

Mild Traumatic Brain Injury Litigation

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Concussion-related litigation, otherwise known as “mild traumatic brain injury” litigation, has increased just as advanced neuroimaging techniques have emerged. But the ways that plaintiffs’ experts interpret the results have some critical methodological flaws.

An Overview of Neuroimaging Techniques

Lawsuits alleging brain injuries have tripled in the past 20 years. (This estimate is based upon a search of civil case law on Lexis-Nexis including occurrence of phrases such as “traumatic brain injury,” “mild TBI,” and “head injury.”

It does not include brain injury litigation settled before trial.) This trend likely arises out of the increasing public awareness of traumatic brain injury (TBI) and will almost certainly continue given the recent publicity about the long-term effects of repeated concussions in professional athletes. These claims also add value to a plaintiff’s case: around the country, legal blogs are replete with discussion of relatively minor accidents resulting in seven- and eight-figure verdicts because of TBI claims.

Although severe TBI claims have always presented significant risk for insurers, mild TBI (concussion) claims are themselves becoming a growing risk as well. Mild TBI claims often involve allegations of considerable impairment and disability that are disproportionate to the severity of the trauma. This disconnect has not stopped some juries from awarding sizeable verdicts. For instance, in a 2015 suit in southern California, a 26-year-old student filmmaker claimed a mild TBI and a jaw injury in a

rear-end collision. The plaintiff contended that his injuries affected his ability to continue making films. The defense countered that there were no objective signs of brain injury and noted that in addition to writing and producing multiple films since the accident, the plaintiff won several filmmaking awards while maintaining a 4.0 grade point average. The jury awarded the plaintiff more than \$17 million.

The runaway verdict in California is not a one-off event. Also in 2015, a Seattle jury awarded a cruise-ship passenger \$21.5 million for a mild TBI he sustained after being struck by the automatic sliding doors on the ship. These eight-figure verdicts represent the growing risk of mild TBI claims nationwide.

This article will provide defense counsel with a brief overview of the neuroimaging techniques utilized by plaintiffs to support mild TBI claims. It will explain the basic principles behind these technologies and discuss the risks they present for



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counsel defending mild TBI claims, as well as strategies for attacking this evidence in litigation.

What Is Mild TBI, and How Do Plaintiffs Prove It?

TBIs are diagnosed based on neurological signs present during, or very shortly after, a traumatic event. Although several different medical organizations have promulgated their own definitions for mild TBIs, the diagnostic criteria usually include loss of consciousness, altered consciousness (such as confusion, dizziness, agitation, and others), post-traumatic amnesia, positive findings on diagnostic imaging such as magnetic resonance imaging (MRI) or computed tomography (CT) scans, and focal neurological abnormalities such as seizures, visual or hearing disturbances, and others. Only one of these neurological signs needs to be present to support a TBI diagnosis. *See generally*, Department of Veterans Affairs and Department of Defense, *Clinical Practice Guideline for Management of Mild TBI/Mild Traumatic Brain Injury* (2009). *See also* U.S. Department of Health and Human Services Center for Disease Control and Prevention, *The Report to Congress Traumatic Brain Injury in the United States: Epidemiology and Rehabilitation* 15 (2015).

Under the guidelines published by major medical organizations around the country, a person can meet the criteria for a mild TBI simply by reporting altered consciousness, which may be described as dizziness, disorientation, confusion, or something similar. This makes it easier to prove a mild TBI claim by reporting subjective symptoms, but less easy to objectively prove the injury.

Although many individuals suspected of having mild TBI undergo computed tomography (CT) or magnetic resonance imaging (MRI) scans of the brain, these imaging modalities often yield normal results even if a mild TBI has occurred. This is possible because the mechanism underlying mild TBI is one of transient dysfunction of neurons rather than physical damage to brain tissue. That is, mild TBI involves a complex series of metabolic changes in the brain that are expected to improve to full resolution over the course of days, weeks, or months after the trauma. *See generally* Matthew T. McCarthy & Barry E. Kosofsky,

Clinical Features and Biomarkers of Concussion and Mild Traumatic Brain Injury in Pediatric Patients, 1345 *Annals of the New York Academy of Sciences* 89, 91 (2015).

In fact, research shows at least 95 percent of individuals who sustain a mild TBI are expected to recover fully from within weeks to months. Grant L. Iverson *et al.*, *Conceptualizing Outcome from Mild Traumatic Brain Injury*, in *Brain Injury Medicine: Principle and Practices* 470 (Nathan D. Zasler *et al.* eds., 2d ed. 2013) (noting that the percentage of all mild TBI patients with symptoms after one year is “clearly less than 5 percent”); Michael A. McCrea, *Mild Traumatic Brain Injury and Postconcussion Syndrome* 165 (2008) (concluding that “[t]he true incidence of PCS would appear to be far less than 5 percent of all MTBI patients” and “could be lower than 1 percent of all MTBI patients.”).

In contrast, moderate and severe TBIs are usually associated with some degree of structural brain damage that may be permanent. This dichotomy between temporary brain dysfunction and permanent brain damage is one of the fundamental matters that plaintiff and defense experts debate in mild TBI litigation. When plaintiffs assert mild TBI claims, they generally seek to persuade jurors that permanent brain damage is the reason for their failure to recover fully from an apparently mild head injury. In contrast, defendants generally argue that a plaintiff’s ongoing cognitive, emotional, and neurological complaints, all of which are usually non-specific to mild TBI, are the result of non-neurological or non-physiological factors.

In an attempt to prove through “objective” means their theory of permanent brain damage, plaintiffs rely upon emerging, advanced neuroimaging techniques that allegedly permit a deeper analysis of the structure and function of the brain. The term “advanced neuroimaging” generally refers to imaging modalities such as diffusion tensor imaging (DTI), positron emission tomography (PET), single photon emission computed tomography (SPECT), functional MRI (fMRI), and quantitative electroencephalography (QEEG).

Advanced neuroimaging techniques create striking, visually appealing demonstrative evidence that purports to bring objectivity to mild TBIs for jurors. How-

ever, the high-tech nature of advanced neuroimaging can obscure some critical methodological flaws in the way that these techniques are administered to patients and interpreted by plaintiffs’ experts. As defense counsel more frequently encounter advanced neuroimaging techniques in mild TBI cases, they can benefit from having a basic understanding of the principles

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underlying the techniques, their inherent methodological flaws, and their potential to mislead jurors.

Structural Neuroimaging

To understand the role of advanced neuroimaging in TBI cases, we must first discuss basic structural neuroimaging techniques, their applications, and their limitations in the study of TBI. Structural imaging examines the physical characteristics of the skull and brain. Basic neuroimaging techniques such as X-ray radiography, computed tomography (CT), and magnetic resonance imaging (MRI) fall into the structural category. More recently, an advanced form of structural neuroimaging called diffusion tensor imaging (DTI), mentioned above, has been added to the list of structural neuroimaging modalities. Plaintiffs generally use structural neuroimaging to support arguments that an accident caused physical brain damage.

Basic Structural Neuroimaging: CT and MRI

CT (also called CAT) is an advanced form of X-ray imaging. CT uses X-rays, but creates more detailed representations of the skull and brain by passing X-rays through the head at different angles. CT works by mea-

asuring the amount of radiation absorbed by different tissues. The differences in X-ray absorption generate cross-sectional images or slices of the head. Measurements taken in these slices, called tomograms, are then stored on a computer. William E. Brant, *Diagnostic Imaging Methods*, in *Fundamentals of Diagnostic Radiology* 5 (William E. Brant & Clyde A. Helms, eds., 4th ed. 2012).

Diffusion tensor imaging

(DTI) is a relatively recent advancement in MRI technology that is gaining attention in TBI litigation because it creates detailed, three-dimensional images of brain structures. It is arguably the most popular of the advanced neuroimaging methods used by plaintiffs.

In cases of suspected brain injury, CT is commonly used in the emergency room setting to assess for intracranial injury, such as swelling, bruising, and bleeding, that may require emergency intervention. CT imaging is relatively inexpensive and quick to administer, which is why it is often the first-round neuroimaging technology used by emergency room doctors to investigate brain injury. David J. Seidenwurm & Govind Mukundan, *Introduction to Brain Imaging, in Fundamentals of Diagnostic Radiology* 42 (William E. Brant & Clyde A. Helms, eds., 4th ed. 2012). CT can provide more detailed images than traditional radiography and can discriminate between different types of tissue, such as fat, blood, bones, and brain tissue. However, due to the limitations of X-rays, CT still cannot reveal precise details of soft tissues. Muriel D. Lezak *et al.*, *Neuropsychological Assessment* 865 (5th ed. 2012).

Unlike CT scans, MRI uses radio-frequency waves rather than X-rays. MRI uses different scan sequences, each of which has particular advantages in highlighting certain types of tissue and discriminating between tissues of different densities. Some of the more commonly used sequences in brain imaging include the following:

- T1 is a commonly used sequence in which solid tissues appear brighter and fluids such as water or cerebrospinal fluid appear darker. It is often referred to as the “anatomical” scan. *Id.* at 865.
- T2 provides additional contrast to fluid-filled areas of the brain, or to areas where fluid collects abnormally. *Id.*
- **Fluid-attenuated inversion recovery (FLAIR)** suppresses the effects of cerebrospinal fluid (CSF), which makes it useful for detecting lesions and plaques within deep structures of the brain. *Id.* at 866.
- **Susceptibility-weighted imaging (SWI)** provides extra contrast to blood and byproducts from the breakdown of blood, which makes it useful for identifying active bleeds or places where bleeds have occurred previously. *Id.*

MRI has several advantages over radiography and CT. First, MRI does not use harmful ionizing radiation. Second, MRI can provide much higher resolution images than CT. Although CT is preferred for detecting bone fractures in an acute setting, MRI is preferred for detecting bleeds and imaging tissues with slight density variances such as those in the brain, muscles, and tumors. Brant, *supra*, at 13–14. However, MRI is usually more expensive to administer than CT, and because scan times may exceed 30 minutes, MRI can be impractical in emergency medical situations that require a quick assessment of the patient. Furthermore, patients with some types of metallic implants or other foreign metal in their bodies cannot safely undergo MRI.

Diffusion Tensor Imaging

Diffusion tensor imaging (DTI) is a relatively recent advancement in MRI technology that is gaining attention in TBI litigation because it creates detailed, three-dimensional images of brain structures. It is arguably the most popular of the

advanced neuroimaging methods used by plaintiffs.

The brain broadly consists of two distinct areas of tissue—gray matter and white matter. Gray matter consists mostly of neuron bodies, whereas white matter consists mostly of axons, the projections of neurons that carry signals between neurons. Because gray matter and white matter have different densities, the gray matter-white matter junction in the brain is an area susceptible to the effects of rotational forces acting on the head. In TBI cases, plaintiffs’ experts often describe the presence of microscopic “shearing” injuries to white matter that do not appear on traditional MRI scans. It is these types of injuries that DTI purports to study.

Some plaintiffs’ experts and attorneys believe that these DTI images can demonstrate abnormalities in white matter that would not normally show up on MRI, CT, or other imaging modalities. Therefore, they believe that DTI can show structural evidence of permanent, microscopic brain abnormalities even in cases of mild TBI. It is easy to see why this technology is becoming more commonplace in mild TBI litigation.

DTI works on the principle that water molecules in the brain tend to move in predictable directions that correlate with the shape, structure, and direction of axons and the pathways that axons create in the brain. DTI detects patterns of diffusion of water molecules in the brain and uses these patterns to draw conclusions about the structure and integrity of the white-matter pathways. DTI cannot actually image brain tissue at the cellular level. Instead, it averages the water flow in millions of neurons in a region of the brain. This is much like observing the paths of millions of cars and using that data to create a general map of roads and highways.

One of the more common ways that DTI measures water diffusion is through fractional anisotropy—the average of the degree to which water molecules are restricted in their ability to diffuse in a region of the brain. Radiologists then use these measurements to infer the integrity and structure of the white matter in the brain. Some scientists believe that areas of abnormally low fractional anisotropy (*i.e.*, areas where water molecules move in a less restricted fashion) indicate brain damage.

Despite the intriguing research potential of DTI, there is ongoing debate in the medical community about whether DTI has undergone enough research to validate its use in the clinical diagnosis of mild TBIs, and whether it is appropriate for forensic use. Hal S. Wortzel *et al.*, *Diffusion Tensor Imaging in Mild Traumatic Brain Injury Litigation*, 39 *Journal of the American Academy of Psychiatry and the Law* 511, 521 (2011). Several shortcomings make interpreting DTI results difficult.

First, DTI cannot distinguish between abnormalities that are naturally present and those that are caused by trauma. DTI may detect white matter abnormalities even in otherwise healthy individuals with no clear history of TBI. DTI cannot distinguish between abnormalities caused by trauma and those abnormalities that may be due to things such as depression, neurodegenerative diseases, chronic alcoholism, or other diseases that are known to affect white matter. Thus, DTI can identify the existence of an abnormality, but it cannot isolate a cause from among several possibilities.

Second, it is difficult to connect a particular abnormality to a specific brain injury symptom. Abnormalities do not necessarily translate into a verifiable symptom in a patient.

Third, the correlation between particular findings in DTI and the particular symptoms reported by a patient is still undetermined. Normally, reduced fractional anisotropy in a particular area of the brain indicates to doctors that the integrity of the white matter has been compromised. However, several studies have actually found *increased* fractional anisotropy in patients with documented brain injuries.

Fourth, artifacts from the data collection during a scan can muddy the results. Because DTI involves collecting data from millions of data points and averaging the data to draw conclusions about the movement of water molecules in particular areas of the brain, very small errors in collecting the data can considerably affect the results. As one example, tiny movements by a patient while in a scanner can cause artifacts and errors in measurement of water diffusion.

DTI's current drawbacks mean that it is not sufficiently valid or reliable for clinical diagnosis of TBI or for use in the courtroom. Carolyn C. Meltzer *et al.*, *Guidelines*

for the Ethical Use of Neuroimages in Medical Testimony: Report of a Multidisciplinary Consensus Conference, 35 *American Journal of Neuroradiology* 632, 634 (2014). At this point, the general consensus in the relevant scientific community is that DTI provides general information about broad clinical populations, but cannot be used to diagnose TBIs in individual patients. *Id.*

Nonetheless, plaintiffs' attorneys nationally who are sophisticated in TBI litigation have adopted DTI as a critical part of their trial strategy. These attorneys collaborate and pool resources by sharing legal and medical research, sample motions, expert affidavits, and briefing strategies to ensure that DTI is admitted over *Daubert* and *Frye* challenges. This collaborative campaign has resulted in varying degrees of success in having DTI admitted into evidence in courts around the country. Defense counsel challenging the admissibility of DTI can expect the plaintiff's attorney to mount a sophisticated and aggressive response with the help and backing of the community of DTI supporters. Accordingly, defense counsel should avoid making generalized arguments about the technology and instead focus on a case-specific, expert-specific approach to argue why a particular expert's use or interpretation of DTI in forming his or her opinions should be excluded at trial.

Functional Neuroimaging

In contrast to structural imaging, functional imaging examines the brain's functioning, rather than the physical appearance or structure of tissues. For example, functional imaging of the brain seeks to study the rate at which brain cells absorb and metabolize glucose for energy, or changes in the oxygen consumption of different areas of the brain. Functional neuroimaging modalities include positron emission tomography, single photon emission computed tomography, and functional MRI. Plaintiffs use functional imaging to argue that a mild TBI has disrupted the functioning of the brain in some way, even if it has not caused physical brain damage.

Positron Emission Tomography and Single Photon Emission Computed Tomography

Positron emission tomography (PET) studies brain function by analyzing the rate at

which different parts of the brain absorb and use certain molecules in their metabolic processes. American Psychological Association, *Function Magnetic Resonance Imaging: A New Research Tool*, 49 (2007). PET uses molecules commonly used by the brain for common processes, such as energy consumption, that have been modified by attaching a radioactive component to make a "tracer." Most commonly, technicians use a radioactive form of glucose, a molecule the brain uses for energy, as a tracer.

The PET technician injects a subject with the radioactive tracer, which travels through the blood and reaches the brain. As the cells in the brain consume the tracer, the tracer emits radiation that is then detected by the PET scanner. Specialized software can then determine what parts of the brain are consuming more of the tracer than others. This data is compared to data derived from "normal" individuals, meaning those without a history of brain injury, to determine whether the patient's brain is functioning abnormally. For example, an expert may opine that a patient's PET scan showing metabolic activity that is two standard deviations below normal indicates an abnormality is present.

Single photon emission computed tomography (SPECT) also uses radioactive molecules as tracers, but it studies different cellular processes. SPECT tracers can measure a wide range of physiological functions in bodily tissues, such as oxygen consumption. These tracers are generally cheaper and easier to administer than those used in PET. However, SPECT scans collect a smaller amount of data from the patient and therefore result in lower resolution images compared to PET. Joseph H. Ricker *et al.*, *Functional Neuroimaging in Brain Injury Medicine: Principle and Practices* 219 (Nathan D. Zasler *et al.*, eds., 2d ed. 2013)

In contrast to brain structure, which stays relatively constant over short periods of time, the functional state of brain tissue can change rapidly within minutes or seconds. Because brain functioning is extremely dependent on the characteristics of the individual patient and can change rapidly depending on the physiological and external environment in which

the imaging takes place, it is important to be aware of several variables that can affect functional imaging results. These variables include (1) medications and commonly consumed psychoactive substances such as caffeine, (2) sleep and fatigue, (3) the age of the patient, (4) preexisting mental illness, and (5) intentional or unintentional mental or sensory stimulation

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of the patient during the scan. A forensic expert using PET or SPECT must explain how he or she has controlled for these variables before arriving at opinions based on the scan results. The expert should also explain in detail the testing protocol used and should justify any aspects of the testing procedures that may affect any of these variables and undermine the validity of the scan results.

PET and SPECT have clinical applications in diagnosing Alzheimer's disease, certain types of cancers, and seizures, among other conditions. Mayo Clinic, *Positron Emission Tomography (PET) Scan, Why It's Done*, <http://www.mayo.org> (May 4, 2015). Plaintiffs' counsel will often argue that PET and SPECT's use in these applications means that it is "generally accepted" for use in any and all diagnostic applications. However, the medical community continues to rate PET and SPECT as inappropriate for clinical diagnosis of mild TBI. Since the 1970s, several studies have used PET to evaluate mild TBIs, but few studies have actually proved a direct relationship exists between PET findings and cognition after trauma. Robert W. Van Boven *et al.*, *Advances in Neuroimaging of Traumatic Brain Injury and Posttraumatic Stress Disorder*, 46 *Journal of Rehabilitation Research*

& Development 717, 739 (2009). Although PET and SPECT can show certain metabolic changes in the brain that may also be seen in some mild TBI patients, there is no "signature" pattern of mild TBI on PET or SPECT scans that distinguishes mild TBI from several other conditions that can affect the brain's metabolism. Research has not reliably correlated PET and SPECT findings and neuropsychological abnormalities. *Id.*

Furthermore, even if a finding on a PET or SPECT scan can be correlated with brain trauma, it does not provide information about the nature of the trauma involved, nor does it allow doctors to say that a particular metabolic abnormality is a result of a particular traumatic event. As explained by one author, the limited understanding of the actual significance of abnormal PET results means that "PET does not have a large role in evaluation of TBI." Jonathan M. Silver *et al.*, *Textbook of Traumatic Brain Injury* 105 (2011) ("Correlation of a specific lesion location with function is often problematic").

Recognizing PET's and SPECT's multitude of limitations in the context of diagnosing mild TBI, several medical organizations agree that PET and SPECT are *not* generally accepted for determining the presence of mild TBI. The American College of Radiology (ACR), an organization of more than 36,000 radiologists, nuclear radiologists, and oncologists, has published a system that rates the appropriateness of various radiological procedures for the diagnosis of minor or mild acute closed head injuries. American College of Radiology, *ACR Appropriateness Criteria*, <http://www.acr.org> (2015). For diagnosis of the clinical condition "minor or mild acute closed head injury" with a Glasgow Coma Scale score greater than or equal to 13 (a concussion), the ACR has given PET and SPECT a 1 out of 7 appropriateness rating (the lowest), indicating that it is "usually not appropriate" for the clinical diagnosis of mild TBI.

The ACR also states that advanced imaging techniques, including PET and SPECT, "have utility in better understanding selected head-injured patients but are not considered routine clinical practice at this time." *Id.* at 13. The exceedingly low ACR appropriateness rating for PET and

SPECT means that these modalities are not accepted by the ACR for use in diagnosing mild TBI and are still in the investigational stages.

Functional MRI

Functional magnetic resonance imaging (fMRI) is a technique that indirectly measures brain activity by measuring the magnetic properties of hemoglobin (an iron-containing protein in blood). Lezak, *supra*, at 869. Brain cells fire in response to the activities that a person engages in; everything from thinking and walking to talking results in a neuronal response. Because individual brain cells do not store energy, they require constant refueling from oxygen in the blood. In theory, more active areas of the brain require more blood; this is called blood oxygen level-dependent response (BOLD). *ACR Appropriateness Criteria*, *supra* at 13. Changes in cerebral blood flow and oxygenation are highlighted as bright areas on fMRI readouts. These highlighted areas indicate increased blood flow to the area, theoretically signifying raised levels of brain activity. *Id.*

fMRI can produce activation maps showing which parts of the brain are involved in a specific mental process. Imaging is conducted while a patient completes an assigned task. An instance of neural activity is noted when an area of the brain consumes more oxygen, and to meet this increased demand, cerebral blood flow increases to the active area. *Id.*

Despite its availability for decades, fMRI has not overcome its significant methodological limitations to become a valid and reliable method for diagnosing mild TBI. The scientific community seldom mentions the reliability of fMRI. Remarkably on fMRI, one MIT researcher stated, "It's a dirty little secret in our field that many of the published findings are unlikely to replicate." Laura Sanders, *Trawling the Brain*, 176 *Science News* (2009). For instance, a primary concern with fMRI is that the statistics used to render an image are appropriately implemented.

Another concern is the fact that MRIs rely upon powerful electromagnets that must be calibrated and maintained by expert technicians. Slight differences in the technological specifications and cali-

bration of different MRI scanners make it difficult to standardize fMRI results across different machines and research facilities. Craig M. Bennett & Michael B. Miller, *How Reliable Are the Results from Functional Magnetic Resonance Imaging?*, 1191 *Annals of the New York Academy of Sciences* 133, 134 (2010). These shortcomings with fMRI, among others, make reproducing fMRI studies' reliability very difficult.

Quantitative Electroencephalography

Although they are not technically brain "imaging," electroencephalography (EEG) and quantitative EEG (QEEG) are forms of physiological measurement used to detect electrical activity in the brain. EEG and QEEG are included in this article because they are often referred to as "brain mapping" for their ability to generate images purporting to depict abnormalities in brain waves.

EEG involves placing electrodes on the scalp to detect electrical activity near the surface of the brain. EEG is inexpensive and useful in identifying epilepsy, pharmacological effects of drugs on the brain, and seizure disorders. National Health Service, *Electroencephalogram (EEG)*, <http://www.nhs.uk> (Nov. 8, 2015). Because EEG can only detect electrical activity near the surface of the brain and is unable to detect electrical activity in the deeper regions of the brain, its utility is somewhat limited.

Currently, there are no clear EEG features that are unique to mild TBI. Some scientists have found that abnormal EEG in mild TBI patients can indicate slowing in certain wave patterns, which may revert to normal within hours after trauma or may require gradual recovery over many weeks. In general, there is a very poor correspondence between EEG findings and the clinical symptoms after head injury. Other studies have demonstrated slowed electrical signals after mild TBI with no functional differences upon neuropsychological testing. Evidence to support slowed activity in all mild TBI cases is very sparse. Marc R. Nuwer *et al.*, *Routine and Quantitative EEG in Mild Traumatic Brain Injury*, 116 *Clinical Neurophysiology* 2001–2025 (2005).

QEEG is essentially computer-enhanced EEG that analyzes the features of an EEG signal. Many QEEG programs compare the

brain activity of a patient with a database of the brain activity of normally functioning individuals. QEEG makes use of quantitative techniques to analyze EEG characteristics such as the amplitude, coherence, symmetry, frequency, phase, and power of electric waves over time. Some QEEG techniques also use "automated event detection" that rely on mathematical algorithms to identify events in the EEG results. L. John Greenfield *et al.*, *New Frontiers in EEG*, 13 *Reading EEGs: A Practical Approach* 299, 311 (2012).

Although some studies have demonstrated QEEG findings in mild TBI patients in the acute, subacute, and chronic stages, "a reliable test or battery of tests that is suited best for different post-injury phases has not been described." Zulfi Haneef *et al.*, *Electroencephalography and Quantitative Electroencephalography in Mild Traumatic Brain Injury*, 30 *J. Neurotrauma* 8 (April 2015) 653–656. Furthermore, "very few test–retest reliability studies have been published with qEEG data obtained from TBI patients," a concern due to the significant variability associated with post-TBI test results. Paul E. Rapp *et al.*, *Traumatic Brain Injury Detection Using Electrophysiological Methods*, 9 *Frontiers in Human Neuroscience* 11, 22 (2015).

QEEG's limitations include (1) the ability of eye movements, drowsiness, muscle activity, and medications to affect test results; (2) the tendency for QEEG to falsely identify normal variations between individuals, or variations over time within the same person, as abnormalities; (3) insufficient normative databases for comparing a patient's test results to those of a normal population; (4) lack of studies confirming the results of earlier exploratory studies; and (5) the lack of scientific scrutiny of QEEG software and equipment due to its proprietary nature. *Id.*

In 1997, the American Academy of Neurology (AAN) funded a review of QEEG to see if the science had evolved to a point of reliability and validity. Nuwer, *supra*, at 2001. The report is particularly relevant to mild TBI litigation because it reviews the efficacy of the QEEG and its validity and reliability in detecting mild TBIs. The report found that previous studies had incorrectly concluded that EEG changes were unaffected by drowsiness, sleep, or

medications. *Id.* at 2021. Further, the article found a number of other problems with the use of QEEG, such as (1) a lack of generally accepted QEEG safeguards and standards; (2) a tendency to identify minor deviations from the norm as clinically significant abnormalities; and (3) false positive rates as high as 50 percent among normal individuals. The study concluded that the disadvantages of QEEG continue to outweigh the advantages. The AAN reaffirmed this position paper in 2003, 2006, and 2013.

Conclusion

TBIs are a rapidly growing category of personal injury claim. To prove these often complicated claims, Plaintiffs' attorneys are turning to emerging neuroimaging techniques. These techniques can provide an impressive amount of information and visually appealing demonstrative evidence regarding the structure and function of a person's brain. However, these techniques are of questionable validity and reliability. As a result, there is a strong risk that these techniques can mislead jurors.

Although some of these advanced imaging modalities have been around for decades (and may be reliably used to diagnose other conditions), this does not necessarily mean that they are valid and reliable methods of diagnosing mild TBIs. In many cases, advanced neuroimaging is used by an expert to demonstrate that a patient sustained a mild TBI. However, there is a difference between what a forensic expert says a particular study shows and what the current state of the medical literature says it can show. In reality, the results of these advanced neuroimaging techniques can be skewed by technical error, statistical misinterpretation, or the influence of patient-specific variables such as comorbid medical conditions, medication use, prior injuries, age, and many other factors. For these reasons, TBI diagnoses and causation opinions that are based on advanced neuroimaging may be ripe for challenges under *Daubert* and *Frye*. Having an adequate understanding of the scientific principles underlying these methods, and their limitations, is critical for defense counsel preparing to cross-examine an expert and to challenge the use of this powerful, but often misleading, evidence in the courtroom.

