

Original Article**A hypothesis of chronic back pain: ligament subfailure injuries lead to muscle control dysfunction****European Spine Journal****July 27, 2005**

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FROM ABSTRACT:

A new hypothesis, based upon the concept that subfailure injuries of ligaments (spinal ligaments, disc annulus and facet capsules) may cause chronic back pain due to muscle control dysfunction, is presented.

The hypothesis has the following sequential steps:

- 1) Single trauma or cumulative microtrauma causes subfailure injuries of the ligaments and embedded mechanoreceptors.
- 2) The injured mechanoreceptors generate corrupted transducer signals, which lead to corrupted muscle response pattern produced by the neuromuscular control unit.
- 3) Muscle coordination and individual muscle force characteristics, i.e. onset, magnitude, and shut-off, are disrupted.
- 4) This results in abnormal stresses and strains in the ligaments, mechanoreceptors and muscles, and excessive loading of the facet joints.
- 5) Due to inherently poor healing of spinal ligaments, accelerated degeneration of disc and facet joints may occur.
- 6) The abnormal conditions may persist, and, over time, may lead to chronic back pain via inflammation of neural tissues.

THIS AUTHOR ALSO NOTES:

70–85% of the population in industrialized societies experience low back pain at least once in their lifetime.

30% of the population has low back pain at any given point in time.

The total cost of low back pain in the US is more than \$50 billion per year.

“Abnormal mechanics of the spinal column has been hypothesized to lead to back pain via nociceptive sensors.”

The path from abnormal mechanics to nociceptive sensation may go via several mechanisms:

- 1) Inflammation
- 2) Biochemical and nutritional changes
- 3) Immunological factors
- 4) Changes in the structure and material of the endplates
- 5) Changes in the structure and material of the discs
- 6) Changes in neural structures, such as nerve ingrowth into diseased intervertebral disc

The abnormal mechanics of the spine has two causes:

- 1) Degenerative changes of the spinal column
- 2) Injury of the spinal ligaments

The most likely cause is spine trauma: **[Important]**

- 1) A single trauma due to an accident
- 2) Microtrauma caused by repetitive motion over a long time

Both of these events cause spinal ligament injury.

Chronic low back pain patients have delayed muscle response when asked to perform a task or when the spine is suddenly loaded.

Chronic low back pain patients have poor spinal posture control and balance.

Nociceptive sensors are present in most components of the spinal column.

“The role played by the injury to the mechanoreceptors embedded in the ligaments of the spinal column has not been explored by any hypothesis.” **[This is completely untrue. Some of you have been attending my classes for nearly 30 years, and this is the key component to my hypothesis of subluxation and whiplash injury. Many others in chiropractic have taught and written about the same mechanoreceptor driven mechanism]**

The [neurological] transducer function of the spine provides the information needed to precisely characterize the spinal posture, vertebral motions, spinal loads etc. to the neuromuscular control unit [spinal cord] via the innumerable

mechanoreceptors present in the spinal column ligaments, facet capsules and the disc annulus. **[VERY IMPORTANT: mechanoreceptors in the spinal ligaments, facet capsules, and annulus of the disc provide the afferent input to the spinal cord to control the precise coordination of posture and segmental motions]. [This is the chiropractic subluxation].**

Mechanoreceptors provide information to the neuromuscular control unit to generate appropriate muscular spinal stability.

"If the structural function is compromised, due to injury or degeneration, then the muscular stability is increased to compensate for the loss." [This results in a reduction of ACTIVE range of motion].

The new hypothesis for back pain consists of the following sequential steps:

- 1) Single trauma or cumulative microtrauma causes subfailure injury of the spinal ligaments and injury to the mechanoreceptors embedded in the ligaments.
[Very Important]
- 2) Altered "corrupted" mechanical input is sent to the spinal cord.
- 3) Altered "corrupted" mechanical input to the spinal cord results in corruption of the neuromuscular control and coordination of spinal function.
- 4) The corrupted muscle response pattern leads to corrupted afferent feedback to the spinal cord via tendon organs of muscles and injured mechanoreceptors, further corrupting the muscle response pattern.
- 5) "The corrupted muscle response pattern produces high stresses and strains in spinal components leading to further subfailure injury of the spinal ligaments, mechanoreceptors and muscles, and overload of facet joints."
- 6) "The abnormal stresses and strains produce inflammation of spinal tissues, which have an abundant supply of nociceptive sensors and neural structures."
- 7) Over time chronic back / neck pain develops.

"The subfailure injury of the spinal ligament is defined as an injury caused by stretching of the tissue beyond its physiological limit, but less than its failure point."
[IMPORTANT: This is the classic definition of a whiplash ligamentous injury].

Dr. Panjabi also notes:

- 1) Subfailure injuries to ligaments "disrupt and/or injure the embedded mechanoreceptors."

- 2) Disrupted/injured mechanoreceptors produce abnormal afferent input to the spinal cord describing vertebral position, motion, and spinal loads for each spinal level.
- 3) The spinal cord neuromuscular control unit senses a mismatch between the normally expected and the received transducer signals and has difficulty in choosing the appropriate muscle response pattern.
- 4) The results are a corrupted muscle response pattern disrupting the various spinal muscles responsible for spinal stability, posture and motion.
- 5) This creates higher stresses and strains, and injuries may develop in the spinal ligaments, and mechanoreceptors.
- 6) "The facet joints may be overloaded, and the spinal muscles may fatigue or be injured."
- 7) Over time, these injurious stresses and strains can initiate inflammation and "accelerate disc and facet joint degeneration."
- 8) "Thus, a vicious cycle is set up, leading to chronic dysfunction of the entire spinal system, resulting in back pain."

DISCUSSION

In the present hypothesis, the focus is on the disruption of the mechanoreceptors due to ligament injury leading to corrupted transducer signals [altered afferent mechanical input to the spinal cord] and muscle response pattern.

Subfailure injuries of the ligaments disrupt mechanical afferent input into the spinal cord "thereby resulting in poor balance and postural control."

"Among chronic whiplash patients, decreased [active] neck motion has been observed in most studies." "However, when the subject was relaxed and the motion was produced passively by the examiner, the motion was found to be increased in the whiplash patients compared to the control group." "How can one explain these contrasting findings? In the active motion studies, corrupted muscle response pattern (generated due to corrupted mechanoreceptor signals) applies higher muscle forces on the cervical spine," which stiffens the spine and reduce the motion. In the relaxed passive motion studies, the abnormal muscle forces were minimized with the passive examination, and the intrinsic injury of the spine was exhibited as the increased motion. **[Extremely important for those evaluating whiplash injuries]**

Muscle spasm is commonly observed in both low back pain and whiplash patients [because of the altered mechanical input and resulting mismatch of motor output].

With ligament injury, the mechanoreceptors generate corrupted transducer signals [altered afferent mechanical input to the spinal cord], and motor control mismatch, simultaneously firing both the agonist and antagonist muscles, stabilizing the spine and minimizing intervertebral motions. This muscle response may become chronic.

“The subfailure injuries of ligaments are incomplete injuries, which may range between tearing of a few fibers to a nearly complete rupture of a ligament.”

ALSO:

- 1) Functional spinal units have many ligament structures that may sustain a wide range of injury, depending upon the magnitude and mode of the trauma.
- 2) The density of the mechanoreceptors imbedded in the various ligament structures varies greatly.
- 3) Therefore, seemingly similar injury-causing events can produce a wide spectrum of corrupted muscle response patterns.
- 4) These altered muscle response patterns may result in muscle atrophy and weakness due to disuse, aggravating the spinal system dysfunction.
- 5) “As the muscles participate in the feedback loop via the mechanoreceptors in the form of muscle spindles and golgi tendon organs, their disruption could further corrupt the muscle response pattern.”

Injured muscles heal relatively quickly due to abundant blood supply and therefore are not the main cause of chronic back pain. **[Important]**

In contrast, ligament injuries heal poorly and therefore lead to tissue degeneration over time.

“Thus, the ligament injuries are more likely to be the major cause of the chronic back pain.” **[Very Important]**

The corrupted transducer signals [altered afferent mechanical input to the spinal cord] may be the result not only of the ligament injury, but also due to ligament fatigue and viscoelastic creep stretch [as from chronic altered posture].

“If the corrupted muscle response pattern becomes permanent, then it may result in abnormal posture, disturbed intervertebral motion pattern, altered gait, and, in general, a less efficient system to perform every day spinal functions.”

“The incoming corrupted transducer data may never become normal, even though the ligaments, incorporating the injured mechanoreceptors, may heal/scar over time.” **[The Fibrosis Of Repair]**

CONCLUSIONS

A new hypothesis of chronic back pain based upon muscle system dysfunction due to ligament injuries.

“Subfailure injuries of the ligaments and embedded mechanoreceptors generate corrupted mechanoreceptor signals.”

“Consequently, the neuromuscular control unit produces corrupted muscle response pattern, resulting in excessive loading and, possibly, injuries of the spinal structures, including additional injuries of the mechanoreceptors.”

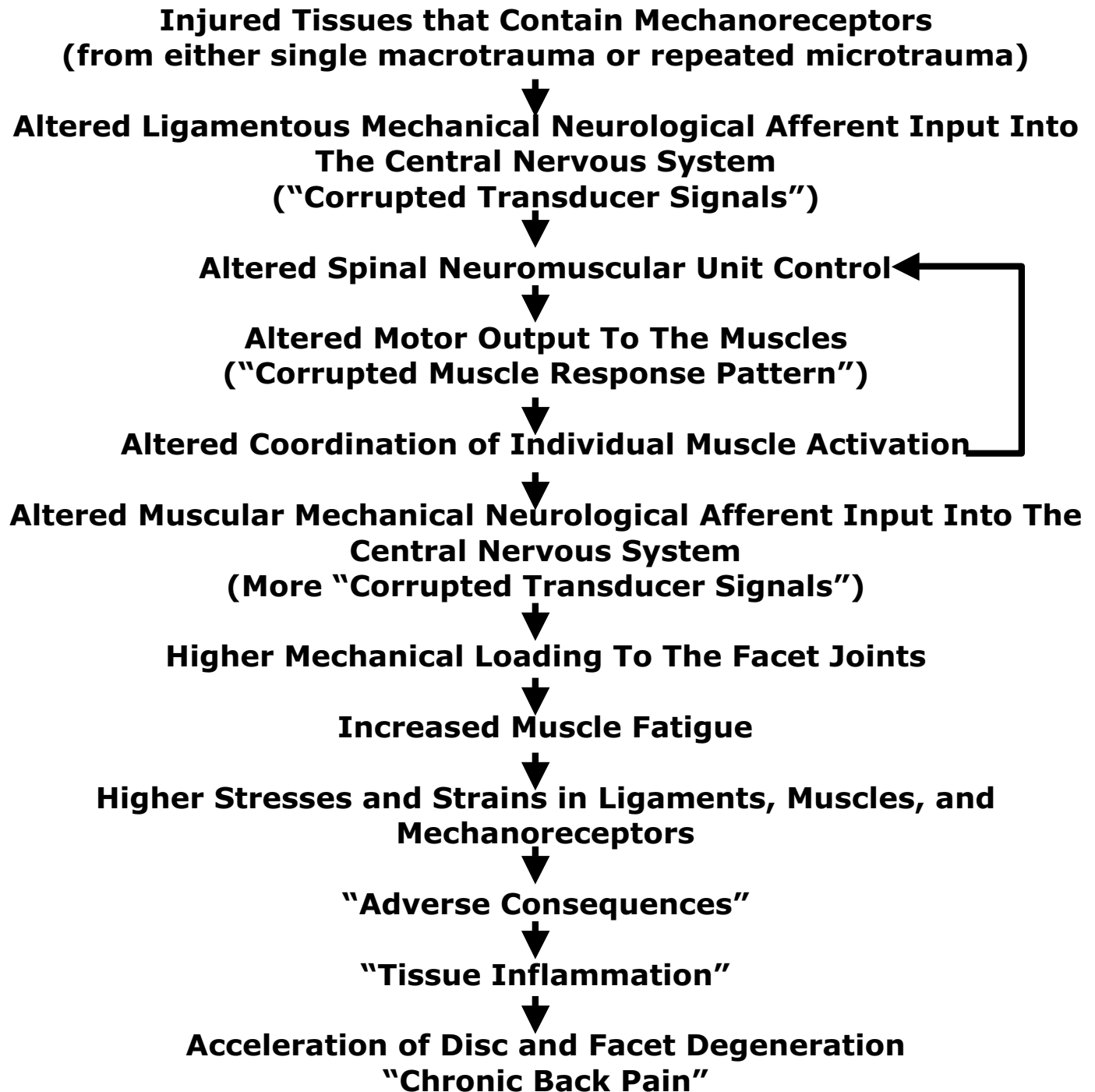
In the whiplash patient, this new hypothesis for back pain accounts for both the decreased motion in active testing and the increased motion in passive-relaxed testing.

“The hypothesis proposes that the dysfunction of the muscle system over time may lead to chronic back pain via additional mechanoreceptor injury, and neural tissue inflammation.”

KEY POINTS FROM DAN MURPHY

- 1) The spinal ligaments, disc annulus and facet capsules are innervated with mechanoreceptors.
- 2) Degenerative spinal disease, single trauma, or cumulative microtrauma causes subfailure injuries of the spinal ligaments, disc and facet capsules, causing abnormal firing of the embedded mechanoreceptors.
- 3) There is increased nerve ingrowth into diseased intervertebral discs.
- 4) Subfailure injury of spinal ligaments is defined as an injury caused by stretching of the tissue beyond its physiological limit, but less than its failure point.
[IMPORTANT: This is the classic definition of a whiplash injury].
- 5) Chronic whiplash patients have decreased active neck range of motion, but an increase in passive neck range of motion.
- 6) Injured muscles heal relatively quickly due to an abundant blood supply and therefore they are not the main cause of chronic back pain. **[Important]**
- 7) Ligament and disc injuries heal poorly and therefore lead to tissue degeneration over time.
- 8) “Thus, the ligament injuries are more likely to be the major cause of the chronic back pain.” **[Very Important]**
- 9) The subfailure ligament injuries may heal with scar tissue over time, resulting in long-term or permanent mechanoreception. **[The Fibrosis Of Repair]**

The Proposed Mechanism For Chronic Back Pain In This Article



"Subfailure injuries of the ligaments. The injured mechanoreceptors send out corrupted transducer signals to the neuromuscular control unit, which finds spatial and temporal mismatch between the expected and received transducer signals, and, as a result, there is muscle system dysfunction and corrupted muscle response pattern is generated. Consequently, there are adverse consequences: higher stresses, strains, and even injuries, in the ligaments, mechanoreceptors, and muscles. There may also be muscle fatigue, and excessive facet loads. These abnormal conditions produce neural and ligament inflammation, and over time, chronic back pain."

Dear Dr. Panjabi:

Congratulations on your article "A hypothesis of chronic back pain: ligament subfailure injuries lead to muscle control dysfunction" European Spine Journal, July 27, 2005.

The hypothesis you presented is consistent with the perspective offered within the chiropractic community for decades. In the parlance of the chiropractic profession you have expertly and vividly described what is referred to as a vertebral subluxation. The chiropractic community has been studying, writing about and modifying its perspective on the phenomenon you articulated for more than a century.

Our present hypothesis suggests that the altered mechanoreceptive afferent driven motor mismatch can be corrected by the firing of the mechanoreceptors of the facet joint capsules which are activated by means of a chiropractic adjustment (1). The hypothesis you articulated, explains why chiropractic spinal adjustments have proven to be more effective in treating chronic spinal pain when compared to medication, exercise, and needle acupuncture (2, 3, 4, 5, 6, 7, 8, 9).

Respectfully,

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References

- 1) Indahl A, Kaigle AM, Reikeras O et al (1997) Interaction between the porcine lumbar intervertebral disc, zygapophysial joints, and paraspinal muscles. *Spine* 22:2834-2840
- 2) WH Kirkaldy-Willis and JD Cassidy, Spinal manipulation in the treatment of low back pain, *Canadian Family Physician*, Vol. 31, March 1985, pp536-40.
- 3) TW Meade, S Dyer, W Browne, J Townsend, AO Frank. Low back pain of mechanical origin: randomised comparison of chiropractic and hospital outpatient treatment. *British Medical Journal*, June 2, 1990;300: 1431-7.
- 4) The Lancet, Chiropractors and low back pain, July 28, 1990, p. 220.
- 5) TW Meade, S Dyer, W Browne, AO Frank. Randomised comparison of chiropractic for low back pain: results from extended follow up. *British Medical Journal*, August 5, 1995;311: 349-51.
- 6) Woodward MN, Cook JC, Gargan MF, Bannister GC. Chiropractic treatment of chronic 'whiplash' injuries. *Injury*. 1996 Nov;27(9):643-5.
- 7) S Khan, J Cook, M Gargan, G Bannister. A symptomatic classification of whiplash injury and the implications for treatment. *Journal of orthopaedic Medicine* 21(1) 1999:22-5.
- 8) Lynton GF Giles and Reinhold Muller, Chronic Spinal Pain: A Randomized Clinical Trial Comparing Medication, Acupuncture, and Spinal Manipulation, *Spine*, July 15, 2003; 28(14): 1490-1502
- 9) Reinhold Muller, PhD, Lynton G.F. Giles, DC, PhD, Long-Term Follow-up of a Randomized Clinical Trial Assessing the Efficacy of Medication, Acupuncture, and Spinal Manipulation for Chronic Mechanical Spinal Pain Syndromes, *Journal of Manipulative and Physiological Therapeutics*, January 2005, Volume 28, Number 1.