactorily between depressive symptoms, depressive mood, and distress but found that a generalized construct of "distress" was a significant predictor of poor treatment outcome, or the transition into chronic pain. Fear avoidance was shown to significantly predict (R-square = 25%) the transition from acute to chronic low back pain in another study (Klenerman, et al., 1995).

In the case of back surgery, elevated depression and anxiety are two constructs that have been demonstrably correlated with the maintenance of chronic pain and poor treatment outcome such as persistent pain and disability and loss of work time. In 13 of 16 lumbar surgical studies evaluated by Celestin, et al. (2009), higher levels of depression predicted poorer outcomes. Similarly, seven of eight studies found a significant correlation with between the presence of anxiety and poorer treatment outcome. Of the four spinal cord stimulator studies included in the analysis, three found that psychological factors were predictive of treatment outcome while patients' reports of pain and disability were not.

Boersma and Linton (2005) classified musculoskeletal pain patients into four clusters based on their fear-avoidance beliefs and a depressed mood (see Figure 1). The clusters did not differ on measures of pain or function. One year after assessment, very few of patients in the "Low Risk" cluster (5%) and "Low Risk-Depressed Mood" (0%) had had absences from work that lasted longer than 15 days. In contrast, 35% of patients in the "Fear Avoidant" cluster and 67% of "Distressed-Fear Avoidant" cluster had had long absences from work.

Figure 1
Clusters based on fear avoidance beliefs and depressed mood

		Fear Avoidance Beliefs	
		Low	High
Depressed Mood	Low	"Low Risk"	"Fear Avoidant"
	High	"Low Risk - Depressed Mood"	"Distressed - Fear Avoidant"

Voorhies, Jiang, and Thomas (2007) used the Short-Form McGill Pain Questionnaire as part of their investigation into predicting the outcome of surgical lumbar radiculopathy. Voorhies found that patients who has a score of 7 or above on the

Affective, or emotion-based, section of the McGill were only 42% as likely to achieve a good or excellent surgical outcome as patients with Affective scores of less than 7.

Cognition

Cognitive factors that influence the patient's emotional state and behaviors can be divided into coping strategies and cognitive beliefs.

Strategies employed by patients to deal with pain are differentially adaptive, and the ability to utilize appropriate skills is an important aspect of recovery. The Coping Strategies Questionnaire-Revised, a pain-coping questionnaire that has been studied extensively in the literature, identifies six types of common coping behaviors: distraction, catastrophizing, distancing, ignoring, coping self-statements, and prayer (J. L. Riley, 3rd & Robinson, 1997). Patients reporting pain of mild severity tend to use ignoring, distraction, and coping self-statements while patients with severe pain use more coping self-statements, catastrophizing, and praying strategies (Estlander, 1989). Catastrophizing has repeatedly been related to reports of greater pain and disability (Estlander & Harkapaa, 1989; Jensen, Turner, & Romano, 1991). Restricted emotional reaction to pain is related to better compliance with treatment and, further, greater recovery of functional capacity (Cipher, Fernandez, & Clifford, 2002). Harkapaa showed positive correlations between the severity of low back pain and the use of passive coping strategies such as prayer and catastrophizing (Harkapaa, 1991). Distraction-prayer as a combined construct was positively correlated with a failure to adjust to pain (Koleck, Mazaux, Rascle, & Bruchon-Schweitzer, 2006) and pain severity (J. L. Riley, 3rd, Robinson, & Geisser, 1999). Active styles of coping are associated with reports of lower pain severity than passive styles (Brown & Nicassio, 1987).

The types of beliefs that are most important in pain management are locus of control, self-efficacy, fear-avoidance, and cognitive errors. A review by Jensen et al showed that patients with an internal locus of control over pain report better functioning than patients with an external locus of control (Jensen, Turner, Romano, & Karoly, 1991). Patients with stronger beliefs in external control over pain also reported pain of greater severity (Harkapaa, 1991). A stronger sense of self-reliance was positively correlated with better adjustment after surgery and negatively correlated with postsurgical pain reports and sleep disturbance (Gross, 1986). Patients who believe strongly that pain would cause them harm were more likely to have less functional activity and more work loss than patients without such strong fear-avoidance beliefs (J. F. Riley, Ahern, & Follick, 1988; Waddell, Newton, Henderson, Somerville, & Main, 1993). Endorsement of cognitive errors such as "I am useless" or "I am a burden on my family" were linked to greater pain reports and greater psychological distress (Gil, Abrams, Phillips, & Keefe, 1989).

Historical Background

Circumstances in a patients background may be associated with a higher risk for developing chronic pain or for having poorer treatment outcome. A physical or sexual abuse history is one potential risk factor. In one investigation of a multidisciplinary pain treatment program, 53% of female patients reported a history of physical or sexual abuse, 90% of which occurred in adulthood (Haber & Roos, 1984). A history of childhood abuse was significantly correlated with lower work retention rates ($p < .000$) and a higher number of postrehabilitation surgeries ($p < .001$) (McMahon, Gatchel, Polatin, & Mayer, 1997). In a study of lumbar spine surgery patients, subjects who had reported three or more of a possible five childhood psychological traumas had an 85% chance of unfavorable outcome compared to a 5% unfavorable outcome rate among patients reporting no childhood trauma (Schofferman, Anderson, Hines, Smith, & White, 1992).

Associations between substance abuse history and the incidence of chronic pain have been established in multiple studies (Fishbain, Goldberg, Meagher, Steele, & Rosomoff, 1986; Polatin, Kinney, Gatchel, Lillo, & Mayer, 1993). However, neither the causal or temporal nature of the relationship between the two has been clearly defined in the literature. One reason that a history of substance abuse is of interest is because of the potential implications for the patient's postoperative behavior and pain perception. An addiction to pain medication could influence a patient to consciously or unconsciously overestimate, exaggerate, or over-report their pain.

A history of past psychological disturbances and treatment is another indicator of response to treatment. In a review of 18 studies on the psychosocial aspects of back pain, Keel (1984) found that while the association between psychopathology and pain seemed to be interactive rather than linear, patients with preexisting psychological disturbances had less favorable outcomes in response to treatment.

Reinforcers for Injury

Environmental factors can act as reinforcers to maintain the pain phenomenon and its associated behaviors. Studies have shown that patients involved in pending litigation or who expect to be compensated for their injuries respond more poorly to treatment than patients who are not connected to such circumstances (Beals & Hickman, 1972; A. R. Block, E. Kremer, & M. Gaylor, 1980a; Davis, 1994). A recent study reported correlations between pre-operative compensation claims and both increased pain and poorer function in a study of lumbar nerve decompression patients. Patients with compensation claims were only 23% as likely as non-compensation patients to have a good or excellent response to surgery (Voorhies, et al., 2007). Another study found that among patients compensated for their injuries, those whose claims involved litigation were significantly more likely to have poorer clinical and cost outcomes than nonlitigated patients (DeBerard, LaCaille, Spielmans, Colledge, & Parlin, 2009). Litigation at the time of lumbar fusion has also been positively associated with higher compensation costs for the injury (LaCaille, DeBerard, LaCaille, Masters, & Colledge, 2007).

Job dissatisfaction is a major risk factor in the development, maintenance, and recovery from chronic pain. In following a group of 3,000 aircraft employees, Bigos et al. (1991) found that those who were the least satisfied with their work were 2.5 times more likely to become injured on the job than were their more satisfied colleagues. Poor motivation to work was linked to a loss of working time among lumbar disc herniation patients (Puolakka, Ylinen, Neva, Kautiainen, & Hakkinen, 2008). In a study of male low back pain patients, greater job satisfaction predicted reduced pain and disability six months after nonsurgical orthopedic treatment (Williams, et al., 1998).

The demands placed on the back are naturally related to the possibility of injury. Additionally, injured patients whose jobs place arduous demands on the spine are less likely to respond well to treatment. Davis (1994) showed that lumbar laminectomy patients whose jobs were classified as "strenuous" were significantly less likely to have good treatment outcomes than homemakers or patients with sedentary jobs. Another study showed that patients whose jobs required heavy manual labor had 3.3 times as likely to have an unfavorable response to discectomy than patients with less strenuous occupations (Loupasis, et al., 1999).

The reactions of family, friends, and coworkers can influence the patient's response to treatment. These satellites may inadvertently reinforce pain behaviors or repress efforts that would benefit the patient's recovery. Several studies have demonstrated that when spouses reward pain behaviors, patients are more likely to report higher pain levels and lower levels of functioning (Block, et al., 1980b; Lousberg, Schmidt, & Groenman, 1992). Back pain syndromes can place a good deal of stress on spousal relationships. Dissatisfied partners exhibit more negative outcome expectations towards interventions and which can distress the patient and influence their own expectations (Block, Boyer, & Silbert, 1985). Outside the home, social support can similarly affect the patient's mood, expectations, and ability to cope with their injury. In a study of acute low back pain patients, social support from co-workers was positively correlated with recovery from pain ($p=.007$) (Mielenz, Garrett, & Carey, 2008).

Having reviewed the many possible influences on the outcome of pain interventions, it is clear that predicting treatment results would be a complicated process. This study seeks to examine one PPS method that was developed based on the literature examining the risk factors associated with pain interventions.

PURPOSE OF THE PRESENT STUDY

Presurgical psychological screening (PPS) benefits both patients and health care providers. PPS provides a prediction of surgical outcome which allows the parties involved to make informed decisions on whether or not to proceed with an invasive surgery. Patients who are evaluated as likely to have poor outcomes can avoid undergoing procedures that are at best unhelpful and at worst harmful. Failed Back Surgery Syndrome, which simply describes patients who have not had successful results from surgery, can be prevented by PPS thus eluding the pain, expense, and distress associated with failed procedures. The surgeon is also spared the ramifications of an unsuccessful procedure, such as litigation, a decline in success rate, or an increase in time spent managing the patient's needs. Treatment duration and costs can be reduced by avoiding ineffective procedures. PPS can also help increase the chance of positive surgical outcomes by identifying and recommending interventions for emotional and behavioral problems that might interfere with the patient's recovery. Patient who have existing issues or are at risk for developing issues with medication or treatment compliance can be identified by PPS, allowing health care providers to proceed appropriately. Therefore, it is important and useful to identify the psychological factors pertinent to TDR treatment response, determine how best to assess those variables, and provide the most accurate prediction possible via PPS methods.

Total disc replacement is a new technique and the literature investigating outcome is limited. The few outcome studies available how focused on preoperative reports of pain, disability, range of motion, and initial satisfaction as predictive factors (Bertagnoli, et al., 2005; Chou, et al., 2009; Huang, et al., 2005; Siepe, Mayer, Heinz-

Leisenheimer, & Korge, 2007; Siepe, et al., 2009). To date, no studies have reported associations between preoperative psychological factors and surgical outcome. The current project seeks to examine those variables to determine whether PPS methods can be useful to patients and physicians considering TDR.

HYPOTHESES

In the context of the above goals, the following hypotheses will be investigated:

Aim 1: Investigate the relationship between treatment outcome and the psychosocial factors identified by PPS.

As demonstrated by the above review of the literature, the variables assessed by presurgical psychological screening have been linked with pain sensation, functional ability, and response to treatment in many studies. In this investigation, patients participating in PPS were evaluated for psychosocial risk factors and were given a prognosis of Good (G), Fair-Good (FG) or Fair (F).

Hypothesis 1: Patients with fewer or less severe psychosocial risk factors will have better treatment outcomes than patients with more or more severe risk factors.

Hypothesis 1a: G patients will have better surgical outcomes than FG or F patients.

Hypothesis 1b: FG patients will have better surgical outcomes than F patients.

Aim 2: Investigate the relationship between treatment outcome and psychological distress as measured by the SCL-90-R.

Examination of chronic pain patient's MMPI data have revealed distinct response patterns in multiple investigations (Bradley, Gentry, Van der Heide, & Prieto, 1981; Keller & Butcher, 1991; Nordin, Eisemann, & Richter, 2005; J. L. Riley, 3rd & Robinson, 1998; Slesinger, Archer, & Duane, 2002). Two investigations were further able to link distinct response patterns to outcome following spinal fusion (Block & Ohnmeiss, 2000; J. L. Riley, 3rd, Robinson, Geisser, Wittmer, & Smith, 1995). In all of these investigations, one identified profile consisted of elevations on the triad of scales Hs, D, and Hy. A pattern of elevation on many scales, conceptualized as a highly distressed profile, was also common. In the studies examining treatment outcome, both the triad and multiple elevations patterns were associated with diminished results compared to a normal profiles.

The SCL-90-R is an instrument similar to the MMPI and is frequently used when a shorter alternative is needed. The DEP and SOM scales of the SCL-90-R are intended to measure the constructs that the D, Hy, and Hs scales of the MMPI measure. Therefore, the following hypotheses are based on the results found in the MMPI literature.

Hypothesis 2: Analysis of the results on SCL-90-R will reveal two or more common response patterns among the population of TDR patients.

Hypothesis 2a: One response pattern will be characterized by elevations on the DEP and SOM scales.

Hypothesis 2b: One response pattern will be characterized by multiple elevations across the content scales, representing high levels of distress.

Hypothesis 3: Highly distressed patients will have poorer outcomes than nondistressed patients.

Aim 3: Investigate the relationship between treatment outcome and the belief that pain necessarily leads to impairment as measured by the PAIRS.

The PAIRS evaluates the strength of the patient's cognitive belief that pain necessarily leads to impairment. There should, then, be a connection between the strength in that belief and the patient's assessment of their functional ability. As cognitions can significantly impact pain perception, a similar connection should be observed between such a belief and the patient's pain reports.

Hypothesis 4: Patients with high scores on the PAIRS will report greater levels of pain and disability.

Hypothesis 4a: Patients with high scores on the PAIRS will have greater levels of pain and disability before surgery.

Hypothesis 4b: Patients with high scores on the PAIRS will have poorer treatment outcomes than patients with low PAIRS scores.

CHAPTER THREE
Methodology

PARTICIPANTS

This was a retrospective study of data collected from 2003 to 2005 at the Texas Back Institute (TBI) and The Wellbeing Group run by Dr. Andrew Block. All subjects were participating in larger studies of the safety and effectiveness of lumbar total disc replacement surgery using the Charité and ProDisc devices (Blumenthal, et al., 2005; Zigler, et al., 2007). The total sample consists of 224 patients who underwent total disc replacement surgery at a single level. Participants were selected by surgeons using the inclusion and exclusion criteria in Table 1. Patients being considered for the study were referred to Dr. Andrew Block for PPS if they met criteria listed in Table 2 or if their injuries were covered by Workman's Compensation. Patients who were given a Poor prognosis by the PPS were excluded from surgery. Of the 224 patients who underwent surgery, 167 also underwent a psychological screening that produced a prognosis. Subjects were followed longitudinally by TBI.

PROCEDURE

Each subject was seen at the Texas Back Institute and was evaluated by a surgeon for their appropriateness for TDR surgery. The surgical evaluations included a clinical interview, history and physical examination, and radiographic tests to confirm disc pathology. Surgeons were instructed to assess for the presence of several psychosocial factors in order to determine whether they needed to evaluated by a psychologist before proceeding with surgery. These risk factors presented in Table 2 include depression, anxiety, sleep disturbances, unreasonable expectations for surgery, marital or sexual difficulties, problems with work, emotional lability or mood swings, litigation, or a history of mental illness. Patients meeting these criteria or who were covered by Workman's Compensation were referred for PPS.

Subjects who participated in PPS were evaluated by the Wellbeing Group. All PPS patients were assessed by a semi-structured clinical interview with a trained psychologist or assessor experienced in evaluating back surgery candidates. Assessors had access to each patient's medical chart for review. Assessors determined on a case-by-case basis whether additional instruments should be administered to further explore the patient's psychological distress, pain expectations, or coping strategies. The information collected from the interview, medical chart, and psychological instruments was then used to generate a prognosis which was recorded in the evaluation that was submitted to the subject's surgeon. The instruments and method by which the prognosis was derived are described below.

All subjects participating in the study were administered clinical assessments 2 to 14 days before surgery and at 6 and 12 months after surgery. These assessments included a Visual Analog Scale (VAS) pain measure and an Oswestry Disability Index (ODI).

INSTRUMENTS AND OUTCOME MEASURES

Psychological Measures

Symptom Checklist-90-R (SCL-90-R).

The SCL-90-R is a broad measure of psychological symptoms and distress. It consists of 90 items on a 5-point rating scale which are used to generate 9 primary symptom indices: Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, and Psychoticism. It also offers 3 global indices summarizing overall psychological distress, symptom intensity, and the number of self-reported symptoms. While the scales themselves have been shown to have construct validity with the scales of the MMPI-2 and other psychiatric symptom measures (Green, Handel, & Archer, 2006; Simonds, Handel, & Archer, 2008), some studies have found that the SCL-90 may be a better measure of generalized psychological distress than of specific symptoms (Cyr, McKenna-Foley, & Peacock, 1985; Kinney, et al., 1991).

Pain and Impairment Rating Scale (PAIRS).

The PAIRS is a 15-item inventory that assesses the patient's belief that pain necessarily leads to a limitation of functioning (J. F. Riley, Ahern, et al., 1988). The patient scores each item using a seven-point Likert scale with a maximum score of 105. A higher score corresponds with a greater belief in the debilitating effect of pain. Because of its limited focus, the PAIRS has been used in a relatively small number of studies, but several investigations have demonstrated its utility and validity (J. F. Riley, Ahern, et al., 1988; Slater, Hall, Atkinson, & Garfin, 1991).

Coping Strategies Questionnaire-Revised (CSQ-R).

The CSQ-R was originally developed to evaluate coping strategies used by chronic pain patients (Rosenstiel & Keefe, 1983). The revised version consists of 27 items that were suggested for use by Riley and Robinson (J. L. Riley, 3rd & Robinson, 1997) after conducting a factor analysis that generated a 6-factor solution. The patient assigns each item a score from 0 to 6 indicating the frequencies with which they employ that particular coping strategy. The items then load onto one of six factors: distraction, catastrophizing, ignoring, distancing, cognitive self-statements, or prayer. Higher scores on each of these factors indicate greater use of that coping style.

PPS Prognosis.

A prognosis was derived from the data accumulated in the semi-structured interview and any additional instruments the assessor deemed necessary. Point values were assigned to psychosocial and medical risk factors that were present for the patient which were then entered into the algorithm shown in Figure 2. Scores from 0 to 3 generated a Good (G) prognosis and no psychological intervention was recommended. When patients had a score between 4 and 13, they were assigned a qualified prognosis. The assessors used their clinical judgment to record these prognoses as Good (G), Fair-Good (FG), or Fair (F) depending on the severity of the patient's risk factors and the presence or absence of adverse clinical features that could negatively influence surgical results. There were no numerical cutoffs used to differentiate between the qualified prognoses. Inconsistency, medication seeking, staff splitting, compliance issues, threatening, resignation, deception, and personality disorders were considered to be unfavorable indicators for surgery. Patients with a qualified diagnoses were given recommendations beyond the surgical prognosis to assist with treatment planning. For example, a qualified G or FG prognosis might be accompanied by a recommendation for psychological intervention before or after surgery, and F prognosis might prompt a suggestion that the patient be considered for a chronic pain management program rather than surgery. Patients with scores greater than 14 were given a Poor (P) prognosis and were recommended for either noninvasive treatment or discharge.

Outcome Measures

Treatment outcome for back surgery can be defined in several ways. Typically, the most looked-for result is a reduction or cessation of pain. When pain has begun to interfere in the patient’s daily life, a restoration of functioning is desirable, as well. Whether a patient is able to return to work or can resume working at their previous capacity is often of interest, particularly when examining the cost-effectiveness of an intervention. A reduction in the need for medical services, meaning fewer visits to the doctor, shorter hospital stays, or less invasive treatment, is sometimes used as a metric of treatment success. Given medication side effects and the cost of prescription drugs, a decrease in the amount or strength of pain medication is frequently desirable, as well. For the purposes of this study, pain reduction and functional restoration were considered the positive treatment outcomes. To that end, the VAS and the ODI were used as the outcome measures in all analyses.

Visual Analog Scale (VAS).

The VAS is a subjective self-report measure that allows patients to describe the degree of their pain using a visual illustration. It consists of a horizontal line ten centimeters in length with the left end representing "No Pain" and the right end representing "Worst Possible Pain". Patients are asked to mark an "X" on the line to indicate the magnitude of their pain. The VAS is often used in studies of pain and its good psychometric properties have been demonstrated in multiple investigations (R. J. Gatchel, Mayer, Capra, Diamond, & Barnett, 1986; Rissanen, Alaranta, Sainio, & Harkonen, 1994).

Oswestry Disability Index (ODI).

The ODI is a brief, self-report instrument that is designed to assess the level of functional impairment in activities of daily living resulting from pain. It has become one of the gold-standard outcome measures for physical functioning since its publication in 1980 (Fairbank & Pynsent, 2000). It consists of ten questions that assess pain intensity, functional abilities, ability to complete daily activities, sleeping and sexual disturbances, and social engagement. It takes approximately five to ten minutes to complete and score. Higher scores represent increased levels of impairment. The ODI has been found to have strong validity, strong internal consistency, and a high degree of test-retest reliability (Fairbank, Couper, Davies, & O'Brien, 1980).

Different versions of the ODI were administered to patients depending upon the study in which they originally participated. Patients receiving Charité discs were given the original version of the Oswestry while ProDisc patients were given the Chiropractic version . The two versions share nine items and differ on one other. The possible score range of 0-100 is the same for both versions. Item 8 from the original ODI asks about changes in the patient's sex life (Fairbank, et al., 1980). The question has proven problematic as it is often considered unacceptable within a culture or as intrusive to the patient. Patients frequently refuse to respond or answer in a way that does not correspond to their true experience (Fairbank & Pynsent, 2000). The Chiropractic version removes the sex life question and replaces it with an item intended to assess the patient's interpretation of their changing pain pattern (Hudson-Cook, Tomes-Nicholson, & Breen, 1989). A recently published Rasch analysis compared these two versions of the Oswestry by testing to see whether the observed pattern of responses within each questionnaire fit an expected pattern. While the author determined that the responses to original version showed adequate fit to the expected model (χ^2 p=.014), the response pattern to the Chiropractic version was considered inadequate (χ^2 p=.006) and that the new item *Changing Degree of Pain* measured a different underlying construct than the other items. However, this departure from unidimensionality did not result in a distortion of the person location estimate using two subsets of items (p=.180, p=.705) (Davidson, 2008).

STATISTICAL ANALYSES

Data was be analyzed using the Statistical Package for the Social Sciences for Windows, version 16.0 (SPSS, Chicago, IL). The probability for significance was set at $p < .05$.

Hypothesis 1: Patients with fewer or less severe psychosocial risk factors will have better treatment outcomes than patients with more or more severe risk factors.

Hypothesis 1 was investigated using repeated measures ANCOVA. The G, FG, and F groups were compared using a repeated measures ANCOVA where baseline VAS and ODI were used as covariates.

Hypothesis 2: Analysis of the results on SCL-90-R will reveal two or more common response patterns among the population of TDR patients.

A cluster analysis seeks to uncover a systematic means of organizing observations, or in this study *patients,* into mutually exclusive groups where members have properties in common. Hypothesis 2 was tested by conducting a hierarchical cluster analysis where the subjects' SCL-90-R content scale scores were the internal variables by which the groups are differentiated. The distribution of the content scale scores, including the DEP and SOM scales, were compared across clusters to determine if the cluster groups differ significantly on those variables.

Hypothesis 3: Highly distressed patients will have poorer outcomes than nondistressed patients.

This hypotheses tested for between-groups differences on the outcome measures where the clusters generated by Hypothesis 2 define the groups. These groups were compared using repeated measures ANCOVA where baseline VAS and ODI were covaried out.

Hypothesis 4: Patients with high scores on the PAIRS will report greater levels of pain and disability.

Hypothesis 4a was tested using linear regression where raw PAIRS score was the independent variable and baseline VAS and ODI scores were the dependent variables. To examine the predictive power of the PAIRS over time, the median split of 75 established in the literature was used to split patients into two groups of high (H-PAIRS) and low (L-PAIRS) scorers (J. F. Riley, Barrios, & Steinberg, 1988). Repeated measures ANCOVAs were used to test compare these groups controlling for baseline measures of VAS and ODI.

CHAPTER FOUR
Results

CHARACTERISTICS OF THE SAMPLE

The overall sample consisted of 234 TDR patients who had surgery at TBI between January 2003 and March 2006 and who met the criteria listen in Table 2. Subjects ranged in age from 18 to 60 and Body Mass Index ranged from 15.6 to 40.8. Gender, race, and insurance characteristics of the total sample are summarized in Table 3. For each test, preliminary analyses were conducted to ensure that no violations of the assumptions appropriate to that statistic occurred. Unless otherwise noted, no such violations occurred in the following analyses.

COMPARISON OF FOLLOW-UP VERSUS NON-FOLLOW-UP SUBJECTS

Data was collected at baseline, 6 months postoperative, and 12 months postoperative. Of the total sample, 190 subjects returned at 6 months to provide follow-up data and 139 returned 12 months after surgery. Depending on the categorical or continuous nature of the variables, chi-squares and one-way analysis of variance (ANOVA) were used to detect demographic differences between the group of subjects who returned to provide follow-up data (FY) and the group who did not (FN). FY subjects who returned at 6 months did not differ significantly from FN patients on any of the following factors: age ($F(1,232) = .077$, $p = .781$), body mass index ($F(1,232) = 2.952$, $p = .087$), gender ($\chi^2(1, N = 234) = .237$, $p = .627$), race ($\chi^2(1, N = 234) = 10.342$, $p = .066$), or insurance ($\chi^2(1, N = 234) = 3.266$, $p = .195$). The groups were also similar on baseline measures of pain (VAS: $F(1,232) = 1.994$, $p = .159$) and impairment (ODI: $F(1,232) = .508$, $p = .480$). Additionally, patients who returned at 12 months did not differ significantly from those who did not return on the same variables: age ($F(1,232) = .741$, $p = .390$), body mass index ($F(1,232) = 2.535$, $p = .113$), gender ($\chi^2(1, N = 198) = .004$, $p = .953$), race ($\chi^2(1, N = 198) = .6.327$, $p = .276$), insurance ($\chi^2(1, N = 198) = 2.643$, $p = .267$), baseline VAS ($F(1,232) = .587$, $p = .444$), or baseline ODI ($F(1,232) = .077$, $p = .781$).

HYPOTHESIS 1: PROGNOSIS AND TREATMENT OUTCOME

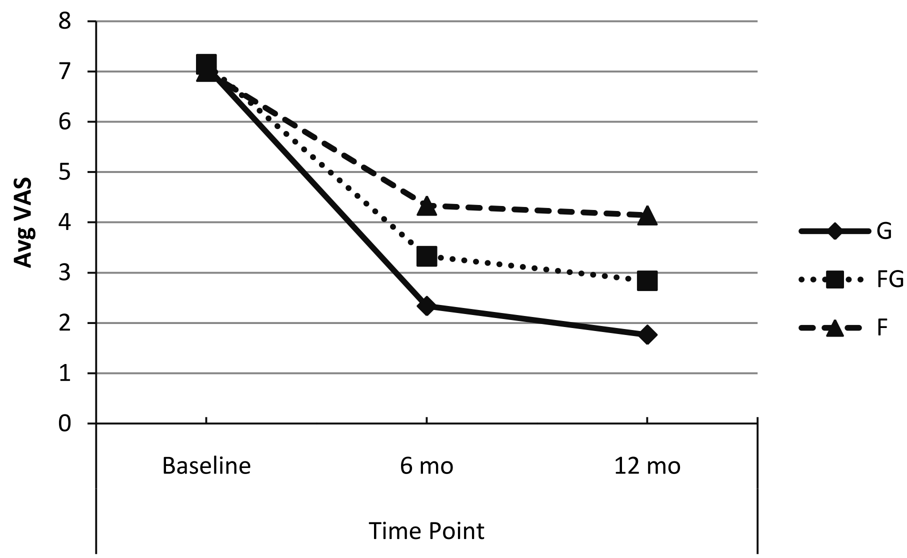
The presence and severity of psychological risk factors was assessed using the PPS method which generates a prognosis. Of the 234 subjects in the total sample, 174 participated in presurgical psychological screening and were given a prognosis. The distribution of subjects across prognosis groups is summarized in Table 4. The groups were compared using chi-square and ANOVA to detect between-groups differences on demographic variables. The groups did differ significantly ($\chi^2 = 6.244$, $p = .044$) on gender where there were twice as many males than females in the G and F groups while the ratio of males to females in the FG group was roughly equal (Table 5). As expected, there was also a significantly higher proportion of Workman's Compensation patients in the F group compared to the G and FG groups ($\chi^2 = 19.573$, $p = .001$) (Table 6). There were no significant between-groups differences in race, age, or body mass index.

The groups were compared on baseline measures of pain and disability using a one-way ANOVA. While the groups were not dissimilar on baseline VAS scores

(*F*(2,171) = .337, *p* = .715, observed power = .103), they were discrepant on ODI scores (*F*(2,171) = 7.762, *p* = .001, observed power = .948). Post hoc comparisons using the Bonferroni method indicated that while the FG and F groups had similar ODI scores (*p* = .179), the G subjects differed significantly from both the FG (*p* = .048) and G (*p* = .001) groups. Further examination showed that the Oswestry scores for the G group were lower than those of the FG and F groups. See Tables 7 and 8 for summaries of the descriptive characteristics of VAS and ODI scores for the prognosis groups.

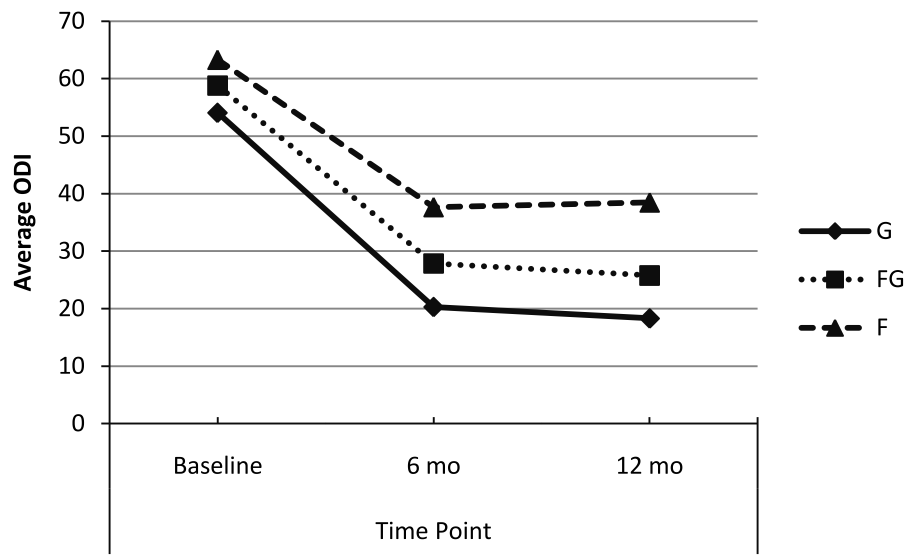
To investigate whether treatment outcome could be predicted by PPS prognosis, repeated measures ANCOVA over three time points were conducted. Each analysis controlled for differences in the baseline treatment variable. Reduction in pain represented by VAS scores was examined first. Of the subjects who received a prognosis, 107 were administered the VAS at each time point. Subjects who were missing a VAS score at any of the three time points were not included in this analysis. The conducted ANCOVA resulted in an observed power of .937. While the average pain reports for all three groups decreased following surgery, prognosis was found to significantly predict which patients would benefit the most from surgery (*F*(2,104) = 7.468, *p* = .001). Post hoc comparisons showed that the G group was significantly different from both the FG (*p* = .048) and F (*p* = .001) groups but the intergroup comparison between the FG and F groups was insignificant (*p* = .179).

Figure 3. Average VAS scores by prognosis over time



Disability as measured by the ODI was examined next. Baseline ODI was factored in as a covariate in the analysis. There were 103 patients for whom ODI data was available at all time points and the observed power for this analysis was .776. The between-groups differences were significant in this case, as well ($F(2,100) = 4.698$, $p = .011$). The post hoc analysis showed that there were significant differences in disability ratings over time between the G and F groups ($p < .000$) as well as the G and FG groups ($p < .000$), but the FG-F($p = .437$) intergroup comparisons were not significant.

Figure 4. Average ODI scores by prognosis over time

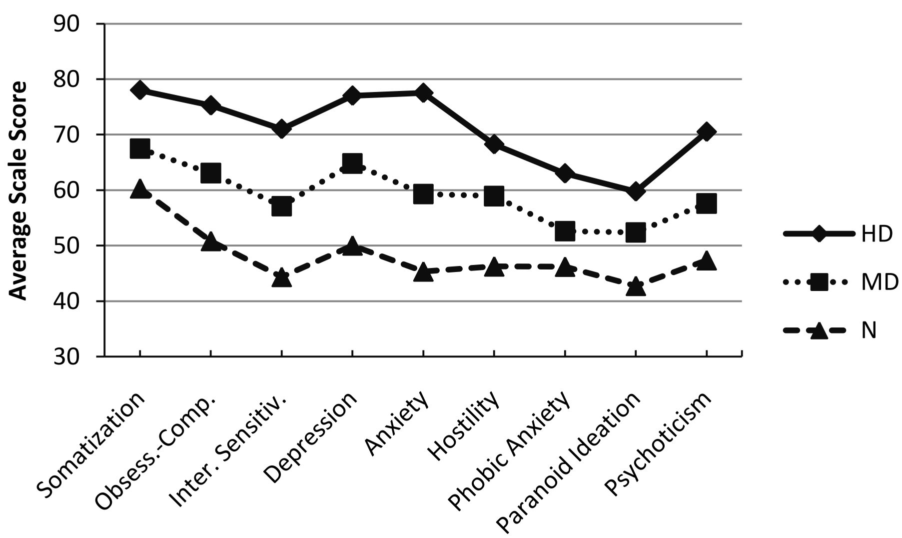


One confounding factor with this outcome data is that it ceases to be normally distributed as patients reach the lower-bound thresholds for pain and impairment. This is particularly apparent at the 12-month time point when a large number patients report a complete restoration of functioning and cessation of pain. This is a common problem in pain treatment literature, and while the violation of the normality assumption is typically ignored, it is possible to perform less powerful nonparametric analyses that allow for this violation (Geisler, 2007). Kruskal-Wallis analyses were conducted to compare the prognosis groups on percent-change scores of the VAS and ODI between time points. Just as with the repeated measures ANCOVA analyses, prognosis was found to discriminate between the degree of the subject's response to treatment. The results of these analyses are summarized in Table 9.

HYPOTHESIS 2: SCL-90 RESPONSE PATTERNS AND CLUSTER ANALYSIS

The objective of the second hypothesis was to examine the SCL-90 data and determine whether there were underlying response patterns that could be used to group the subjects. Within the total sample, 102 subjects provided a valid and interpretable SCL-90. The nine content scores were used to conduct a hierarchical cluster analysis and a three-cluster solution was generated. The mean values of the content scales for each cluster are described in Table 10 and charted in Figure 5.

Figure 5. Average SCL-90 content scale scores by cluster



The first cluster of cases has the highest mean elevation on each scale and will be termed the Highly Distressed (HD) cluster. The second cluster, which falls between the first and third clusters on the mean distributions, will be called the Moderately Distressed (MD) while the third cluster whose observed means hover around the expected means for the SCL-90 will be termed the Normal (N) Cluster.

The number of cases per cluster are strikingly disparate. There are only 4 cases in HD cluster while there are 42 and 56 cases in the MD and N clusters, respectively. This is to be expected because of the nature of the selection process for inclusion in this study. The large majority of patients experiencing high levels of distress would have been excluded from participation as being psychologically ill-suited for surgical intervention or for complying with treatment and study protocols. Therefore the potential sample of subjects who may have produced a HD profile was truncated. Nevertheless, results using these clusters must be interpreted with caution.

HYPOTHESIS 3: SCL-90 CLUSTERS AND TREATMENT OUTCOME

The objective of this hypothesis is to determine whether highly distressed patients, as defined by the SCL-90 response patterns uncovered in the preceding step, respond more poorly to treatment than patients not exhibiting normal levels of distress. First, the three clusters groups - HD, MD, and N - were compared across demographic variables using chi-square and ANOVA and there were no significant between-groups differences in gender, age, race, body mass index, or insurance coverage.

Next the groups were compared on baseline measures of pain and disability using a one-way ANOVA. The cluster groups were not significantly different on either baseline VAS ($F(2,99) = .620$, $p = .540$, observed power = .151) or ODI ($F(2,99) = .909$, $p = .406$, observed power = .203) scores. Repeated measures ANCOVA analyses over three time points were conducted to determine whether the SCL-90 clusters could predict treatment outcome. As with the testing of Hypothesis 1, these analyses controlled for differences on the baseline treatment variable. Of the subjects who produced a SCL-90 profile, 57 provided VAS data at each time point. With a low observed power of .424, there was not a significant difference in pain reduction over time between clusters ($F(2,54) = 2.166$, $p = .125$). Fifty-four SCL-90 subjects provided ODI data across all time points. Here, the differences between cluster groups approached but did not reach significance ($F(2,51) = 2.896$, $p = .065$, observed power = .541). See Tables 12 and 13 for summaries of the descriptive characteristics of VAS and ODI scores for the cluster groups.

Figure 6. Average VAS scores by cluster over time

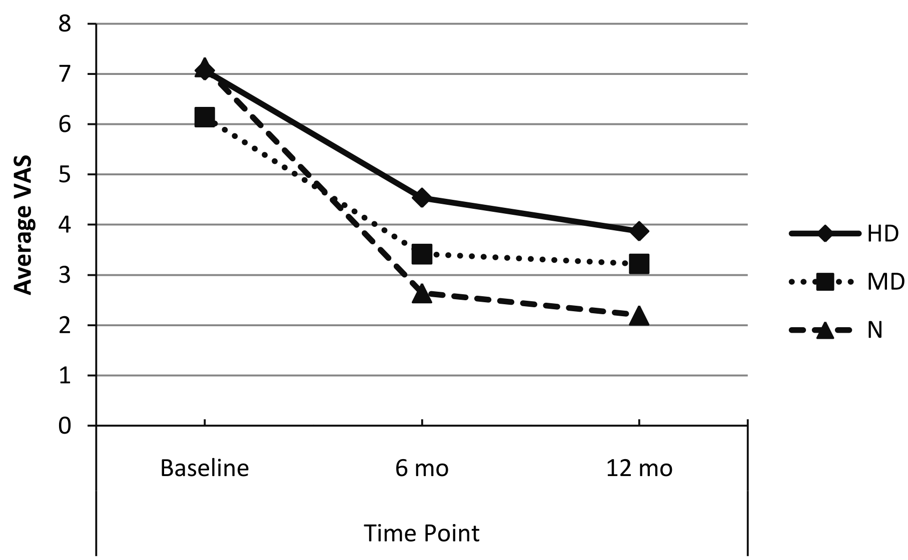
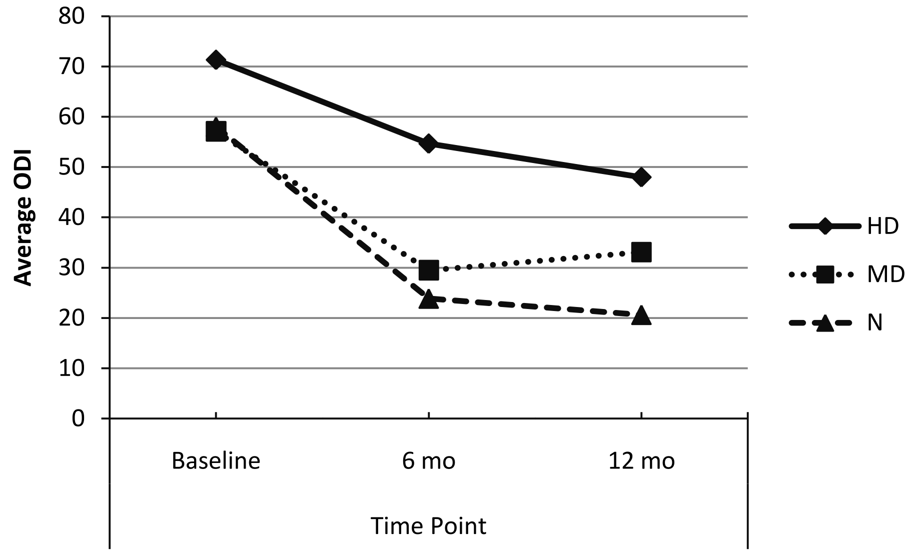


Figure 7. Average ODI scores by cluster over time



As with Hypothesis 1, the floor effect on the treatment outcome variables provides a confounding factor to the analytic process. A nonparametric analysis of percent-change scores by cluster was conducted and the results are summarized in Table 14. While cluster was not found to predict variable treatment outcome at the 6-month mark for either pain or disability, there were significant between-groups effects from baseline to 12 months for both VAS (χ^2 = 8.679, p = .013) and ODI (χ^2 = 8.300, p = .016) scores. However, this analysis does not tell us which of the group comparisons were significant.

HYPOTHESIS 4: PAIRS SCORE AND TREATMENT OUTCOME

The purpose of the fourth hypothesis is to examine the relationship between PAIRS scores and measures of pain and disability, both before treatment and as a result of surgery. Eighty-four subjects completed a PAIRS questionnaire prior to surgery.

First, linear regression was conducted using PAIRS total score as the independent variable. These scores did not significantly predict pain reports at baseline (β = .019, $F(1, 82) = 1.681$, p =.198). PAIRS total scores did significantly predict self-reported disability at baseline (β = .342, $F(1, 82) = 13.181$, $p < .001$) and explained a significant proportion of the variance ODI scores ($R^2 = .138$, $p < .001$).

Using the median split of 75, the subjects with PAIRS scores were divided into two groups: H-PAIRS (N = 23) and L-PAIRS (N = 61). The groups were compared using chi-square and independent t-tests to evaluate between-groups differences on demographic variables. There were no significant differences found between the groups on age, gender, race, or body mass index. However, the groups were significantly dissimilar on insurance ($\chi^2(1, N = 84) = 10.62$, $p = .005$) where the ratio of H-PAIRS to L-PAIRS was much higher for the Workman's Compensation subjects than for the Private Insurance or Self-Pay subjects. Going forward, insurance would be used as a covariate in analyses comparing the H-PAIRS and L-PAIRS groups.

Complete follow-up data for PAIRS subjects was available for only 44 of the 84 subjects. Initial ANOVA comparisons showed that the H-PAIRS and L-PAIRS groups differed significantly at baseline on measures of disability ($F(1,82) = 6.448$, $p = .013$, observed power = .709) but not pain ($F(1,82) = .465$, $p = .497$, observed power = .103). A repeated measures ANCOVA which controlled for Insurance Type and Baseline VAS did not uncover a significant difference in pain reduction over time between the H-PAIRS and L-PAIRS groups ($F(1,40) = .839$, $p = .365$, observed power = .145). Similarly, a repeated measures ANCOVA controlling for Insurance Type and Baseline ODI with an observed power of .072 found that the between-groups differences in functional restoration over time were insignificant ($F(1,40) = .195$, $p = .661$). See Tables 15 and 16 for summaries of the descriptive characteristics of VAS and ODI scores for the PAIRS groups.

Figure 8. Average VAS scores by PAIRS group over time

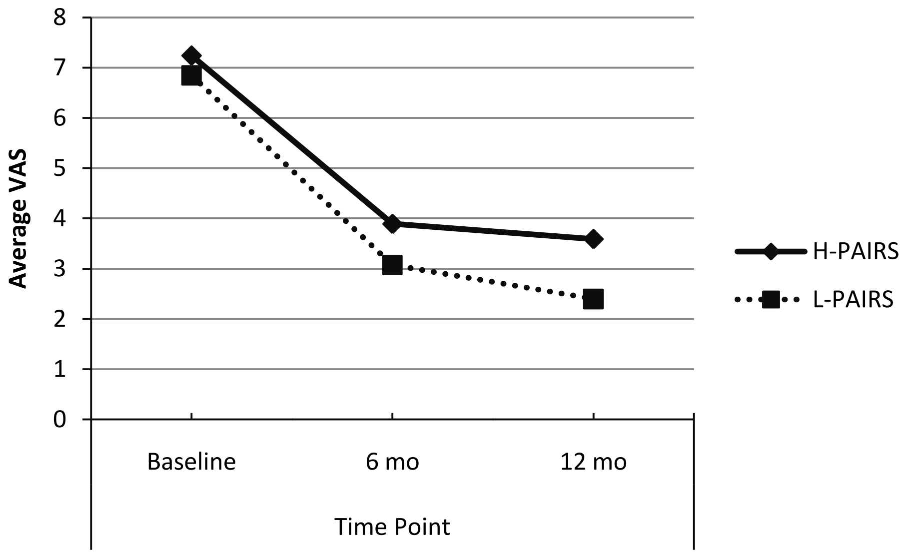
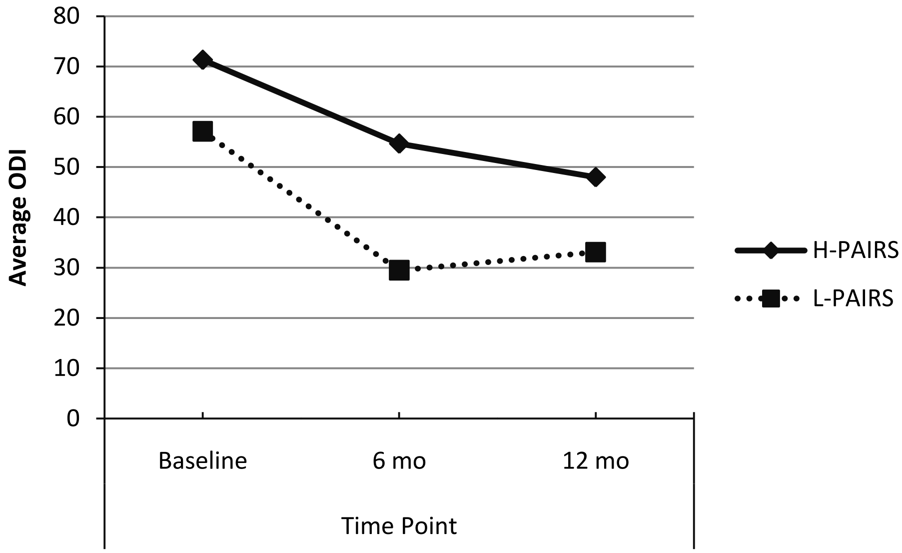


Figure 9. Average ODI scores by PAIRS group over time



A final nonparametric test was conducted using the PAIRS groups to address the floor effect on the treatment outcome scores. The Mann-Whitney chi-square results uncovered no significant between-groups differences in percent-change scores for either pain or disability. Results are summarized in Table 17.

CHAPTER FIVE
Discussion

Psychological screening is becoming a more accepted part of the presurgical process for many types of back surgery and pain intervention. Although a large body of research looks at the correlations between psychological variables and pain as well as the efficacy of presurgical psychological screening in predicting treatment outcome, no studies have yet examined the linkages between pre-treatment psychological variables and Total Disc Replacement surgery.

This study had three aims. The primary goal was to evaluate the effectiveness of the PPS Method developed by Dr. Block in predicting the outcome of TDR as measured by patient reports of pain and disability. The secondary aims involved the evaluation of two instruments used as part of the PPS process. While research has established that the MMPI-2 has linkages with pain reports and is an effective tool in predicting outcome, the difficulty of administration within a pain population makes it undesirable. Therefore demonstrating the value of a shorter, broad measure of psychological symptoms such as the SCL-90 would be of use to clinicians conducting presurgical assessments. The PAIRS inventory, another instrument that may be used in the presurgical screening, purports to measure the patient's belief that pain leads to impairment. Whether such an instrument could be useful in predicting the patient's response to treatment is a question worth further investigation.

Preliminary analyses compared patients who followed through with the research protocols to the 6- and 12-month time points (FY) to those who did not (FN). These groups were not dissimilar on age, body mass index, race, gender, or insurance coverage. They also could not be differentiated based on baseline measures of pain or impairment. Therefore, only the FY subjects were analyzed with respect to the study's hypotheses.

DISCUSSION OF HYPOTHESES

Presurgical Psychological Screening

The first hypothesis posits that patients with more, or more severe, psychological risk factors would have poorer treatment outcomes than less distressed patients. For this study, the severity of symptoms was indicated by the PPS prognosis. An initial examination of the prognosis groups uncovered between-groups differences on gender and insurance coverage. The latter was expected as Workman's Compensation is considered a risk factor for poor outcome and is part of the PPS algorithm. The difference in gender by group was unexpected. Gender has not been shown to be a risk factor for low back surgery, nor is it a variable in the PPS prognosis-generating algorithm. Gender did not significantly predict either pain reduction ($F(1,133) = 1.525$, $p = .219$) or restoration of function ($F(1,128) = .161$, $p = .689$) in this study, either. For these reasons, neither gender nor insurance coverage was used as a covariate in analysis investigating prognosis.

Overall, both parametric and nonparametric analyses confirm the first hypothesis. The G, FG, and F groups reported similar degrees of pain at baseline. While the pain reports for all three groups declined, by the 12-month mark, the G group pain reports had decreased by 75% while the FG and F groups' reports had declined by 60% and 41%, respectively. PPS Prognosis was most successful in distinguishing the patients who would experience the greatest reduction in pain following surgery, as the G group improved significantly more than both the FG and F subjects. A comparison of the FG and F groups indicated the improvement of the groups could not be statistically distinguished from each other. It is possible that a larger sample of subjects may have resulted in a significant finding, and the PPS method may indeed be sensitive enough to differentiate FG patients from F patients.

Unlike with pain, functional disability reports were different between groups at baseline. The average ODI score for patients in the G group was almost 5 points below that of the FG group and almost 10 points below that of the F group. Part of the PPS process takes into account the patient's perception of the impact of pain on their daily lives, and patients who experience a disproportionate impact on functioning as a result of pain are considered at greater risk for poor surgical outcome. It makes sense, then, that while the groups were equivalent on VAS scores before surgery, the ODI scores of the F group would be elevated by those patients experiencing a proportionally more negative impact on functional ability.

From pre- to post-surgery, all three groups improved on reports of functional disability. Here again, the G group showed to greatest improvement with a 66% reduction in ODI scores at 12-months. The FG group showed 56% improvement and the F group showed only 39% improvement. While the F group's improvement was significantly less than that of the G group, prognosis was unable to differentiate the FG subjects from the G and F groups. One interpretation of this finding is that delineation between the groups as determined by the PPS algorithm would benefit from refinement. It is also possible that a larger sample would confirm that FG subjects' improvement in functional ability is statistically different from that of G or F subjects. Overall, however, the first hypothesis was borne out by the data. The greater presence or severity of psychological risk factors as measured by the PPS method is a risk factor for lesser pain reduction and restoration of functioning following TDR surgery.

SCL-90: Pattern Response Detection

The second hypothesis was formulated based on the results of cluster analyses of MMPI data. It was hypothesized first that response patterns would emerge from the content scale scores, and second that the uncovered patterns would have particular characteristics. One of the hypothesized clusters would be characterized by elevations on the Depression and Somatization scales while another would be distinguished by across-the-board elevations. A hierarchical cluster analysis did uncover a 3-cluster solution as seen in Figure 3. The clusters were distinguished by the general level of elevation on all content scores rather than a one or two scales. The clusters were examined scale by scale and significant between-groups differences were found on all of the content scales. Post hoc analyses for these differences are summarized in Table 11. The Paranoid Ideation scale stands out as the only scale unable to differentiate the HD subjects from either the MD or N subjects. Earlier studies have suggested that the SCL-90 is a better measure of generalized distress than of particular symptoms. The cross-scale-elevation response pattern found in this study would support such a notion. One possibility is that the SCL-90 measures demoralization, a nonspecific psychological distress dimension that is often inadvertently picked up on by psychological instruments (Dohrenwend, Shrout, Egri, & Mendelsohn, 1980; Frank, 1974; Tellegen, et al., 2003). Demoralization is characterized by dysphoria, unhappy mood, helplessness, general dissatisfaction, and an inability to cope (Sellbom, Ben-Porath, & Bagby, 2008). As depression, poor coping, and generalized distress have been linked to increased pain and poor treatment outcome, a measure of a construct incorporating these factors could have some predictive utility.

SCL-90 Clusters & Treatment Outcome

Once the SCL-90 response patterns were identified, the next step was to determine whether they could be useful in predicting a patient's response to surgical intervention. There was no correlation found between the clusters and baseline measures of pain or disability. The original hypothesis speculated that highly distressed patients would have less reduction in pain and restoration of functional ability after TDR than normally distressed patients. Pain and disability were reduced over time for all three cluster groups following surgery. The response pattern clusters did not, in fact, predict which patients would have a better improvement on VAS scores. Similarly, cluster did not sufficiently predict which patients would have greater functional restoration though the results of the ANCOVA approached significance (p = .065). The HD group improved on their ODI scores by only 32% at 12 months while the MD group's ODI scores had improved by 42% and the N group's scores had dropped by 64%.

It should be noted that the size of the HD group was very small, and perhaps a larger sample would have shown the SCL-90 clusters to be more predictive. As discussed previously, the small size of the HD group may be attributed to the fact that very highly distressed patients were often considered unfit to participate in the study or to proceed with surgery. Additionally, it may be that patients in a normal spine surgery population are non-normally distributed into these three clusters with the fewest patients falling naturally into the HD cluster. A study of MMPI-2 data reported detecting three response patterns among spine surgery candidates: a Normal pattern, a Pain Sensitive pattern, and a Pathological pattern (Block, Ben-Porath, & Burchett, 2009; Block, Ohnmeiss, Guyer, Rashbaum, & Hochschuler, 2001). The Pathological pattern consisted of elevations across all of the scales except the Mf and Si scales. While the Normal and Pain Sensitive groups contained 114 and 86 subjects respectively, the pathological group had 22 subjects, only 10% of the total sample. While the psychological prognoses were communicated to surgeons, psychological preparedness was not among the inclusion criteria for surgery and some patients with Fair-Poor and Poor prognoses proceeded with treatment. That study was able to detect significant between-groups difference in both pain reduction and functional restoration as a result of surgery. It would interesting to see if a larger sample were able detect between-groups differences in pain reduction and functional restoration using the SCL-90 and the response patterns reported in this investigation.

Pain and Impairment Rating Scale

When looking at the PAIRS inventory, this study proposed two objectives: to evaluate the correlation between the PAIRS and measures of functioning and pain prior to surgery, and to determine whether the PAIRS was useful in predicting response to treatment. The regression analysis did not demonstrate a relationship between PAIRS scores and VAS scores at baseline, but it did show a link between the PAIRS and ODI scores at that time point. As the PAIRS measures the subject's belief that pain necessarily leads to impairment, it makes sense that the subjects with a stronger endorsement of that belief would report greater levels of disability compared to subjects experiencing an equivalent degree of pain but less conviction that the pain impaired them.

Repeated measures ANCOVAs uncovered no significant differences between the H-PAIRS and L-PAIRS groups on either pain reduction or functional disability over time. While both groups showed improvement, the variance in scores was great at all time points for all groups. Similarly, nonparametric analyses failed to find any significant differences between the H-PAIRS and L-PAIRS groups. As the power for these analyses were extremely low, the hypothesis that H-PAIRS subjects would have better treatment outcomes than L-PAIRS subjects can be neither accepted nor rejected.

LIMITATIONS

Despite the significant findings and implications for presurgical psychological screening with TDR, this study was hampered by several limitations. First and foremost, this was a retrospective study that relied on data gathered for other investigations. There was no opportunity to define the parameters of the investigation, select the instruments used, or oversee the collection of data.

Another major drawback of this study was the sample size for several of the analyses. These small N's were the result of several limitations in the study design. Not all of the TDR candidates participated in PPS and the reasons for nonparticipation were not recorded. The patients may have declined, the doctors may have seen it as unnecessary, the insurance provider may have refused reimbursement, there may have been a scheduling conflict, or another unknown variable could have interfered. A more systemic insistence on participation in PPS would have resulted in a more comprehensive examination of the potential TDR patients and their responses to treatment. An analysis of nonparticipants would also be of interest particularly if a particular subset of nonparticipants had poorer treatment results than patients who passed the psychological screening. One artifact of the study design was the exclusion of subjects who would have been given a Fair-Poor or Poor prognosis in the screening process. While this protected the patients and doctors from unnecessary risk, it hindered the examination of the PPS method's full potential. Follow-up data was not collected aggressively for the majority of subjects. Consequently, only 84% of PPS subjects provided data at 6 months, and the follow-up rate had declined to 63% at 12 months.

FUTURE DIRECTIONS

Future research into PPS and TDR would greatly benefit from addressing some of the limitations discussed above. A prospective, longitudinal study where all potential subjects participated in PPS would be an improvement, particularly if follow-up data was pursued more effectively. It would also be interesting to investigate what happens to patients with a Poor PPS prognosis. These patients are usually referred for less invasive treatment methods such as physical therapy, drug therapy, or chronic pain management programs. They could be compared to other patients who were given better prognoses but who went with a less invasive treatment method.

This study highlighted a few potential directions for improving the PPS method itself. Perhaps the PPS algorithm could be refined to better differentiate between all five prognoses (G, FG, F, FP, and P). Future research could break down the components of the algorithm to determine which were the most useful or least in predicting outcome. Instruments could be evaluated, selected, and weighted for inclusion in the algorithm. Ongoing studies at are investigating the MMPI-2-RF which includes a scale for measuring demoralization. The utility of such an instrument within the context of PPS would be of interest, given the current study's findings regarding the SCL-90. Finally, a large body of research focuses on coping and how it influences both pain and response to treatment. The means of coping used by TDR patients and whether analysis of that coping could be used to predict a response to treatment would be interesting alleys of investigation.

CONCLUSION

This study has demonstrated the effectiveness of the PPS method in predicting which patients are more likely to experience pain reduction and restoration of functioning after TDR surgery. Not only was this study able to validate the utility of presurgical screening, it was the first to investigate psychological correlates with Total Disc Replacement. Hopefully these findings will lead to the more widespread implementation of psychological evaluation as a routine part of highly invasive procedures to help doctors and patients make informed decisions regarding treatment.

The specific findings regarding the other two evaluated measures will perhaps be of lesser significance within clinical settings. While distinct response patterns were detected in the SCL-90 data, they were not proven to be predictive so the utility of the SCL-90 within the PPS context remains in question. Further investigation is needed to determine whether other instruments could be more useful or efficient in evaluating TDR risk factors and predicting response to treatment. The PAIRS was shown to correlate with baseline measures of functional disability, but the sample size was simply too small to provide a valid analysis of treatment effect over time. Given these findings, future research should focus on refining and improving the PPS algorithm and on identifying the most effective instruments for assessing risk factors.

APPENDIX A
Tables

Table 1
Inclusion and exclusion criteria for current study

Inclusion Criteria	Exclusion Criteria
Age 18 to 60 years	Previous thoracic or lumbar fusion
Symptomatic Disc Degenerative Disease (DDD) confirmed by discography	Current or prior fracture at L2 to S1
One- or Two-Level DDD at L2-S1	Noncontained herniated nucleus pulposus
Oswestry score ≥ 40	Spondylosis
Failed ≥ 6 months of appropriate nonoperative care	Spondylolisthesis > 3mm
Back and/or leg pain with no nerve root compression	Scoliosis > 11°
Able to tolerate anterior approach	Midsagittal stenosis < 8mm
Able and willing to comply with follow-up schedule	Positive straight leg raise
Willing to give written informed consent	Spinal tumor
Psychosocially, mentally, and physically able to comply fully with protocol, including adhering to follow-up schedule and requirements, and filling out forms	Osteoporosis, osteopenia, or metabolic bone disease
	Infection
	Facet joint arthrosis
	Morbid obesity
	Metal allergy
	Use of a bone growth stimulator
	Arachnoiditis
	Chronic steroid use
	Autoimmune disorder
	Pregnancy
	Other spinal surgery at affected level (except discectomy, laminotomy/ectomy, without accompanying facetotomy or nucleolysis at the same level to be treated)

Table 2
Referral criteria used by surgeons to assess the need for psychological assessment

Referral Criteria for Presurgical Psychological Screening
Symptoms inconsistent with identified pathology
High levels of depression or anxiety
Sleep disturbance - insomnia or hypersomnia
Excessively high or low expectations regarding treatment outcome
Marital distress or sexual difficulties
Negative attitudes towards work or employer
Emotional lability or mood swings
Unable to work or decreased functional activity ≥ 3 months
Escalation in use or dosage of narcotics or anxiolytics
Litigation or continuing disability benefits as a result from injury
History of noncompliance with medical treatment
History of psychiatric or psychological treatment

Table 3
Demographics of the total sample

Total Sample (N=234)	N	%
Gender		
Male	130	55.6
Female	104	44.4
Race		
Caucasian	206	88
Hispanic	14	6
African American	5	2.1
Native American	3	1.3
Asian	2	0.9
Other	4	1.7
Insurance		
Private Insurance	198	84.6
Workman's Compensation	31	13.2
Other / Self Pay	5	2.1

Table 4

Prognosis Sample: Group Size

Prognosis Sample (N=174)	N	%
Good	66	37.9
Fair-Good	73	42.0
Fair	35	20.1

Table 5

Prognosis Sample: Gender by Prognosis

Prognosis Sample (N=174)	Male	Female	Total N
Good	44	22	66
Fair-Good	34	39	73
Fair	22	13	35

Table 6

Prognosis Sample: Insurance Coverage by Prognosis

Prognosis Sample (N=174)	Private	WC	Self-Pay	Total N
Good	61	5	0	66
Fair-Good	63	7	3	73
Fair	23	12	0	35

Table 7

Prognosis Sample: A descriptive summary of the VAS scores

	Mean	SD	Range
Baseline			
Good	7.093	1.668	3.6-10
Fair-Good	7.142	1.362	3.6-9.8
Fair	6.995	2.215	2-10
6 Months			
Good	2.338	2.495	0-9.1
Fair-Good	3.326	2.663	0-8.4
Fair	4.336	2.398	0.5-8
12 Months			
Good	1.767	2.034	0-8
Fair-Good	2.837	2.513	0-8.6
Fair	4.145	2.852	0.4-8.2

Table 8

Prognosis Sample: A descriptive summary of the ODI scores

	Mean	SD	Range
Baseline			
Good	54.03	12.201	30-82
Fair-Good	58.79	11.169	36-84
Fair	63.29	10.921	44-84
6 Months			
Good	20.29	20.306	0-60
Fair-Good	27.85	21.125	0-74
Fair	37.64	18.044	6-62
12 Months			
Good	18.30	19.240	0-68
Fair-Good	25.76	18.607	0-74
Fair	38.45	19.760	6-80

Table 9

Prognosis Sample: Nonparametric analyses of between-group effects

Prognosis is the independent variable and the percent-change scores between two time points are the dependent variables

	N	χ^2	*p*
VAS % Change			
Baseline to 6 months	147	11.515	.003
Baseline to 12 months	110	14.607	.001
ODI % Change			
Baseline to 6 months	140	6.957	.031
Baseline to 12 months	106	11.15	.004

** This type of analysis does not allow for post hoc comparisons of between-group differences.*

Table 10
SCL-90 Sample: Means and standard deviations of the content scales by cluster

Content Scale	Cluster 1 (N = 4)	Cluster 2 (N = 42)	Cluster 3 (N = 56)
Somatization			
mean	78	67.5	60.3
std dev	4.761	6.134	4.910
Obsessive-Compulsive			
mean	75.25	63.07	50.82
std dev	6.449	6.923	8.176
Interpersonal Sensitivity			
mean	71	57.12	44.36
std dev	7.257	6.053	5.108
Depression			
mean	77	64.81	50.02
std dev	4.899	5.452	7.101
Anxiety			
mean	77.50	59.29	45.34
std dev	3.109	6.368	6.884
Hostility			
mean	68.25	58.93	46.25
std dev	4.646	6.627	5.160
Phobic Anxiety			
mean	63.00	52.60	46.20
std dev	3.266	8.323	3.113
Paranoid Ideation			
mean	59.75	52.38	42.75
std dev	13.937	8.202	4.218
Psychoticism			
mean	70.5	57.6	47.36
std dev	8.185	6.611	6.383

Table 11

SCL-90 Sample: Post hoc analyses of between-group differences by scale

Content Scale Clusters Compared	Mean Difference	Std Error	*p*
Somatization			
1-2	10.500	2.562	.032*
1-3	17.696	2.469	.007*
2-3	7.196	1.152	.000*
Obsessive-Compulsive			
1-2	12.179	3.397	.055
1-3	24.429	3.404	.006*
2-3	12.250	1.528	.000*
Interpersonal Sensitivity			
1-2	13.881	3.747	.056
1-3	26.643	3.692	.009*
2-3	12.762	1.157	.000*
Depression			
1-2	12.190	2.590	.023*
1-3	26.982	2.627	.001*
2-3	14.792	1.268	.000*
Anxiety			
1-2	18.214	1.839	.000*
1-3	32.161	1.806	.000*
2-3	13.946	1.346	.000*
Hostility			
1-2	9.321	2.538	.041*
1-3	22.000	2.423	.003*
2-3	12.679	1.233	.000*
Phobic Anxiety			
1-2	10.405	2.077	.003*
1-3	16.804	1.685	.003*
2-3	6.399	1.350	.000*
Paranoid Ideation			
1-2	7.369	7.083	.603
1-3	17.000	6.991	.176
2-3	9.631	1.385	.000*
Psychoticism			
1-2	12.905	4.218	.095
1-3	23.143	4.181	. 019*
2-3	10.238	1.330	.000*

** The mean difference is significant at the .05 level*

Table 12
SCL-90 Sample: A descriptive summary of the VAS scores

	Mean	SD	Range
Baseline			
HD	7.067	1.266	5.7-8.2
MD	6.140	2.132	2.0-9.8
N	7.135	1.552	3.8-10.0
6 Months			
HD	4.533	1.332	3.4-6.0
MD	3.415	2.490	0.1-8.4
N	2.642	2.688	0.0-8.0
12 Months			
HD	3.867	1.834	1.8-5.3
MD	3.220	2.746	0.0-8.2
N	2.200	2.589	0.0-8.6

Table 13
SCL-90 Sample: A descriptive summary of the ODI scores

	Mean	SD	Range
Baseline			
HD	71.33	5.033	66-76
MD	57.10	8.932	40-72
N	58.00	10.979	36-78
6 Months			
HD	54.67	7.572	46-60
MD	29.50	22.032	0-74
N	23.87	21.694	0-72
12 Months			
HD	48.00	5.292	44-54
MD	33.10	18.756	2-68
N	20.65	20.287	0-74

Table 14
SCL-90 Sample: Nonparametric analyses of between-group effects
SCL-90 cluster is the independent variable and the percent-change scores between two time points are the dependent variables

	n	χ^2	*p*
VAS % Change			
Baseline to 6 months	80	4.652	.098
Baseline to 12 months	59	8.679	.013
ODI % Change			
Baseline to 6 months	78	5.598	.061
Baseline to 12 months	56	8.300	.016

** This type of analysis does not allow for post hoc comparisons of between-group differences.*

Table 15
PAIRS Sample: A descriptive summary of the VAS scores

	Mean	SD	Range
Baseline			
H-PAIRS	7.242	1.610	3.8-9.9
L-PAIRS	6.847	1.876	2.0-10.0
6 Months			
H-PAIRS	3.892	3.3274	0.0-8.4
L-PAIRS	3.075	2.520	0.1-9.1
12 Months			
H-PAIRS	3.592	3.171	0.0-8.2
L-PAIRS	2.397	2.483	0.0-8.6

Table 16

PAIRS Sample: A descriptive summary of the ODI scores

	Mean	SD	Range
Baseline			
H-PAIRS	66.00	6.606	58-78
L-PAIRS	58.12	9.311	38-74
6 Months			
H-PAIRS	32.17	26.839	0-74
L-PAIRS	28.31	22.759	0-72
12 Months			
H-PAIRS	30.17	22.890	0-60
L-PAIRS	24.62	20.818	0-74

Table 17

PAIRS Sample: Nonparametric analyses of between-group effects

PAIRS group is the independent variable and the percent-change scores between two time points are the dependent variables

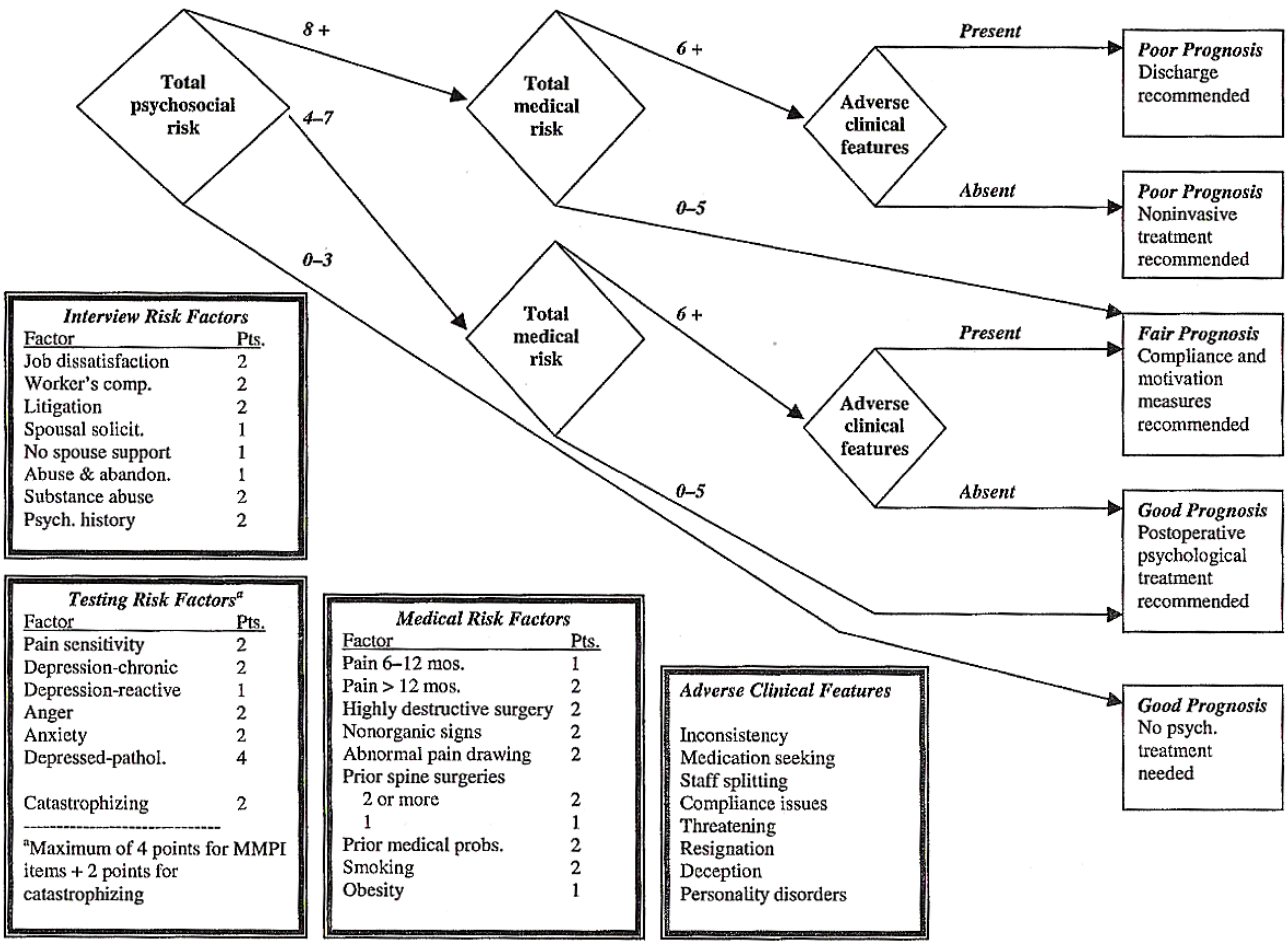
	n	*U*	*p*
VAS % Change			
Baseline to 6 months	64	439	.988
Baseline to 12 months	46	166	.341
ODI % Change			
Baseline to 6 months	61	369	.640
Baseline to 12 months	46	182	.581

APPENDIX B

Figures

Figure 2

Algorithm for determining presurgical psychological screening prognosis



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REFERENCES

Ayers, D. C., Franklin, P. D., Ploutz-Snyder, R., & Boisvert, C. B. (2005). Total knee replacement outcome and coexisting physical and emotional illness. *Clinical Orthopaedics and Related Research, 440*, 157-161.

Beals, R. K., & Hickman, N. W. (1972). Industrial injuries of the back and extremities. Comprehensive evaluation--an aid in prognosis and management: a study of one hundred and eighty patients. *The Journal of Bone and Joint Surgery, American volume, 54*(8), 1593-1611.

Bertagnoli, R., Yue, J. J., Shah, R. V., Nanieva, R., Pfeiffer, F., Fenk-Mayer, A., et al. (2005). The treatment of disabling multilevel lumbar discogenic low back pain with total disc arthroplasty utilizing the ProDisc prosthesis: a prospective study with 2-year minimum follow-up. *Spine (Phila Pa 1976), 30*(19), 2192-2199.

Bigos, S. J., Battie, M. C., Spengler, D. M., Fisher, L. D., Fordyce, W. E., Hansson, T. H., et al. (1991). A prospective study of work perceptions and psychosocial factors affecting the report of back injury. *Spine, 16*(1), 1-6.

Block, A. R. (1996). *Presurgical psychological screening in chronic pain syndromes : a guide for the behavioral health practitioner*. Mahwah, N.J.: L. Erlbaum Associates.

Block, A. R., Ben-Porath, Y. S., & Burchett, M. A. (2009). *The MMPI-2-RF in pre-surgical psychological screening of spine surgery candidates: preliminary results*. Paper presented at the MMPI-2 and MMPI-2-RF Annual Workshop.

Block, A. R., Boyer, S. L., & Silbert, R. K. (1985). Spouse's perception of the chronic pain patient: Estimates of exercise tolerance. In H. L. Fields, R. Dubner & F. Cervero (Eds.), *Advances in Pain Research and Therapy* (Vol. 9, pp. 897-904). New York: Raven Press.

Block, A. R., Gatchel, R. J., Deardorff, W. W., & Guyer, R. (2003). *The psychology of spine surgery* (1st ed.). Washington, DC: American Psychological Association.

Block, A. R., Kremer, E., & Gaylor, M. (1980a). Behavioral treatment of chronic pain: variables affecting treatment efficacy. *Pain, 8*(3), 367-375.

Block, A. R., Kremer, E. F., & Gaylor, M. (1980b). Behavioral treatment of chronic pain: the spouse as a discriminative cue for pain behavior. *Pain, 9*(2), 243-252.

Block, A. R., & Ohnmeiss, D. D. (2000). *MMPI profiles predict the outcome of spinal surgery.* Paper presented at the North American Spine Society, 15th Annual Meeting, New Orleans.

Block, A. R., Ohnmeiss, D. D., Guyer, R. D., Rashbaum, R. F., & Hochschuler, S. H. (2001). The use of presurgical psychological screening to predict the outcome of spine surgery. *Spine Journal: Official Journal of the North American Spine Society, 1*(4), 274-282.

Block, A. R., Vanharanta, H., Ohnmeiss, D. D., & Guyer, R. D. (1996). Discographic pain report. Influence of psychological factors. *Spine, 21*(3), 334-338.

Blumenthal, S., McAfee, P. C., Guyer, R. D., Hochschuler, S. H., Geisler, F. H., Holt, R. T., et al. (2005). A prospective, randomized, multicenter Food and Drug Administration investigational device exemptions study of lumbar total disc replacement with the CHARITE artificial disc versus lumbar fusion: part I: evaluation of clinical outcomes. *Spine, 30*(14), 1565-1575; discussion E1387-1591.

Boersma, K., & Linton, S. J. (2005). Screening to identify patients at risk - Profiles of psychological risk factors for early intervention. *Clinical Journal of Pain, 21*(1), 38-43.

Bradley, L. A., Gentry, C. K., Van der Heide, L. H., & Prieto, E. J. (1981). Assessment of chronic pain. In C. K. Prokop & L. A. Bradley (Eds.), *Medical Psychology: Contributions to Behavioral Medicine* (pp. 91-117). New York: Academic Press.

Brander, V., Gondek, S., Martin, E., & Stulberg, S. D. (2007). Pain and depression influence outcome 5 years after knee replacement surgery. *Clinical Orthopedics and Related Research, 464*, 21-26.

Breuer, J., & Freud, S. (1895). *Studien über Hysterie*. Leipzig: F. Deuticke.

Brown, G. K., & Nicassio, P. M. (1987). Development of a questionnaire for the assessment of active and passive coping strategies in chronic pain patients. *Pain, 31*(1), 53-64.

Cairns, D., & Pasino, J. A. (1977). Comparison of verbal reinforcement and feedback in the operant treatment of disability due to chronic low back pain. *Behavior Therapy, 8*(4), 621-630.

Canetti, L., Berry, E. M., & Elizur, Y. (2009). Psychosocial predictors of weight loss and psychological adjustment following bariatric surgery and a weight-loss program: the mediating role of emotional eating. *International Journal of Eating Disorders*, *42*(2), 109-117.

Carragee, E. J. (2001). Psychological screening in the surgical treatment of lumbar disc herniation. *Clinical Journal of Pain, 17*(3), 215-219.

Carroll, L. J., Cassidy, J. D., & Cote, P. (2004). Depression as a risk factor for onset of an episode of troublesome neck and low back pain. *Pain, 107*(1-2), 134-139.

Celestin, J., Edwards, R. R., & Jamison, R. N. (2009). Pretreatment Psychosocial Variables as Predictors of Outcomes Following Lumbar Surgery and Spinal Cord Stimulation: A Systematic Review and Literature Synthesis. *Pain Medicine, 10*(4), 639-653.

Chou, R., Baisden, J., Carragee, E. J., Resnick, D. K., Shaffer, W. O., & Loeser, J. D. (2009). Surgery for low back pain: a review of the evidence for an American Pain Society Clinical Practice Guideline. *Spine, 34*(10), 1094-1109.

Ciol, M. A., Deyo, R. A., Kreuter, W., & Bigos, S. J. (1994). Characteristics in Medicare beneficiaries associated with reoperation after lumbar spine surgery. *Spine, 19*(12), 1329-1334.

Cipher, D. J., Fernandez, E., & Clifford, P. (2002). Coping style influences compliance with multidisciplinary pain management. *Journal of Health Psychology, 7*(6), 665-673.

Coppes, M. H., Marani, E., Thomeer, R. T., & Groen, G. J. (1997). Innervation of "painful" lumbar discs. *Spine, 22*(20), 2342-2349; discussion 2349-2350.

Cyr, J. J., McKenna-Foley, J. M., & Peacock, E. (1985). Factor structure of the SCL-90-R: is there one? *J Pers Assess, 49*(6), 571-578.

Davidson, M. (2008). Rasch analysis of three versions of the Oswestry Disability Questionnaire. *Man Ther, 13*(3), 222-231.

Davis, R. A. (1994). A Long-Term Outcome Analysis of 984 Surgically Treated Herniated Lumbar Disks. *Journal of Neurosurgery, 80*(3), 415-421.

DeBerard, M. S., LaCaille, R. A., Spielmans, G., Colledge, A., & Parlin, M. A. (2009). Outcomes and presurgery correlates of lumbar discectomy in Utah Workers' Compensation patients. *Spine Journal, 9*(3), 193-203.

Derby, R., Lettice, J. J., Kula, T. A., Lee, S. H., Seo, K. S., & Kim, B. J. (2005). Single-level lumbar fusion in chronic discogenic low-back pain: psychological and emotional status as a predictor of outcome measured using the 36-item Short Form. *Journal of Neurosurgery: Spine, 3*(4), 255-261.

Dersh, J., Polatin, P. B., & Gatchel, R. J. (2002). Chronic pain and psychopathology: research findings and theoretical considerations. *Psychosomatic Medicine, 64*(5), 773-786.

Deyo, R. A., & Mirza, S. K. (2006). Trends and variations in the use of spine surgery. *Clinical Orthopedics and Related Research, 443*, 139-146.

Dohrenwend, B. P., Shrout, P. E., Egri, G., & Mendelsohn, F. S. (1980). Nonspecific psychological distress and other dimensions of psychopathology. Measures for use in the general population. *Arch Gen Psychiatry, 37*(11), 1229-1236.

Dvorak, J., Valach, L., Fuhrimann, P., & Heim, E. (1988). The outcome of surgery for lumbar disc herniation. II. A 4-17 years' follow-up with emphasis on psychosocial aspects. *Spine, 13*(12), 1423-1427.

Dworkin, S. F., Turner, J. A., Wilson, L., Massoth, D., Whitney, C., Huggins, K. H., et al. (1994). Brief group cognitive-behavioral intervention for temporomandibular disorders. *Pain, 59*(2), 175-187.

Ekman, P., Moller, H., Shalabi, A., Yu, Y. X., & Hedlund, R. (2009). A prospective randomised study on the long-term effect of lumbar fusion on adjacent disc degeneration. *European Spine Journal, 18*(8), 1175-1186.

Engel, G. L. (1959). Psychogenic pain and pain-prone patient. *Am J Med, 26*(6), 899-918.

Estlander, A.-M. (1989). Coping strategies in low back pain: Effects of severity of pain, situation, gender and duration of pain. *Scandinavian Journal of Behaviour Therapy, 18*(1), 21-29.

Estlander, A.-M., & Harkapaa, K. (1989). Relationships between coping strategies, disability and pain levels in patients with chronic low back pain. *Scandinavian Journal of Behaviour Therapy, 18*(2), 59-69.

Fairbank, J. C., Couper, J., Davies, J. B., & O'Brien, J. P. (1980). The Oswestry low back pain disability questionnaire. *Physiotherapy, 66*(8), 271-273.

Fairbank, J. C., & Pynsent, P. B. (2000). The Oswestry Disability Index. *Spine (Phila Pa 1976), 25*(22), 2940-2952; discussion 2952.

Fishbain, D. A., Goldberg, M., Meagher, B. R., Steele, R., & Rosomoff, H. (1986). Male and female chronic pain patients categorized by DSM-III psychiatric diagnostic criteria. *Pain, 26*(2), 181-197.

Flor, H., Fydrich, T., & Turk, D. C. (1992). Efficacy of multidisciplinary pain treatment centers: a meta-analytic review. *Pain, 49*(2), 221-230.

Fordyce, W. E. (1976). *Behavioral methods for chronic pain and illness*. Saint Louis: Mosby.

Fordyce, W. E. (1978). Learning process in pain. In R. A. Sternbach (Ed.), *The Psychology of Pain* (pp. 49-72). New York: Raven Press.

Frank, J. D. (1974). Common factors of psychotherapies and their patients. *Psychotherapy and Psychometrics, 24,* 3.

Freemont, A. J., Peacock, T. E., Goupille, P., Hoyland, J. A., O'Brien, J., & Jayson, M. I. (1997). Nerve ingrowth into diseased intervertebral disc in chronic back pain. *Lancet, 350*(9072), 178-181.

Gatchel, R. J. (2004). *Clinical essentials of pain management* (1st ed.). Washington, DC: American Psychological Association.

Gatchel, R. J., Mayer, T. G., Capra, P., Diamond, P., & Barnett, J. (1986). Quantification of lumbar function. Part 6: The use of psychological measures in guiding physical functional restoration. *Spine (Phila Pa 1976), 11*(1), 36-42.

Gatchel, R. J., Polatin, P. B., & Mayer, T. G. (1995). The dominant role of psychosocial risk factors in the development of chronic low back pain disability. *Spine, 20*(24), 2702-2709.

Geisler, F. H. (2007). Surgical Treatment for Discogenic Low-Back Pain: Lumbar Arthroplasty Results in Superior Pain Reduction and Disability Level Improvement Compared With Lumbar Fusion. *SAS Journal*, *1*(1), 5.

Gil, K. M., Abrams, M. R., Phillips, G., & Keefe, F. J. (1989). Sickle cell disease pain: relation of coping strategies to adjustment. *Journal of Consulting and Clinical Psychology 57*(6), 725-731.

Grahek, N. (2007). *Feeling pain and being in pain* (2nd ed.). Cambridge, Mass.: MIT Press.

Gray, H., & Clemente, C. D. (1985). *Anatomy of the human body* (30th American ed.). Philadelphia: Lea & Febiger.

Green, B. A., Handel, R. W., & Archer, R. P. (2006). External correlates of the MMPI-2 content component scales in mental health inpatients. *Assessment*, *13*(1), 80-97.

Gross, A. R. (1986). The effect of coping strategies on the relief of pain following surgical intervention for lower back pain. *Psychosomatic Medicine, 48*(3-4), 229-241.

Guyer, R. D., & Zigler, J. E. (2005). *Spinal arthroplasty : a new era in spine care*. St. Louis, Mo.: Quality Medical Pub.

Haber, J. D., & Roos, C. (1984). Effects of spouse abuse and/or sexual abuse in the development and maintenance of chronic pain in women. *Advances in Pain and Research Therapy, 9*, 889-895.

Harkapaa, K. (1991). Relationships of psychological distress and health locus of control beliefs with the use of cognitive and behavioral coping strategies in low back pain patients. *Clinical Journal of Pain, 7*(4), 275-282.

Hernandez-Reif, M., Field, T., Krasnegor, J., & Theakston, H. (2001). Lower back pain is reduced and range of motion increased after massage therapy. *International Journal of Neuroscience*(3-4), 131-145.

Hochschuler, S. H. (2008, November 14). Back Pain Overview: A Guide for Understanding Back Pain. Retrieved October 19, 2009, from http://www.spine-health.com/conditions/back-pain/back-pain-overview-a-guide-understanding-back-pain

Huang, R. C., Girardi, F. P., Cammisa, F. P., Jr., Lim, M. R., Tropiano, P., & Marnay, T. (2005). Correlation between range of motion and outcome after lumbar total disc replacement: 8.6-year follow-up. *Spine (Phila Pa 1976), 30*(12), 1407-1411.

Hudson-Cook, N., Tomes-Nicholson, K., & Breen, A. (1989). Revised Oswestry Pain Questionnaire. In M. D. Roland & J. R. Jenner (Eds.), *Back pain: New approaches to rehabilitation and education* (pp. 187-204). Manchester, UK: Manchester University Press.

Jensen, M. P., Turner, J. A., & Romano, J. M. (1991). Self-efficacy and outcome expectancies: relationship to chronic pain coping strategies and adjustment. *Pain, 44*(3), 263-269.

Jensen, M. P., Turner, J. A., Romano, J. M., & Karoly, P. (1991). Coping with chronic pain: A critical review of the literature. *Pain, 47*(3), 249-283.

Keel, P. J. M. D. (1984). Psychosocial Criteria for Patient Selection: Review of Studies and Concepts for Understanding Chronic Back Pain. *Neurosurgery, 15*(6), 935-941.

Keller, L. S., & Butcher, J. N. (1991). *Assessment of chronic pain patients with the MMPI-2 (MMPI-2 Monographs, Vol. 2)*. Minneapolis: University of Minnesota Press

Kinney, R. K., Gatchel, R. J., & Mayer, T. G. (1991). The SCL-90R evaluated as an alternative to the MMPI for psychological screening of chronic low-back pain patients. *Spine, 16*(8), 940-942.

Kleinke, C. L., & Spangler, A. S., Jr. (1988). Predicting treatment outcome of chronic back pain patients in a multidisciplinary pain clinic: methodological issues and treatment implications. *Pain, 33*(1), 41-48.

Klenerman, L., Slade, P. D., Stanley, I. M., Pennie, B., Reilly, J. P., Atchison, L. E., et al. (1995). The prediction of chronicity in patients with an acute attack of low back pain in a general practice setting. *Spine, 20*(4), 478-484.

Koleck, M., Mazaux, J. M., Rascle, N., & Bruchon-Schweitzer, M. (2006). Psycho-social factors and coping strategies as predictors of chronic evolution and quality of life in patients with low back pain: a prospective study. *European Journal of Pain, 10*(1), 1-11.

LaCaille, R. A., DeBerard, M. S., LaCaille, L. J., Masters, K. S., & Colledge, A. L. (2007). Obesity and litigation predict workers' compensation costs associated with interbody cage lumbar fusion. *Spine Journal, 7*(3), 266-272.

Lindsay, P. G., & Wyckoff, M. (1981). The depression-pain syndrome and its response to antidepressants. *Psychosomatics, 22*(7), 571-573, 576-577.

Linton, S. (2005). *Understanding pain for better clinical practice : a psychological perspective*. Edinburgh ; New York: Elsevier.

Loupasis, G. A., Stamos, K., Katonis, P. G., Sapkas, G., Korres, D. S., & Hartofilakidis, G. (1999). Seven- to 20-year outcome of lumbar discectomy. *Spine, 24*(22), 2313-2317.

Lousberg, R., Schmidt, A. J., & Groenman, N. H. (1992). The relationship between spouse solicitousness and pain behavior: Searching for more experimental evidence. *Pain, 51*(1), 75-79.

Martin, B. I., Deyo, R. A., Mirza, S. K., Turner, J. A., Comstock, B. A., Hollingworth, W., et al. (2008). Expenditures and health status among adults with back and neck problems. *Journal of the American Medical Association, 299*(6), 656-664.

McMahon, M. J., Gatchel, R. J., Polatin, P. B., & Mayer, T. G. (1997). Early childhood abuse in chronic spinal disorder patients. A major barrier to treatment success. *Spine, 22*(20), 2408-2415.

Melzack, R., & Dennis, S. G. (1978). Neurophysiological foundations of pain. In R. A. Sternbach (Ed.), *The Psychology of Pain* (pp. 1-24). New York: Raven Press.

Melzack, R., & Wall, P. D. (1965). Pain mechanisms: a new theory. *Science, 150*(699), 971-979.

Merskey, H. (1965). The effect of chronic pain upon the response to noxious stimuli by psychiatric patients. *Journal of Psychosomatic Research, 8*, 405-419.

Mielenz, T. J., Garrett, J. M., & Carey, T. S. (2008). Association of psychosocial work characteristics with low back pain outcomes. *Spine, 33*(11), 1270-1275.

Mixter, W. J., & Barr, J. S. (1934). Rupture of the Intervertebral Disc with Involvement of the Spinal Canal. *New England Journal of Medicine, 211*, 210-214.

National Center for Health Statistics (2006). *Health, United States*. Rockville, MD: U.S. Dept. of Health, Education, and Welfare, Public Health Service, Health Resources Administration.

Nordin, H., Eisemann, M., & Richter, J. (2005). MMPI-2 subgroups in a sample of chronic pain patients. (2), 209-216.

Pheasant, H. C., Gilbert, D., Goldfarb, J., & Herron, L. (1979). The MMPI as a predictor of outcome in low-back surgery. *Spine, 4*(1), 78-84.

Pincus, T. P., Burton, A. K. P., Vogel, S. D. O., & Field, A. P. P. (2002). A Systematic Review of Psychological Factors as Predictors of Chronicity/Disability in Prospective Cohorts of Low Back Pain. *Spine, 27*(5), E109-E120.

Polatin, P. B., Kinney, R. K., Gatchel, R. J., Lillo, E., & Mayer, T. G. (1993). Psychiatric illness and chronic low-back pain. The mind and the spine--which goes first? *Spine, 18*(1), 66-71.

Puolakka, K., Ylinen, J., Neva, M. H., Kautiainen, H., & Hakkinen, A. (2008). Risk factors for back pain-related loss of working time after surgery for lumbar disc herniation: a 5-year follow-up study. *European Spine Journal, 17*(3), 386-392.

Riley, J. F., Ahern, D. K., & Follick, M. J. (1988). Chronic pain and functional impairment: assessing beliefs about their relationship. *Archives of Physical Medicine and Rehabilitation 69*(8), 579-582.

Riley, J. F., Barrios, F. X., & Steinberg, J. L. (1988). *Pain beliefs moderate the relationship between pain, depression, and impairment in chronic low back pain*. Paper presented at the 22nd Annual Meeting of the Association for the Advancement of Behavior Therapy.

Riley, J. L., 3rd, & Robinson, M. E. (1997). CSQ: five factors or fiction? *Clinical Journal of Pain, 13*(2), 156-162.

Riley, J. L., 3rd, & Robinson, M. E. (1998). Validity of MMPI-2 profiles in chronic back pain patients: differences in path models of coping and somatization. (4), 324-335.

Riley, J. L., 3rd, Robinson, M. E., & Geisser, M. E. (1999). Empirical subgroups of the Coping Strategies Questionnaire-Revised: a multisample study. *Clinical Journal of Pain, 15*(2), 111-116.

Riley, J. L., 3rd, Robinson, M. E., Geisser, M. E., Wittmer, V. T., & Smith, A. G. (1995). Relationship between MMPI-2 cluster profiles and surgical outcome in low-back pain patients. *J Spinal Disord, 8*(3), 213-219.

Rissanen, A., Alaranta, H., Sainio, P., & Harkonen, H. (1994). Isokinetic and non-dynamometric tests in low back pain patients related to pain and disability index. *Spine (Phila Pa 1976), 19*(17), 1963-1967.

Rolfson, O., Dahlberg, L. E., Nilsson, J. A., Malchau, H., & Garellick, G. (2009). Variables determining outcome in total hip replacement surgery. *Journal of Bone and Joint Surgery, British volume, 91*(2), 157-161.

Rosenstiel, A. K., & Keefe, F. J. (1983). The use of coping strategies in chronic low back pain patients: relationship to patient characteristics and current adjustment. *Pain, 17*(1), 33-44.

Schofferman, J., Anderson, D., Hines, R., Smith, G., & White, A. (1992). Childhood psychological trauma correlates with unsuccessful lumbar spine surgery. *Spine, 17*(6 Suppl), S138-144.

Scholtz, S., Bidlake, L., Morgan, J., Fiennes, A., El-Etar, A., Lacey, J. H., et al. (2007). Long-term outcomes following laparoscopic adjustable gastric banding: postoperative psychological sequelae predict outcome at 5-year follow-up. *Obesity Surgery, 17*(9), 1220-1225.

Schwartz, R. A., Greene, C. S., & Laskin, D. M. (1979). Personality characteristics of patients with myofascial pain-dysfunction (MPD) syndrome unresponsive to conventional therapy. *Journal of Dental Research, 58*(5), 1435-1439.

Seligman, M. E. P. (1975). *Helplessness : on depression, development, and death*. San Francisco: W. H. Freeman.

Sellbom, M., Ben-Porath, Y. S., & Bagby, R. M. (2008). On the hierarchical structure of mood and anxiety disorders: confirmatory evidence and elaboration of a model of temperament markers. *J Abnorm Psychol, 117*(3), 576-590.

Siepe, C. J., Mayer, H. M., Heinz-Leisenheimer, M., & Korge, A. (2007). Total lumbar disc replacement: different results for different levels. *Spine (Phila Pa 1976), 32*(7), 782-790.

Siepe, C. J., Mayer, H. M., Wiechert, K., & Korge, A. (2006). Clinical results of total lumbar disc replacement with ProDisc II: three-year results for different indications. *Spine (Phila Pa 1976), 31*(17), 1923-1932.

Siepe, C. J., Tepass, A., Hitzl, W., Meschede, P., Beisse, R., Korge, A., et al. (2009). Dynamics of improvement following total lumbar disc replacement: Is the outcome predictable? *Spine, 34*(23), 2579-2586.

Simonds, E. C., Handel, R. W., & Archer, R. P. (2008). Incremental validity of the Minnesota Multiphasic Personality Inventory-2 and symptom checklist-90-revised with mental health inpatients. *Assessment, 15*(1), 78-86.

Slater, M. A., Hall, H. F., Atkinson, J. H., & Garfin, S. R. (1991). Pain and impairment beliefs in chronic low back pain: validation of the Pain and Impairment Relationship Scale (PAIRS). *Pain, 44*(1), 51-56.

Slesinger, D., Archer, R. P., & Duane, W. (2002). MMPI-2 characteristics in a chronic pain population. *Assessment*(4), 406-414.

Stewart, W. F., Ricci, J. A., Chee, E., & Morganstein, D. (2003). Lost productive work time costs from health conditions in the United States: results from the American Productivity Audit. *Journal of Occupational and Environmental Medicine 45*(12), 1234-1246.

Tellegen, A., Ben-Porath, Y. S., McNulty, J. L., Arbisi, P. A., Graham, D. C., & Kaemmer, B. (2003). *MMPI-2 Restructured Clinical (RC) Scales: Development, validation, and interpretation*. Minneapolis, MN: University of Minnesota Press.

Trief, P. M., Ploutz-Snyder, R., & Fredrickson, B. E. (2006). Emotional health predicts pain and function after fusion: a prospective multicenter study. *Spine, 31*(7), 823-830.

Turner, J. A., Ersek, M., Herron, L., Haselkorn, J., Kent, D., Ciol, M. A., et al. (1992). Patient outcomes after lumbar spinal fusions. *Journal of the American Medical Association, 268*(7), 907-911.

Vendrig, A. A., Derksen, J. J., & de Mey, H. R. (1999). Utility of selected MMPI-2 scales in the outcome prediction for patients with chronic back pain. *Psychological Assessment, 11*(3), 381-385.

Voorhies, R. M., Jiang, X., & Thomas, N. (2007). Predicting outcome in the surgical treatment of lumbar radiculopathy using the Pain Drawing Score, McGill Short Form Pain Questionnaire, and risk factors including psychosocial issues and axial joint pain. *Spine Journal, 7*(5), 516-524.

Waddell, G. (1987). 1987 Volvo award in clinical sciences. A new clinical model for the treatment of low-back pain. *Spine, 12*(7), 632-644.

Waddell, G., Newton, M., Henderson, I., Somerville, D., & Main, C. J. (1993). A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain, 52*(2), 157-168.

Williams, R. A., Pruitt, S. D., Doctor, J. N., Epping-Jordan, J. E., Wahlgren, D. R., Grant, I., et al. (1998). The contribution of job satisfaction to the transition from acute to chronic low back pain. *Archives of Physical Medicine and Rehabilitation 79*(4), 366-374.

Young Casey, C., Greenberg, M. A., Nicassio, P. M., Harpin, R. E., & Hubbard, D. (2008). Transition from acute to chronic pain and disability: a model including cognitive, affective, and trauma factors. *Pain, 134*(1-2), 69-79.

Zigler, J., Delamarter, R., Spivak, J. M., Linovitz, R. J., Danielson, G. O., 3rd, Haider, T. T., et al. (2007). Results of the prospective, randomized, multicenter Food and Drug Administration investigational device exemption study of the ProDisc-L total disc replacement versus circumferential fusion for the treatment of 1-level degenerative disc disease. *Spine, 32*(11), 1155-1162; discussion 1163.