From the Desk of Brian Guetter, D.C. at Exacta Care

Traumatic Ligament Laxity of the Spine and

Associated Physical Impairment

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TRAUMATIC LIGAMENT LAXITY OF THE SPINE

Abstract

This paper explores the relationship between traumatic ligament laxity of the spine and the resultant instability that may occur. Within is a discussion of the various spinal ligamentous structures that may be affected by both macro and micro traumatic events, as well as the neurologic and musculoskeletal effects of instability. Also included are details on the diagnosis, quantification, and documentation.

Keywords: ligament laxity, instability

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Soft tissue cervical and lumbar strains are the most common injury in motor vehicle collisions, with 28% to 53% of victims sustaining this type of injury (Galasko et al., 1993; Quinlan et al., 2000). The annual societal costs of these injuries in the United States are estimated to be between 4.5 and 8 billion dollars (Kleinberger et al., 2000; Zuby et al., 2010). Soft tissue injuries of the spinal column very often become chronic, with the development of long-term symptoms, adversely affecting the victim's quality of life. Research has indicated that 24% of motor vehicle collision victims experience symptoms one year after an accident and 18% after two years (Quinlan et al., 2004). Additional studies show that between 38% and 52% of motor vehicle collision cases involved rear-impact scenarios

(Kleinberger et al.,2000; Galasko et al., 1993).

It is well known that the primary cause of chronic pain due to these injuries is directly related to the laxity of spinal ligamentous structures (Ivancic, et al., 2008). One must fully understand the structure and function of ligaments to realize the effects of traumatic ligament laxity. Ligaments are fibrous bands or sheets of connective tissue which link two or more bones, cartilages, or structures together. We know that one or more ligaments provide stability to a joint during rest as well as movement. Excessive movements such as hyperextension or hyperflexion, which occur during a traumatic event such as a motor vehicle collision, may be restricted by ligaments unless these forces are beyond the tensile strength of these structures. This will be discussed later in this paper.

Three of the more important ligaments in the spine are the ligamentum flavum, the anterior longitudinal ligament, and the posterior longitudinal ligament (Gray's Anatomy, 40th Edition). The ligamentum flavum forms a cover over the dura mater, which is a layer of tissue that protects the spinal cord. This ligament connects under the facet joints to create a small curtain, so to speak, over the posterior openings between vertebrae (Gray's Anatomy, 40th edition). The anterior longitudinal ligament attaches to the front (anterior) of each vertebra and runs vertical or longitudinal (Gray's Anatomy, 40th edition). The posterior longitudinal ligament also runs vertically or longitudinally behind (posterior) the spine and inside the spinal canal (Gray's Anatomy, 40th Edition). Additional ligaments include facet capsular ligaments, interspinous ligaments, supraspinous ligaments, and intertransverse ligaments. The aforementioned ligaments limit flexion and extension. The ligamentum nuchae, which is a fibrous membrane, limits flexion of the cervical spine (Gray's Anatomy, 40th Edition). The four ligaments of the sacroiliac joints (iliolumbar, sacroiliac, sacrospinous, sacrotuberous) provide stability and some motion. The upper cervical spine has its own ligamentous structures or systems: occipitoatlantal ligament complex, occipitoaxial ligament complex, atlantoaxial ligament complex, and the cruciate ligament complex (Gray's Anatomy, 40th Edition). The upper cervical ligament system is especially important in stabilizing the upper cervical spine from the skull to C2 (axis) (Stanley Hoppenfeld, 1976). It is important to note that although the cervical vertebrae are the smallest, the neck has the greatest range of motion.

Ligament laxity may happen as a result of a "macro trauma", such as a motor vehicle collision or it may develop over time as a result of repetitive use or work-related injuries. No matter the cause, it leads to an excessive motion of the facet joints resulting in varying degrees of physical impairment. When ligament laxity develops over time, under a constant or repetitive stress, it is referred to as "creep" (Frank CB, 2004). Low-level ligament injuries, or those where the ligaments are simply elongated, represent the vast majority of cases and can potentially incapacitate a patient due to disabling pain, vertigo, tinnitus, etc. Unfortunately, these types of strains may progress to sub-failure tears of ligament fibers, which will lead to instability at the level of facet joints (Chen HB et al., 2009). Traumatic or repetitive causes of ligament laxity will ultimately produce abnormal motion and function between vertebrae under normal physiological loads, inducing irritation to nerves, possible structural deformation, and incapacitating pain.

Patients who have suffered a motor vehicle or work-related injury very often have chronic pain symptoms due to ligament laxity. The ligaments surrounding the facet joints of the spinal column, known as capsular ligaments, are highly innervated mechanoreceptive and nociceptive free nerve endings. Therefore, the facet joint is thought of as the primary source of chronic spinal pain (Boswell MV et al., 2007; Barnsley L et al., 1995). When the mechanoreceptors and nociceptors are injured, or just irritated, the overall joint function of the facet joints is altered (McLain RF, 1993).

One must realize that instability is not similar to hypermobility. Instability in the clinical context implies a pathological condition with associated symptomatology whereas joint hypermobility alone does not. Ligament laxity that produces instability refers to a loss of "motion stiffness" in a particular spinal segment when a force is applied. This produces a greater displacement than would be observed in a typical motion segment. In Chiropractic, we understand that there is a "guarding mechanism" triggered after an injury - the muscle spasm.

This spasm occurs as the ligamentous spinal supporting structures act as sensory organs which initiate a ligamentomuscular reflex. The reflex is a "protective reflex" or "guarding mechanism" produced by the mechanoreceptors of the joint capsule, transmitting ultimately to the muscles. These spasms can cause intense pain and are the body's response to instability. Activation of surrounding musculature, or guarding, will help to maintain or preserve joint stability either directly, by muscles crossing the joint, or indirectly, by muscles that do not cross the joint but limit joint motion (Hauser RA et al., 2013). This reflex is fundamental to the understanding of traumatic injuries.

The reflex is designed to prevent further injury. However, the continued feedback and reinforcement of pain and muscle spasm delays the healing process. The 'perpetual loop" may continue for a long period of time, the muscle contraction making further injury more likely. Disrupting this cycle of pain and inflammation is key to resolution.

When traumatic ligament laxity produces joint instability with neurologic compromise, we know that the joint has sustained considerable damage to its stabilizing structures, including the vertebrae themselves. However, research indicates that joints that are hypermobile are still able to maintain their stability and function normally under physiological loads (Bergmann TF et al., 1993).

Clinicians classify instability into three categories: mild, moderate, and severe. Severe instability is associated with a catastrophic injury, such as a motor vehicle collision. Mild or moderate clinical instability is usually without neurologic injury and is most commonly due to cumulative microtrauma, such as those associated with repetitive use injuries - prolonged sitting, standing, flexed postures, etc.

In a motor vehicle collision, up to 10 times more force is absorbed in the capsular ligaments versus the intervertebral disc (Ivancic PC et al., 2007). Unlike the disc, the facet joint has a much smaller area in which to disperse this force. Ultimately, as previously discussed, the capsular ligaments become elongated, resulting in abnormal motion in the affected spinal segments (Ivancic PC et al., 2007; Tominaga Y et al., 2006). This sequence has been clearly documented with both in vitro and in vivo studies of segmental motion characteristics after torsional loads and resultant disc degeneration (Stokes IA et al., 1987; Veres SP et al., 2010). Injury to the facet joints and capsular ligaments has been further confirmed during simulated whiplash traumas (Winkelstein BA et al., 2000).

Maximum ligament strains occur during shear forces, such as when a force is applied while the head is rotated (axial rotation). While capsular ligament injury in the upper cervical spine region can occur from compressive forces alone, exertion from a combination of shear, compression and bending forces is more likely and usually involves much lower loads to cause injury (Siegmund GP et al., 2001). If the head is turned during whiplash trauma, the peak strain on the cervical facet joints and capsular ligaments can increase by 34% (Siegmund GP et al., 2008). One research study reported that during an automobile rear-impact simulation, the magnitude of the joint capsule strain was 47% to 196% higher in instances when the head was rotated 60 degrees during impact compared with those when the head was forward facing (Storvik SG et al., 2011). Head rotation to 60 degrees is similar to an individual turning his/her head to one side while checking for oncoming traffic. In these cases, impact is greatest in the ipsilateral facet joints.

Other research has illustrated that motor vehicle collision trauma has been shown to reduce ligament strength (i.e., failure force and average energy absorption capacity) compared with controls or computational models (Ivancic PC et al., 2007; Tominaga Y et al., 2006). We know that this applies in particular to the case of capsular ligaments since this type of trauma causes capsular ligament laxity. Interestingly, one research study conclusively demonstrates that whiplash injury to the capsular ligaments results in an 85% to 275% increase in ligament elongation (laxity), compared to that of controls (Ivancic PC et al., 2007).

The study also reported evidence that tension of the capsular ligaments due to trauma is requisite for producing pain from the facet joint. Whiplash injuries cause compression injuries to the posterior facet cartilage. This injury also results in bleeding, inflammation, trauma to the synovial folds, and of course, pain. Simply stated, this stretching injury to the facet capsular ligaments will result in joint laxity and instability.

Traumatic ligament laxity resulting in instability is a diagnosis based primarily on a patient's history (symptoms) and physical examination. Subjective findings are the patient's complaints in their own words, or their perception of pain, sensory changes, motor changes, or range of motion alterations. After the patient presents their subjective complaints to the clinician, these subjective findings must be correlated and confirmed through a proper and thorough physical examination, including the utilization of imaging diagnostics that objectively explain a particular symptom, pattern, or area of complaint. Without some measure of concrete evidence that explains a patient's condition, we merely have symptoms with no forensic evidence. Documentation is critical, as well as quantifying the patient's injuries objectively.

In order to adequately quantify the presence of instability due to ligament laxity, the clinician could utilize functional computerized tomography, functional magnetic resonance imaging scans, and digital motion x-ray (Radcliff K et al., 2012; Hino H et al., 1999). Studies using functional CT for diagnosing ligamentous injuries have demonstrated the ability of this technique to show excess movement during axial rotation of the cervical spine (Dvorak J et al., 1988; Antinnes J et al., 1994).

This is important to realize when patients have the signs and symptoms of instability but have normal MRI findings in the neutral position. Functional imaging technology, as opposed to standard static films, is necessary for the adequate radiologic depiction of instability because they provide dynamic imaging during movement and are extremely helpful for evaluating the presence and degree of instability.

Although functional imaging may be superior, plain-film radiography is still a powerful diagnostic tool for the evaluation of instability due to ligament laxity. When a patient presents status post motor vehicle collision, it is common practice to perform a "Davis Series" of the cervical spine. This x-ray series consists of 7 views: anterior-posterior open mouth, anterior-posterior, lateral, oblique views, and flexion-extension views. The lumbar spine is treated in similar fashion. X-ray views will include: anterior-posterior, lateral, oblique views, and flexion-extension views. The flexion-extension views are key in the diagnosis of instability. It is well known that the dominant motion of the cervical and lumbar spine, where most pathological changes occur, is flexion-extension. Translation of one vertebral segment in relation to the one above and/or below will be most evident in these views. Translation is the total anterior-posterior movement of vertebral segments. After the appropriate views are taken, the images may be evaluated utilizing CRMA or Computed Radiographic Mensuration Analysis. These measurements are taken to determine the presence of ligament laxity. In the cervical spine, a 3.5mm or greater translation of one vertebra on another is an abnormal and ratable finding, indicative of instability (AMA Guides to the Evaluation of Permanent Impairment, 6th Edition).

Alteration of Motion Segment Integrity (AOMSI) is extremely crucial as it relates to ligament laxity. The AMA Guides to the Evaluation of Permanent Impairment 6th Edition recognize linear stress views of radiographs, as the best form of diagnosing George's Line (Yochum & Rowe's Essentials of Radiology, page 149); they state that if there is a break in the line on a radiograph, this could be a sign of instability due to ligament laxity.

Our discussion of ligament laxity and instability continues with the "Criteria for Rating Impairment Due to Cervical and Lumbar Disorders," as described in the AMA Guides to the Evaluation of Permanent Impairment, 6th Edition. According to the guidelines, a DRE (Diagnosed Related Estimate) Cervical Category IV is considered to be a 25% to 28% impairment of the whole person. Category IV is described as "alteration of motion segment integrity or bilateral or multilevel radiculopathy." Alteration of motion segment integrity is defined from flexion and extension radiographs as at least 3.5mm of translation of one vertebra on another or angular motion of more than 11 degrees greater than at each adjacent level. Alternatively, an individual may have loss of motion of a segment due to a developmental fusion or successful or unsuccessful attempt at surgical arthrodesis. Radiculopathy, as defined in Cervical Category III, need not be present if there is an alteration of motion segment integrity or fractures. One can compare a 25% to 28% cervical impairment of the whole person to the 22% to 23% impairment due to an amputation of the thumb at or near the carpometacarpal joint.

Additionally, according to the guidelines, a DRE (Diagnosed Related Estimate) Lumbar Category IV is considered to be a 20% to 23% impairment of the whole person. Category IV is described as a loss of motion segment defined from flexion and extension radiographs as at least 4.5mm of translation of one vertebra on another, or angular motion greater than 15 degrees at L1-2. L2-3, and L3-4; greater than 20 degrees at L4-5; and greater than 25 degrees at L5-S1. An individual may have complete, or near complete, loss of motion of a segment due to developmental fusion, or successful or unsuccessful attempt at surgical arthrodesis or fractures. One can compare a 20% to 23% lumbar impairment of the whole person to the 20% impairment due to an amputation of the first metatarsal bone.

CONCLUSIONS

After careful interpretation of the AMA Guides to the Evaluation of Permanent Impairment, 6th Edition, regarding whole person impairment due to ligament laxity/instability of the cervical and lumbar spine, one can certainly see the severity and degree of disability that occurs. Once ligament laxity is correctly diagnosed, it will objectively quantify a patient's spinal injury regardless of symptoms, disc lesions, range of motion, reflexes, etc. When we quantify the presence of ligament laxity, we also provide a crucial element with which to demonstrate instabilities in a specific region. Overall, clarification and quantification of traumatic ligament laxity will help the patient legally, objectively, and most importantly, clinically.

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