Bracing against the floor pan or brake pedal during a frontal collision may result in injuries to the hip, knee, ankle, and foot. During a collision, these parts of the car may also intrude violently into the occupant compartment, compounding the effect. This is why race car drivers are taught to pull their extremities away from the controls immediately before contact with another vehicle or obstacle.

As in other body sections, initial examination requires a visual and palpatory assessment. Examiners should record ROM for any involved joints. Similar to previous sections, ongoing studies have been targeting popular orthopedic tests, but there are many. And these tests are merely a part of the mélange of the overall assessment, which is likely also to include plain radiographs and perhaps MRI. When doctors suspect a fracture, they still prefer doing a CT scan; they don't often use SPECT for the lower extremity.

Non-Organic Signs and *Biopsychosocial Phenomena*

In the 1980s, Waddell and colleagues described five general categories of what to them appeared to be *non-organic signs* that they observed in a group of chronic low-back-pain patients.[43] They proposed that when three or more categories of these non-organic signs are present, the patient should be evaluated for psychological problems. These categories included tenderness, simulation, distraction, regional, and overreaction to stimulus (Table 2). These subsequently became known simply as *Waddell's signs* and have since been reinterpreted or misinterpreted in a number of ways. Most commonly in the world of forensic medicine, the doctrinaire assertion is that they are good evidence of *illness behavior, somatic amplification,* or outright *malingering.*

[43] Gordon Waddell, John McCulloch; Ed Kummel; Robert Venner, "Nonorganic Physical Signs in Low-Back Pain," *Spine* 5 vol. 2 (March–April 1980): 117–125.

Table 2. Waddell's Signs

Tenderness	• Superficial skin tender to light touch • Non-anatomic deep tenderness not localized to one area
Simulation	• Axial loading pressure on the skull of a standing patient induces lower back pain • Rotation: Shoulders and pelvis rotated in the same plane induces pain
Distraction	• Difference in straight leg raising in supine and sitting positions
Regional	• Weakness: Many muscle groups, "give-away weakness" (patient does not give full effort on minor muscle testing) • Sensory: Sensory loss in a stocking or glove distribution, non-dermatomal
Overreaction	• Disproportionate facial or verbal expression (that is, pain behavior)

The "tenderness" category is potentially problematic because it requires the practitioner to presume the actual state of the patient's nervous system, which requires something beyond mere clinical acumen. And as noted above, *hypersensitivity* has been described in the whiplash literature as an organic condition, ineffable as it may seem to some of us. Moreover, non-anatomic deep tenderness is rather poorly defined at best and again requires examiners to make assumptions of how the patient experiences the examination.

There has been a long-standing belief that the results of the straight leg raise (SLR) test performed in the supine position should not differ from the results when performed in the sitting position. A recent study showed, however, that the sensitivity of the seated and supine SLR differed significantly, which invalidates the "distraction" category of Waddell's signs.[44]

In a separate study of cervical nerve root stimulation, researchers demonstrated that non-dermatomal distribution of pain and

[44] A. Rabin, P. C. Gerszten, P. Karausky, C. H. Bunker, D. M. Potter, W. C. Welch, "The sensitivity of the seated straight-leg raise test compared with the supine straight-leg raise test in patients presenting with magnetic resonance imaging evidence of lumbar nerve root compression," *Arch Phys Med Rehabil* 88 vol. 7 (2007): 840–843.

other symptoms is common in people following mechanical irritation of nerve roots.[45] This study effectively invalidates the "regional" category, at least in the case of the cervical spine.

Finally, as with the "tenderness" category, to accuse the patient of overreaction requires the examiner to presume the state of the patient's pain level in order to decide what facial or verbal expression would actually have been appropriate. In both cases, the potential for observer bias looms large.

In 2003 a team of researchers undertook a large, evidence-based review of all available studies of Waddell's signs.[46] They reported that there was no association between Waddell's signs and psychological stress (which was the original hypothesis), illness behavior, or social gain. They also found that Waddell's signs are organic phenomena and cannot be used to discriminate organic from nonorganic problems. Nor was there evidence for inter-rater reliability or reproducibility. Another study showed that Waddell's signs are not associated with secondary gain or malingering.[47]

A number of papers within the whiplash literature suggest that the common chronicity seen among these patients can largely be explained by various so-called *biopsychosocial* factors. These include sex, age, employment status, educational attainment, marital status, income level, and so on. But the literature has failed to show any consistency in these factors, strongly suggesting that the reported statistical relationships in some papers are most likely the result of chance statistical significance secondary to data dredging. Statistical significance does not always imply clinical relevance.

[45] C. W. Slipman, C. T. Plastaras, R. A. Palmitier, C. W. Huston, E. B. Sterenfeld. "Symptom provocation of fluoroscopically guided cervical nerve root stimulation. Are dynatomal maps identical to dermatomal maps?" *Spine* 23 vol. 20 (1998): 2235–2242.

[46] D. A. Fishbain, B. L. Cole, R. B. Cutler, J. Lewis, H. L. Rosomoff, R. Rosomoff, "A structured evidence-based review on the meaning of nonorganic physical signs: Waddell signs," *Pain Medicine* 4 vol. 2 (2003): 141–154.

[47] D. A. Fishbain, R. B. Cutler, H. L. Rosomoff, R. S. Rosomoff, "Is there a relationship between nonorganic physical findings (Waddell Signs) and secondary gain/malingering?" *Clin J Pain* 20 (2004): 399–408.

The Frequency of Disc Herniations in Asymptomatic People

In 1984 radiologists published a paper describing the findings of a study in which they categorized the abnormal findings they had observed in a series of CT scans obtained from asymptomatic subjects.[48] Among the abnormal findings, many were relatively benign. In a subgroup of test subjects forty years or older, the authors reported that about half had one or more *abnormal findings.* One of those findings was disc herniation. One way or another, this transmogrified into a very popular medicolegal legend: that 50 percent of all normal, asymptomatic adults will have at least one herniated disc in the lumbar spine. Gradually, the legend expanded to include any part of the spine.

In truth, the researchers found disc herniations in the lumbar spine in only 19 percent of subjects under age forty, which is in line with subsequent studies reporting the incidence of herniation at 4–28 percent.[49] These do increase with age, so it can be said that the proportion of true positives (that is, symptomatic disc herniations) will be higher among younger people.

Note that these statistics cannot be extrapolated to other parts of the spine. In the cervical spine, for example, the proportion of asymptomatic people with herniated discs is much lower: 8 percent in one study and 4 percent in another.[50] These statistics do not apply to spines with multiple herniations. More importantly, it is inappropriate to offer statistics such as these as evidence that a specific symptomatic person with a disc herniation might actually

[48] S. Weisel, "A study of computer assisted tomography: I. the incidence of positive CAT scans in an asymptomatic group of patients," *Spine* 9 vol. 6 (1984): 549–551.

[49] D. L. Kent, D. R. Haynor, E. B. Larson, "Diagnosis of lumbar spinal stenosis in adults-a meta-analysis of the accuracy of CT, MR and myelography-review," *Am J Roentgenol Radium Ther Nucl Med* 158 vol. 5 (1992): 1135–1144.

[50] A. D'Antoni and A. C. Croft, "Prevalence of herniated intervertebral discs of the cervical spine in asymptomatic subjects using MRI scans: a qualitative systematic review," *Journal of Whiplash and Related Disorders* 5 vol. 1 (2005) 5–13.