

DIFFUSION TENSOR IMAGING: FAILING *DAUBERT* AND FED.
R. EVID. 702 IN TRAUMATIC BRAIN INJURY LITIGATION

Andrew M. Lehmkuhl II

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I. INTRODUCTION

With jury awards as high as \$21.5 million and \$28.5 million, lawsuits alleging traumatic brain injuries have become high profile in recent years.¹ Traumatic brain injury (“TBI”) lawsuits have also nearly tripled in the past two decades.² With the emergence of TBI lawsuits with significant monetary damages in play, courts are best served to develop a detailed understanding of the science behind the scientific tools commonly utilized in bringing and defending these types of claims in order to effectively fulfill their responsibility of being a gatekeeper to expert testimony and scientific evidence.

1. Hausman v. Holland America Line-U.S.A., 2015 Jury Verdicts LEXIS 11837 (E.D. Wash. 2015); Adams v. The Imported Car Store, Inc., The Dingman Group, Inc., and Jason Andrew Neal, 2012 Jury Verdicts LEXIS 25024 (Fla. 18th Cir. Ct. 2012).

2. Brandon A. Woodard et al., *Mild Traumatic Brain Injury Litigation: An Overview of Neuroimaging Techniques*, in FOR THE DEFENSE (2016).

The phrase “traumatic brain injury” covers a vast category of damage to the brain.³ Injuries range from being isolated to one point of impact to more widespread throughout the brain.⁴ Likewise, the severity of a TBI encompasses a wide range, with unique combinations of symptoms attributed to each individual.⁵ Many individuals in the field question whether a comprehensive understanding of the biomechanics of TBI is even possible.⁶ The complexity of traumatic brain injuries presents a significant challenge to clinical diagnosis and injury management, as well as litigation. Clinicians must evaluate several measures featuring diverse spectra of outcomes to assess prognosis and treatment of TBI, including mechanism of injury, pathophysiology, and clinical severity. Doctors and plaintiffs both seek diagnostic tools to provide indisputable evidence of TBI. In addition to proof of injury, a powerful tool establishing the severity of TBI would be extremely valuable to plaintiffs seeking large damages rewards. Expert witnesses in TBI cases frequently offer images collected from complex advanced neuroimaging technologies as evidence of a grim prognosis, often leading jurors to believe that a plaintiff has suffered permanent brain damage when in reality, the plaintiff’s injury may be treatable, or their symptoms may be attributable to other factors, such as underlying psychological conditions or orthopedic injury. In fact, research shows that approximately 95% of individuals fully recover within weeks to months after sustaining a mild TBI.⁷

As our understanding of neuroscience and TBI grows, several technologies have emerged that show promise as future diagnostic tools. However, the process of thoroughly developing this type of a technology for clinical use is an arduous one, and the adversarial model that frames our legal system encourages the misuse of technologies that have yet to be fully developed enough to serve as reliable scientific evidence.⁸

One such technology applicable to TBI litigation, known as diffusion tensor imaging (DTI), serves as an effective model to examine the court’s role as a gatekeeper in assessing the admissibility of expert

3. See *Traumatic Brain Injury Information Page*, National Institute of Neurological Disorders and Stroke, <https://goo.gl/9JkyZF> (last visited Jan. 24, 2018).

4. See Nigel A. Shaw, *The Neurophysiology of Concussion*, in 67 *PROGRESS IN NEUROBIOLOGY* 281, 288 (2002).

5. Robert C. Cantu, *Concussion*, in *Head Trauma and Brain Injuries For Lawyers* 155, 157-159 (2016).

6. SHAW, *supra* note 4 at 287.

7. Grant L. Iverson *et al.*, *Conceptualizing Outcome from Mild Traumatic Brain Injury*, in 2 *BRAIN INJURY MEDICINE: PRINCIPLE AND PRACTICES* 470 (2013).

8. Hal S. Wortzel *et al.*, *Diffusion Tensor Imaging in Mild Traumatic Brain Injury Litigation*, in 39 *THE JOURNAL OF THE AMERICAN ACADEMY OF PSYCHIATRY AND THE LAW* 511, 512 (2011).

testimony and scientific evidence. Despite clearly falling short of the standards that guide admissibility of scientific evidence in the courtroom, DTI is still overwhelmingly admitted. Courts reason that litigants should present any limitations during cross-examination of the expert witness presenting the evidence. Not only does this practice circumvent the purposes of standards of admissibility of scientific evidence, but it also raises serious concern for confusing and misleading jurors.

This article will first introduce TBI before providing an overview of DTI and how it works. Next, this article will summarize the primary standards of admissibility of scientific evidence that govern the admissibility of DTI as evidence and lay out why DTI does not meet these evidentiary standards. Finally, using a case study, this article will explore the trend of admitting DTI evidence despite not meeting these standards.

II. BACKGROUND

Advanced neuroimaging such as DTI is best understood in context. Therefore, this section provides context for understanding the shortcomings of using DTI in a legal setting, including: (a) the major concepts of TBI; (b) the physiology, physics, and imaging technology involved in the technique of DTI; and (c) the jurisdictional landscape of admissibility standards for expert testimony relying on scientific evidence.

A. Traumatic Brain Injury

An introduction to traumatic brain injury provides context for understanding the appeal of diffusion tensor imaging (DTI) to plaintiffs. A TBI occurs when an external force disrupts normal brain function. The source of this external force can vary greatly. According to the Center for Disease Control, the three leading causes of TBI are (1) falls, (2) being struck by or against an object, and (3) car accidents.⁹ Thus, the vast majority of TBI litigation centers on a claim of TBI stemming from these causes.

To best understand the mechanisms of injury¹⁰ and general

9. Christopher A. Taylor et al., *Traumatic Brain Injury–Related Emergency Department Visits, Hospitalizations, and Deaths — United States, 2007 and 2013*, in 66 *MMWR SURVEILLANCE SUMMARIES* 1 (2017), <https://goo.gl/2K846s> (last visited Jan. 24, 2018).

10. Mechanism of injury means the manner in which an injury occurs. See Erin D. Bigler, *Overview of Traumatic Brain Injury*, in 1 *Management of Adults With Traumatic Brain Injury* 3, 4 (2013).

pathophysiology of TBI, it is necessary to briefly study foundational concepts of neuroanatomy. Brain tissue is comprised of two primary components: gray matter and white matter.¹¹ In a basic sense, gray matter broadly refers to the cell bodies of neurons, while white matter refers to axons, the connections between neurons.¹² Inside of the skull, the human brain is suspended in a fluid known as cerebrospinal fluid.¹³

When the head receives a violent blow or jolt, the brain, suspended in fluid, collides with the inner wall of the skull.¹⁴ In this situation, the brain likely receives a focal injury – where damage occurs in the brain at the site of impact.¹⁵ This type of injury, known as a coup injury, may occur when a moving object forcibly strikes a resting head, such as a thrown or falling object.¹⁶ A coup injury can also occur when the moving head forcibly strikes a resting object.¹⁷ In the context of litigation, this type of claimed injury commonly arises when a car collides head-on with another, the car suddenly decelerates, but a passenger's head continues forward, striking the steering wheel or dashboard.

Another type of focal injury, known as a contrecoup injury, occurs when the brain collides with the inner wall of the skull opposite to the site of impact between the head and external object.¹⁸ When the force of the initial impact is great enough, it is possible to experience a coup injury immediately followed by a contrecoup injury.¹⁹ The biomechanics involved in these types of injuries are incredibly complex, not well documented, and often debated.²⁰

In addition to linear impact and linear acceleration/deceleration, the brain may also experience rotational forces, such as when the head accelerates tangentially.²¹ In this situation, rotational forces can cause the brain to collide with multiple points of the inner wall of the skull,

11. Cindy K. Barha et al., *Basics of Neuroanatomy and Neurophysiology*, in 138 HANDBOOK OF CLINICAL NEUROLOGY: NEUROEPIDEMIOLOGY 53, 59 (2016).

12. *Id.*

13. John J. Laterra et al., *The Blood-Brain Barrier, Choroid Plexus, and Cerebrospinal Fluid*, in 5 PRINCIPLES OF NEURAL SCIENCE 1565, 1575 (2013).

14. Teuntje M. J. C. Andriessen et al., *Clinical Characteristics And Pathophysiological Mechanisms Of Focal And Diffuse Traumatic Brain Injury*, in 14 JOURNAL OF CELLULAR AND MOLECULAR MEDICINE 2382, 2383 (2010).

15. *Id.*

16. Michael P. Poirier, *Concussions: Assessment, Management, and Recommendations for Return to Activity*, in 4 CLINICAL PEDIATRIC EMERGENCY MEDICINE 179, 180 (2003).

17. *Id.*

18. POIRIER, *supra* note 16.

19. *Id.*

20. Nigel A. Shaw, *The Neurophysiology of Concussion*, in 67 PROGRESS IN NEUROBIOLOGY 281, 288 (2002).

21. POIRIER, *supra* note 16 at 179.

resulting in multiple focal point lesions.²² When the brain violently rotates, the long axons that comprise white matter tear, breaking connections between neurons and leading to more widespread damage.²³ This type of injury is referred to as diffuse axonal injury (DAI).²⁴ DAI is believed to result in the more persisting and debilitating symptoms resulting from TBI.²⁵ Being able to produce imaging evidence of white matter injury such as DAI would greatly strengthen a claim of TBI and could lead to potentially great damages available to the plaintiff.

B. Overview of Diffusion Tensor Imaging

Part (B) introduces diffusion tensor imaging (DTI) and explains the appeal of the use of DTI in TBI litigation. DTI is a technique based on magnetic resonance (MR) imaging, specifically a form of diffusion-weighted magnetic resonance imaging.²⁶ This section first provides a brief introduction into MR before diving into the inner workings of DTI and discussing the manner in which DTI takes advantage of the movement of water in the brain to allow for calculations into the structural integrity of white matter in the brain.

1. MR and Diffusion Weighted Imaging: Precursors to Diffusion Tensor Imaging

DTI is a modified magnetic resonance (MR) imaging technique.²⁷ While magnetic resonance imaging was established as a widely used clinical tool for several decades, the DTI technique has only been tested since the early 1990s.²⁸

MR takes advantage of the fact that the human body is comprised mostly of water. In MR, magnets force protons in that water to align in the magnetic field.²⁹ A radiofrequency current is then pulsed through the patient, causing the protons to spin out of equilibrium and against the

22. SHAW, *supra* note 20.

23. *Id.* at 285.

24. John T. Povlishock et al., *The Pathobiology of Traumatically Induced Axonal Injury in Animals and Humans: A Review of Current Thoughts*, in 12 JOURNAL OF NEUROTRAUMA 555 (1995).

25. Konstantinos Arfanakis et al., *Diffusion Tensor MR Imaging in Diffuse Axonal Injury*, in 23 AMERICAN JOURNAL OF NEURORADIOLOGY 794 (2002).

26. Aaron Filler, *MR Neurography and Diffusion Tensor Imaging: Origins, History & Clinical Impact of the first 50,000 cases with an Assessment of Efficacy and Utility in a Prospective 5,000 Patient Study Group*, 65 NEUROSURGERY A29 (2009).

27. *Id.*

28. *Id.*

29. *Magnetic Resonance Imaging (MRI)*, National Institute of Biomedical Imaging and Bioengineering, <https://goo.gl/H3auWv> (last visited Jan. 24, 2017).

pull of the magnetic field.³⁰ When the radiofrequency pulse stops, the protons realign with the magnetic field, releasing energy.³¹ This energy, known as the magnetic resonance signal, can be detected and displayed as radiofrequency intensities, which form an image of the patient's tissue.³²

DTI is a form of diffusion-weighted MR, which modifies the MR technique based on natural properties of water in the body.³³ Water molecules in the human body sustain constant motion – a phenomenon known as Brownian motion, or diffusion.³⁴ When diffusion of water molecules occurs along a magnetic field gradient, the magnetic resonance signal is greatly reduced.³⁵ A lack of diffusion therefore means a lack of signal loss, resulting in a bright magnetic resonance signal.³⁶ This allows diffusion-weighted MR to highlight areas with disruption of water diffusion in damaged brain tissue by portraying bright signals at those areas.³⁷ However, DWI is not able to distinguish between possible causes of the disruption, whether trauma, stroke, or some other cause.³⁸

2. Diffusion Tensor Imaging

Adding another layer of complexity onto diffusion-weighted MR imaging, DTI capitalizes on the directionality of water diffusion in different tissue types in the body.³⁹ In the gray matter of the brain diffusion of water occurs at a similar speed in all directions, a concept known as isotropic diffusion.⁴⁰ Conversely, in white matter, water diffuses much faster parallel to axons than across them, known as anisotropic diffusion.⁴¹ Water undergoes anisotropic diffusion in white matter because axons are constrained by obstacles known as myelin sheaths,⁴² causing water to diffuse in the direction of least resistance.⁴³

30. *Id.*

31. *Id.*

32. *Id.*

33. FILLER, *supra* note 26.

34. Denis Le Bihan et al., *Diffusion Magnetic Resonance Imaging: What Water Tells Us about Biological Tissues*, in 13 PLOS BIOLOGY 1, 2 (2015).

35. *Id.* at 5.

36. *Id.*

37. *Id.*

38. WORTZEL, *supra* note 8, at 512.

39. Katherine H. Taber et al., *The Future for Diffusion Tensor Imaging in Neuropsychiatry*, in 14 Journal of Neuropsychiatry and Clinical Neurosciences 1, 2 (2002).

40. *Id.*

41. *Id.*

42. A fatty substance surrounding axons.

43. Marilyn F. Kraus et al., *White matter integrity and cognition in chronic traumatic brain*

The degree of anisotropy suggests information about the structural integrity of white matter.⁴⁴ Intact white matter will exhibit higher anisotropy, whereas damaged white matter allows for more diffusion in multiple directions because the obstacles constraining the environment are damaged.⁴⁵ Damaged white matter is a hallmark of diffuse axonal injury, a severe form of TBI.⁴⁶

While DWI allows for only measurement of the magnitude of diffusivity, DTI allows for measurement of the directionality of diffusion as well.⁴⁷ When applied in the brain, DTI can measure the magnitude and directionality of diffusion within and between brain tissues.⁴⁸ In DTI, several images are acquired for each target brain section.⁴⁹ A magnetic gradient for a different direction is applied to each image.⁵⁰ The speed of diffusion in each direction is then calculated for each voxel (a three-dimensional space in computer modeling representing a small space in the brain) creating a matrix of these values, known as a diffusion tensor.⁵¹

The diffusion tensor allows calculation of multiple outcome measures.⁵² By determining the average diffusion direction for each voxel, the principal diffusion direction can be determined, which allows for mapping of fiber tracts (Fig. 1),⁵³ and the degree of isotropy or anisotropy for the diffusion tensor at each voxel can be determined.⁵⁴ This measure, termed fractional anisotropy, provides insight into the

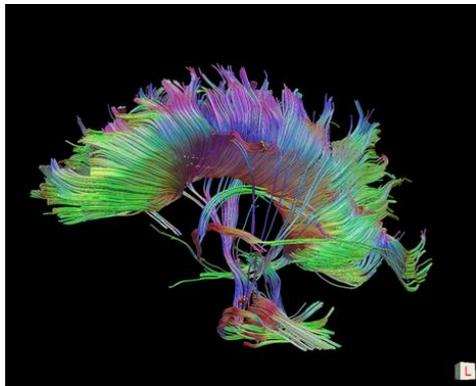


Figure 1. DTI tractography of the corpus callosum in the brain.

injury: a diffusion tensor imaging study, 130 BRAIN 2508 (2007).

44. *Id.*

45. *Id.*

46. ARFANAKIS, *supra* note 25.

47. KRAUS, *supra* note 43.

48. *Id.*

49. LE BIHAN, *supra* note 34.

50. *Id.*

51. TABER, *supra* 39, at 2.

52. *Id.*

53. Do Tromp, *Colorful Corpus Callosum Tractography* (2017), <https://goo.gl/zguzwD> (last visited Jan. 24, 2018).

54. TABER, *supra* 39.

integrity of the microstructure of white matter.⁵⁵ However, fractional anisotropy cannot provide insight into what specifically caused the change, or even whether the change is due to naturally occurring biological variation.⁵⁶ A reduced fractional anisotropy finding in a DTI scan indicates that the integrity of the white matter in that brain area has been compromised. Therefore, an individual with a TBI should theoretically exhibit reduced fractional anisotropy in a DTI scan.⁵⁷

C. Standards for the Admissibility of Scientific Evidence

Part (C) briefly summarizes the general standards for the admissibility of scientific evidence in litigation. A minority of state jurisdictions follows the standard identified in *Frye v. United States*.⁵⁸ However, these standards are currently dominated by the criteria set forth by the United States Supreme Court in *Daubert v. Merrell Dow Pharms., Inc.* and subsequent modifying cases known as the “*Daubert* trilogy.”⁵⁹ This section will also briefly describe the role of expert testimony in scientific evidence and discuss the exclusion of inadmissible scientific evidence.

1. The *Frye* predecessor and the dominant *Daubert* standard

The *Frye* general acceptance standard originates from a 1923 decision out of the D.C. Court of Appeals in *Frye v. United States*.⁶⁰ In *Frye*, the Court determined that a blood pressure-based lie detection test was not admissible as evidence because it had not been generally accepted in the scientific community.⁶¹ Under the resulting *Frye* test, scientific evidence supported must “be sufficiently established to have gained general acceptance in the particular field in which it belongs.”⁶² While *Frye* has been superseded by *Daubert* in the majority of jurisdictions, *Frye* is still relevant to scientific evidence because its general acceptance standard

55. KRAUS, *supra* note 43.

56. Andrew L. Alexander et al., *Diffusion Tensor Imaging of the Brain*, in 4 NEUROTHERAPEUTICS 316, 323-324 (2007). Other commonly used outcome measures: mean diffusivity (MD) (calculated mean of the three primary diffusion directions, which provides information about membrane density); axial diffusivity (AD); radial diffusivity (RD).

57. *Id.*

58. *Frye v. United States*, 293 F. 1013 (1923).

59. *Daubert v. Merrell Dow Pharms., Inc.*, 509 U.S. 579 (1993); *GE v. Joiner*, 522 U.S. 136 (1997); *Kumho Tire Co. v. Carmichael*, 526 U.S. 137 (1999); Congress codified the *Daubert* standard into Fed. R. Evid. 702 and most states have codified a similar rule, if not effectively identical.

60. *Frye*, 293 F. 1013 (1923).

61. *Id.*

62. *Id.* at 1014.

remains active in several population-heavy states, including: California,⁶³ Illinois,⁶⁴ Maryland,⁶⁵ New Jersey,⁶⁶ New York,⁶⁷ Pennsylvania,⁶⁸ and Washington.⁶⁹

In the 1980s, numerous commentators began criticizing the utility of the *Frye* test, arguing that proponents of the evidence should have the burden of establishing the scientific validity of the evidence.⁷⁰ Several years later, the United States Supreme Court granted certiorari in *Daubert v. Merrell Dow Pharmaceuticals, Inc.* out of the Ninth Circuit to review the standard of admissibility for scientific evidence.⁷¹ In *Daubert*, the plaintiffs presented the testimony of eight scientific experts to support their claim that the drug Bendectin, manufactured by Merrell Dow, caused birth defects.⁷² In determining the admissibility of the scientific evidence offered by the experts, the Supreme Court expressly rejected the *Frye* general acceptance test and developed a new standard.⁷³

The *Daubert* standard assigns the role of gatekeeper to trial judges, placing upon them the responsibility to make a preliminary assessment to ensure that scientific evidence is scientifically valid and can properly be applied to the facts at issue in the particular case.⁷⁴ The trial judge is to consider the following factors: (1) whether the theory or technique behind the evidence can be and has been tested; (2) whether it has been subjected to peer review and publication; (3) its known or potential error rate; (4) the existence and maintenance of standards controlling its operation; and (5) whether it has attracted widespread acceptance within its relevant scientific community.⁷⁵ After *Daubert*, Congress amended Fed. R. Evid. 702 to codify this standard.⁷⁶

63. *People v. Kelly*, 549 P.2d 1240 (Cal. 1976).

64. *Donaldson v. Central Illinois Public Service Co.*, 199 Ill.2d 63, 767 N.E.2d 314 (2002); Ill. R. Evid. 702 (Admissibility of scientific evidence is based on the “general acceptance in the particular field in which it belongs.”)

65. *Reed v. State*, 283 Md. 374 (Md. Ct. App. 1978).

66. *State v. Harvey*, 699 A.2d 596 (N.J. 1996); *Kemp v. State*, 809 A.2d 77 (N.J. 2000).

67. *People v. Wesley*, 633 N.E.2d 451 (N.Y. 1994)

68. *Grady v. Frito-Lay, Inc.*, 839 A.2d 1038 (Pa. 2003).

69. *State v. Copeland*, 922 P.2d 1304 (Wash. 1996); *State v. Riker*, 869 P.2d 43 (Wash. 1994); *Lewis v. Simpson Timber Co.*, 189 P.3d 178 (Wash. Ct. App. 2008).

70. *United States v. Downing*, 753 F.2d 1224, 1233 (3rd Cir. 1985) (outlining the emerging criticism of *Frye*); Paul C. Giannelli, *The Admissibility of Novel Scientific Evidence: Frye v. United States, a Half-Century Later*, 80 COLUM. L. REV. 1197, 1250 (1980)

71. *Daubert*, 509 U.S. 579 (1993).

72. *Id.*

73. *Id.* at 585-589.

74. *Id.* at 592-593.

75. *Id.* at 593-596.

76. Fed. R. Evid. 702.

2. Role of an Expert in DTI Evidence

Generally, expert testimony must accompany evidence that requires specialized scientific knowledge or experience.⁷⁷ Accordingly, lay witnesses are barred from presenting scientific evidence.⁷⁸ The American Medical Association (AMA) established its position on the qualifications of an expert medical professional in its Code of Ethics:

Physicians who testify as expert witnesses must: (h) Testify only in areas in which they have appropriate training and recent, substantive experience and knowledge. (i) Evaluate cases objectively and provide an independent opinion. (j) Ensure that their testimony: (i) reflects current scientific thought and standards of care that have gained acceptance among peers in the relevant field; (ii) appropriately characterizes the theory on which testimony is based if the theory is not widely accepted in the profession; (iii) considers standards that prevailed at the time the event under review occurred when testifying about a standard of care.⁷⁹

The American College of Radiology (ACR) offers a similar directive that is specifically applicable to experts presenting DTI evidence.⁸⁰ Following the AMA and ACR guidelines, the expert witness presenting DTI evidence should be a licensed and actively practicing neuroradiologist who has recent experience using DTI. This expert could be the treating doctor who administered DTI under his or her own directive when treating the patient for purpose outside of litigation. Alternatively, this expert could be an expert witness hired solely for the purpose of litigation.

3. Excluding Inadmissible Scientific Evidence

DTI is often the target of evidentiary motions in TBI litigation.⁸¹ When expert testimony or scientific evidence fails to meet the jurisdiction's standards for admissibility set forth in *Frye*, *Daubert*, or

77. Fed. R. Evid. 701.

78. *Id.*

79. American Medical Association. *Code of Medical Ethics*, 2016 Edition, <https://www.ama-assn.org/sites/default/files/media-browser/code-of-medical-ethics-chapter-9.pdf> (last visited Oct. 23, 2017).

80. American College of Radiology ACR Appropriateness Criteria, <https://goo.gl/LySgvu> (last visited Feb. 14, 2018).

81. *See infra* section IV(c).

Fed. R. Evid. 702, a party may utilize a motion in limine⁸² or a *Daubert* motion⁸³ to exclude the particular evidence. This motion should be filed within a reasonable time after the close of discovery, and a hearing on the admissibility should be made in advance of the case appearing on the docket.

Fed. R. Evid. 403

To prevent evidence suggesting a “decision on an improper basis,” Congress enacted Fed. R. Evid. 403 (“Rule 403”).⁸⁴ Under this Rule, a court may exclude “evidence if its probative value is substantially outweighed” by risk of unfair prejudice, confusion of the issues, misleading the jury, or by considerations of undue delay, waste of time, or needless presentation of cumulative evidence.⁸⁵

III. DTI IS INADMISSIBLE IN ALL TBI CLAIMS

The power of DTI as a research tool is undeniable, but the current state of the technology limits its clinical use. This section discusses the literature surrounding DTI, revealing the significant potential for misuse when litigants purport to use DTI to prove TBI in a specific individual. Because of these clinical and scientific shortcomings, DTI does not meet the standards set forth in *Frye*, *Daubert*, or Fed. R. Evid. 702. Moreover, the significant potential for misuse provides an immense opportunity to assign great evidentiary weight to DTI where it is not scientifically justifiable. The complexity and impressiveness of DTI leads to a great likelihood of confusing and misleading jurors, as well as unfair prejudice. Thus, DTI also does not pass the balancing test for admissibility under Fed. R. Evid. 403.

A. DTI fails the *Frye* test

The *Frye* test asks if the scientific evidence is generally accepted in its particular field.⁸⁶ The ability of DTI to characterize white matter integrity is difficult to deny. Nonetheless, numerous authoritative academic organizations in medicine have published express cautions when using and interpreting DTI in a clinical context.⁸⁷

First, The American Society for Functional Neuroradiology

82. An evidentiary motion to exclude certain evidence from being presented at trial.

83. A modified motion in limine aimed specifically at evidence that requires accompaniment by expert testimony.

84. Fed. R. Evid. 403 advisory comm. nn. (1975).

85. *Id.*

86. *Frye*, 293 F. 1013.

87. *Infra* notes 89 and 89.

guidelines include a suggested disclaimer in clinical reports of DTI and note that “it is critical that physicians basing clinical decisions on DTI be familiar with the limitations and potential pitfalls inherent to the technique.”⁸⁸

Second, In December 2012, a multidisciplinary conference, primarily hosted by the American College of Radiology, was held at Emory University to address the “use and abuse” of neuroimaging in the courtroom by developing a consensus regarding the standardization of neuroimaging such as DTI.⁸⁹ The conference resulted in thirteen proposed standards for using neuroimaging in legal matters.⁹⁰ However, the resulting paper specifically acknowledges that “the neuroradiology community has not arrived at a consensus view of the value of DTI in . . . head trauma.”⁹¹ A consensus conference which resulted in a finding that there is a lack of consensus regarding the utility of DTI in brain injury litigation strongly supports the notion that DTI is not generally accepted in the field, but on the contrary, is quite debated.

Third, The Clinical Practice Guidelines developed by the Veteran’s Affairs (VA) and Department of Defense (DOD) specifically indicates that while DTI shows great potential, its current state is “inadequate for routine use at this time.”⁹² This mountain of doubt from academic and professional organizations demonstrates that even though some practitioners accept DTI, it is not widely accepted in the field, and thus, does not meet the *Frye* standard.

B. DTI fails Daubert analysis

The first two prongs of the *Daubert* analysis go hand-in-hand in most situations. The first prong of the *Daubert* analysis asks whether scientific evidence can or has been tested.⁹³ The second prong asks whether the scientific evidence has been subjected to peer review and publication.⁹⁴ DTI clearly satisfies both of these prongs, as it can be tested and clearly has been tested. At the time of this writing, 786 research grants from the National Institute of Health involved a DTI

88. *ASFNR Guidelines for Clinical Application of Diffusion Tensor Imaging*, American Society of Functional Neuroradiology, <https://goo.gl/48Lkwa> (last visited Feb. 5, 2018).

89. 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 (2014).

90. *Id.* at 635.

91. *Id.*

92. VA/DOD Clinical Practice Guideline For The Management Of Concussion Mild Traumatic Brain Injury, <https://goo.gl/SxYrqG> (last visited Feb. 5, 2018).

93. *Daubert v. Merrell Dow Pharms., Inc.*, 509 U.S. 579 (1993).

94. *Id.* at 593-594.

component.⁹⁵ These particular grants are just one sample of the ongoing experimentation with DTI that happens around the country.⁹⁶ A quick Google Scholar search for the phrase “diffusion tensor imaging” reveals hundreds of peer-reviewed and published papers involving DTI research. The article titled “A Decade of DTI in Traumatic Brain Injury: 10 Years and 100 Articles Later” by Hulkower et al. demonstrates that as of 2011, there were 100 peer-reviewed publications available via PubMed that were relevant to the use of DTI in TBI.⁹⁷ Because DTI clearly satisfies both of these prongs, challenging DTI on either ground is futile. The factors to be evaluated in the *Daubert* analysis serve as a guide rather than a comprehensive and dispositive list,⁹⁸ so litigants are better suited to focus efforts elsewhere.

The third *Daubert* prong asks whether the challenged technique has a known or potential error rate.⁹⁹ DTI indeed fails this prong. To determine the error rate of DTI, clinicians would need a definitive process to confirm each TBI diagnosis with an independent measure. One primary research objective in the field of TBI is discovering a measurable substance, known as a biomarker, in the brain where the presence of the substance is indicative of TBI.¹⁰⁰ However, there is no established biomarker for TBI in a clinical setting.¹⁰¹ Confirming a TBI diagnosis based on DTI without an established biomarker is extremely difficult. Currently, the basis for TBI diagnosis relies primarily on patient history and symptom presentation.¹⁰² A major portion of these diagnoses is based on self-reporting of the patient. Patients notoriously report symptoms inaccurately and inconsistently.¹⁰³ Additionally, the reporting of symptoms varies from patient-to-patient due to variability in perception and other confounding factors.¹⁰⁴ Because of these

95. *Research Portfolio Online Reporting Tools (RePORT)*, National Institutes of Health, <https://goo.gl/auh6X2> (last visited Feb. 5, 2018).

96. Other neuroscience grant programs include: Alfred P. Sloan Foundation, American Academy of Neurology, Collaborative Research in Computational Neuroscience, Grass Foundation, The McKnight Foundation, The Brain and Behavior Research Fund, National Academy of Sciences, and the National Science Foundation.

97. Miriam B. Hulkower et al., *A Decade of DTI in Traumatic Brain Injury: 10 Years and 100 Articles Later*, 34 *AMERICAN JOURNAL OF NEURORADIOLOGY* 2064 (2013).

98. *Daubert*, 509 U.S. at 597.

99. *Id.* at 594.

100. See Jin Zhang et al., *Biomarkers of Traumatic Brain Injury and Their Relationship to Pathology*, in *TRANSLATIONAL RESEARCH IN TRAUMATIC BRAIN INJURY* 263 (2016).

101. *Id.*; VA/DOD CLINICAL PRACTICE GUIDELINE, *supra* 92 at 23-24.

102. *Id.*

103. See James W. Pennebaker et al., *Psychological Parameters of Physical Symptoms*, in 4 *Personality and Social Psychology Bulletin* 524 (1978).

104. *Id.*; Anthony L. Komaroff, *The Variability and Inaccuracy of Medical Data*, in 67 *PROCEEDINGS OF THE IEEE* 1196 (1979).

inaccuracies, quantitatively determining the exact error rate of DTI is quite difficult, but this further demonstrates that the error rate is certainly high.

One way to address the issue of inaccuracy in patient reporting is through the use of normative data.¹⁰⁵ Tests are developed to measure or detect certain symptoms. These tests are administered to “healthy”¹⁰⁶ patients to form a control group. The results of the tests administered to the control group are known as normative data.¹⁰⁷ The same tests can then be administered to patients suspected of being injured, and the results compared to the normative data. If the patient scored worse than a certain percentile of the normative data, then he or she is considered afflicted or injured. Normative databases for DTI remain underdeveloped, and research into comparisons between DTI of healthy individuals and DTI of individuals with TBI is still emerging.¹⁰⁸ Preliminary research using the limited normative data that exists suggests that there is a significant amount of overlap between the DTI findings in healthy controls and individuals with a TBI.¹⁰⁹ This is because DTI cannot distinguish between the causes of diffusion disruption, whether TBI, tumor, or another cause. In fact, a broad range of common neuropsychiatric conditions may result in abnormal DTI findings, including early life stress, verbal abuse, substance abuse, and sleep apnea.¹¹⁰ Nor can TBI distinguish between pathological disruption and natural variation of diffusion in healthy brains.¹¹¹

105. Maura Mitrushina et al., *Introduction*, in 2 HANDBOOK OF NORMATIVE DATA FOR NEUROPSYCHOLOGICAL ASSESSMENT 3 (2005).

106. In this context, healthy means individuals who are not neurologically injured or ill.

107. MITRUSHINA, *supra* note 105.

108. Mansi Bharat Parekh et al., *Recent Developments in Diffusion Tensor Imaging of Brain*, in 1 RADIOLOGY OPEN JOURNAL 1, 7 (2015); David Bonekamp et al., *Diffusion Tensor Imaging in Children and Adolescents: Reproducibility, Hemispheric, and Age-Related Differences*, in 34 Neuroimage 733, 734 (2007).

109. Marilyn F. Kraus et al., *White matter integrity and cognition in chronic traumatic brain injury: a diffusion tensor imaging study*, in 130 BRAIN 2508, 2518 (2007); Harvey S. Levin et al., *Diffusion Tensor Imaging of Mild to Moderate Blast-Related Traumatic Brain Injury and Its Sequelae*, in 27 Journal of NEUROTRAUMA 683 (2010).

110. Robert Paul et al., *The Relationship Between Early Life Stress And Microstructural Integrity Of The Corpus Callosum In A Non-Clinical Population*, in 4 NEUROPSYCHIATRIC DISEASE AND TREATMENT 193 (2008); Jeewook Choi et al., *Preliminary Evidence for White Matter Tract Abnormalities in Young Adults Exposed to Parental Verbal Abuse*, in 65 BIOLOGICAL PSYCHIATRY 227 (2009); Kelvin O. Lim et al., *Reduced Frontal White Matter Integrity in Cocaine Dependence: A Controlled Diffusion Tensor Imaging Study*, in 51 BIOLOGICAL PSYCHIATRY 890 (2002); Ping-Hong Yeh et al., *Tract-Based Spatial Statistics (TBSS) Of Diffusion Tensor Imaging Data In Alcohol Dependence: Abnormalities Of The Motivational Neurocircuitry*, in 173 PSYCHIATRY RESEARCH 22 (2009); Paul M. Macey et al., *Brain Structural Changes in Obstructive Sleep Apnea*, in 31 SLEEP 967 (2008).

111. Gregory L. Katzman et al., *Incidental Findings on Brain Magnetic Resonance Imaging From 1000 Asymptomatic Volunteers*, in 282 JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION 36 (1999).

Indeed, the error rate that has been established in DTI is high, creating significant issues for the interpretation of DTI used clinically in an individual patient. Another limitation to the DTI technique that exasperates this error rate is that it is difficult to establish a connection between DTI findings and a particular symptom of brain injury.¹¹² This raises significant concerns with expert opinions that rely on DTI findings to establish a prognosis for a plaintiff's TBI claim. Without the ability to accurately link DTI findings with TBI symptoms that are verifiable by neuropsychological evaluation, allowing such an opinion based on DTI findings may provide a greater likelihood for a jury to erroneously call for a defendant to pay damages that are substantially higher than would be justifiable without the speculation involved in DTI.

Additionally, neuroimaging researchers are still aiming to decipher exactly what certain DTI findings mean in terms of brain function. The general theory has been that fractional anisotropy (FA) is decreased in patients with TBI because reduced fractional anisotropy indicates white matter damage.¹¹³ However, two major limitations restrict this theory. First, White matter integrity is compromised in a vast range of neurological disorders, from traumatic brain injury to neurodegenerative disease, and therefore, fractional anisotropy cannot be a specific biomarker for TBI.¹¹⁴ Moreover, several studies have shown *increased* fractional anisotropy in patients with documented brain injuries.¹¹⁵ It may not be known exactly how these contradictory fractional anisotropy findings affect the error rate of DTI, but it certainly contributes to establishing that the error rate is high.

Finally, the hindsight bias phenomenon significantly affects DTI interpretation. Hindsight bias in this context means that when presented with the knowledge or suggestion of a TBI, neuroradiologists are more likely to detect an abnormality.¹¹⁶ This is more likely to be a concern in the context of an expert hired to review DTI findings because expert

112. Calvin Lo et al., *Diffusion Tensor Imaging Abnormalities in Patients With Mild Traumatic Brain Injury and Neurocognitive Impairment*, in 33 JOURNAL OF COMPUTER ASSISTED TOMOGRAPHY 293, 297 (2009); Michael L. Lipton et al., *Multifocal White Matter Ultrastructural Abnormalities In Mild Traumatic Brain Injury With Cognitive Disability: A Voxel-Wise Analysis Of Diffusion Tensor Imaging*, in 25 JOURNAL OF NEUROTRAUMA 1335, 1340-41 (2008).

113. ALEXANDER, *supra* note 56.

114. *Id.*

115. Elizabeth A. Wilde et al., *Diffusion tensor imaging of acute mild traumatic brain injury in adolescents*, in 70 NEUROLOGY 948 (2008); Josef M. Ling et al., *Biomarkers Of Increased Diffusion Anisotropy In Semi-Acute Mild Traumatic Brain Injury: A Longitudinal Perspective*, in 135 BRAIN 1281 (2012).

116. MELTZER, *supra* note 89; Thomas B. Hugh et al., *Hindsight Bias And Outcome Bias In The Social Construction Of Medical Negligence: A Review*, in 16 JOURNAL OF LAW AND MEDICINE 846 (2009).

review is almost entirely retrospective. The expert may genuinely strive to be objective and impartial in his or her review, but when presented with a case involving an adverse event and a plaintiff claiming TBI, it is impossible for an expert to completely eliminate hindsight bias.¹¹⁷ However, the hindsight bias concern extends much more broadly to expert review in legal cases as a whole, and that discussion is beyond the scope of this article.¹¹⁸

Another factor evaluated under the *Daubert* standard asks whether there are standards controlling the operation of the scientific evidence.¹¹⁹ In the past few years, there have been proposals to standardize DTI, but standardization has yet to be achieved. In DTI, imaging artifacts (blemishes in the measured imaging brightness) present a significant obstacle to imaging accuracy and must be accounted for to achieve accurate interpretation.¹²⁰ Such artifacts are primarily attributed to method of obtaining the images and movement of the patient during image acquisition.¹²¹ Currently, there is a lack of consensus on the optimal parameters to prevent or reduce artifacts, with parameters and methods varying from facility-to-facility and doctor-to-doctor.¹²² To detect and correct artifacts, software processing is often necessary before and after the images are acquired.¹²³ There are more than twenty software tools being used for pre- and post-processing, which again shows a lack of consensus in the ideal method for accuracy assurance.¹²⁴ DTI also fails the final *Daubert* prong – whether the scientific evidence has widespread acceptance within its relevant scientific community.¹²⁵

C. DTI Fails Rule 403 Analysis

Rule 403 analysis weighs the probative value of the evidence against

117. *Id.*; Thomas B. Hugh et al., *Hindsight Bias In Medicolegal Expert Reports*, in 176 *MEDICAL JOURNAL OF AUSTRALIA* 277, 277-278 (2002).

118. For further discussion, please read HUGH *supra* note 116 and HUGH *supra* note 117.

119. *Daubert*, 509 U.S. at 594.

120. Jose M. Soares et al., *A Hitchhiker's Guide To Diffusion Tensor Imaging*, 7 *FRONTIERS IN NEUROSCIENCE* 31, 33 (2013).

121. *Id.*; Jonathan A.D. Farrell et al., *Effects of SNR on the Accuracy and Reproducibility of DTI-derived Fractional Anisotropy, Mean Diffusivity, and Principal Eigenvector Measurements at 1.5T*, in 26 *JOURNAL OF MAGNETIC RESONANCE IMAGING* 756 (2010); Seongjin Choi et al., *DTI at 7 and 3 T: systematic comparison of SNR and its influence on quantitative metrics*, in 29 *MAGNETIC RESONANCE IMAGING* 739 (2011).

122. SOARES, *supra* note 120.

123. *Id.*

124. *Id.* at 34; Vishal Patel et al., *LONI MiND: Metadata in NIfTI for DWI*, in 51 *NEUROIMAGE* 665, 666 (2010).

125. *Daubert*, 509 U.S. at 594. See *supra* section III(A).

the risk of unfair prejudice, confusion of the issues, misleading the jury, or by considerations of undue delay, waste of time, or needless presentation of cumulative evidence.¹²⁶ In lawsuits alleging TBI, the probative value of DTI evidence is considerably low due to significant pitfalls when applying DTI to individual cases. Because of the significant level of complexity, substantial risk exists for confusing and misleading a jury using DTI evidence.

Evidence with high probative value tends to prove or disprove an element of a claim in a lawsuit, or to make an element of a claim more or less likely.¹²⁷ In its current state, DTI lacks significant probative value in litigating TBI because of the several shortcomings related to the lack of specificity in using DTI to assess brain damage in an individual.¹²⁸ Admittedly, DTI exhibits great sensitivity in detecting white matter changes in the brain, but without being able to determine the cause of these changes or whether the changes are pathological or due to natural variation, DTI cannot prove that the changes it measures are the result of a TBI.¹²⁹ Further, DTI does not directly measure damage in the brain, but rather measures changes in diffusion of water, from which inferences are made regarding structural integrity of brain tissue.¹³⁰ This increases the chain of inferences necessary for DTI to support the likelihood that brain damage exists in an individual situation, and in turn, further reduces the probative value of DTI. On the other hand, the admission of DTI evidence greatly risks a confusion of the issues, a substantial likelihood of misleading the jury, as well as unfair prejudice towards the defendant.

First, testimony involving DTI evidence creates a substantial risk of confusing and misleading jurors regarding an accurate understanding of the connection between DTI and TBI or how much weight to afford DTI evidence.¹³¹ Without adequate or accurate presentation, there is a great risk that jurors believe that DTI images portray actual connections in the brain, but in reality, the fiber tracts visualized by DTI are based on statistical calculations and probability calculations rather than true neuroanatomy.¹³² In other words, there is a great risk that lay persons believe DTI images to be actual photographs of an individual's brain,

126. Fed. R. Evid. 403

127. Fed. R. Evid. 401.

128. *Supra* section III(b).

129. KRAUS, *supra* note 43; ALEXANDER, *supra* note 56.

130. KRAUS, *supra* note 43.

131. *Ali v. Connick*, 2016 U.S. Dist. LEXIS 67466 *28 (E.D.N.Y. 2016).

132. Guenther C. Feigl et al., *Magnetic Resonance Imaging Diffusion Tensor Tractography: Evaluation of Anatomic Accuracy of Different Fiber Tracking Software Packages*, in 81 *WORLD NEUROSURGERY* 144, 145 (2014); See MELTZER, *supra* note 89.

whereas DTI tractography¹³³ requires significant post-image collection processing to form an estimated image of the brain.¹³⁴ Neuroimaging technologies such as DTI that experts offer as “‘images of’ or ‘windows to’ the mind are especially compelling and enticing to general audiences,” such as jurors.¹³⁵

Notably, the sole act of presenting brain images as opposed to graphs of data has been shown to enhance a perception of scientific value in the minds of laypersons.¹³⁶ These impressive, colorful images induce assurance in jurors regarding the credibility of the technology as well as the interpretation offered by expert testimony.¹³⁷ Gurley and Marcus presented information about a violent crime to lay persons accompanied either by expert testimony or expert testimony accompanied by neuroimaging purporting to show brain damage.¹³⁸ When asked to report whether the defendant should be found not guilty or not guilty by reason of insanity, the participants answered not guilty by reason of insanity 44% of the time when brain imaging accompanied expert testimony versus only 11% of the time with expert testimony alone.¹³⁹

Likewise, an inevitable problem arises out of expert testimony when jurors uncritically accept an expert’s opinion based on impressive qualifications. Jurors often perceive greater credibility of experts based on the expert’s education and experience, rather than evaluate the scientific reasoning applied to their testimony.¹⁴⁰ Accordingly, jurors tend to view expert testimony provided by medical doctors with an “aura of authority,” assigning greater credibility solely based on the expert’s qualifications.¹⁴¹ Interestingly, Weisberg et al. shows that providing neuroscientific information specifically persuades laypersons to perceive inaccurate or deficient explanations of psychological phenomena more favorably and more accurate, even if the

133. Mapping of brain fiber tracts to create a structural image of the brain.

134. See Adina L. Roskies et al., *Brain Images as Evidence in the Criminal Law*, in 13 LAW AND NEUROSCIENCE: CURRENT LEGAL ISSUES 97, 100 (2010).

135. MELTZER, *supra* note 89.

136. David P. McCabe et al., *Seeing is believing: The effect of brain images on judgments of scientific reasoning*, in 107 COGNITION 343 (2008). Generally, research shows that the “mere admission of photographic evidence, even when it does not substantively add to the case, affects jurors’ decisions.” ROSKIES, *supra* note 134; David A. Bright et al., *Gruesome evidence and emotion: anger, blame, and jury decision-making*, in 30 LAW AND HUMAN BEHAVIOR 183 (2006).

137. Jonathan H. Marks, *Interrogational Neuroimaging in Counterterrorism: A “No-Brainer” or a Human Rights Hazard*, in 33 AMERICAN JOURNAL OF LAW AND MEDICINE 483, 486 (2007).

138. Jessica R. Gurley et al., *The Effects of Neuroimaging and Brain Injury on Insanity Defenses*, in 26 Behavioral Sciences and the Law 85 (2008).

139. *Id.*

140. Sanja K. Ivkovic, *Jurors’ Evaluations of Expert Testimony: Judging the Messenger and the Message*, in 28 LAW AND SOCIAL INQUIRY 441, 445 (2013).

141. Ali, 2016 U.S. Dist. LEXIS 67466 at *28.

neuroscientific information provided is *completely irrelevant*.¹⁴² This research not only suggests that mentioning marginally irrelevant brain information may confuse or mislead a jury, but also could mistakenly enhance a jurors assurance in a piece of neuroimaging evidence like DTI when it is not due.¹⁴³

Finally, the risk of unfair prejudice in TBI cases generally has risen considerably with the increasing publicity of concussions in the context of the NFL. Recently, the media has widely reported on the effects of repeated brain injuries in professional athletes – particularly in the NFL.¹⁴⁴ This widespread reporting creates a preconception in jurors that the prognosis of *every* mild TBI/concussion is grim.¹⁴⁵ Realistically, the vast majority of individuals with mild TBI recover shortly after injury.¹⁴⁶ Courts exclude gruesome images for providing a substantial risk of unfair prejudice that outweighs probative value, and DTI images should be similarly excluded for the same reason.¹⁴⁷

In following Rule 403, evidence should be excluded when the risk of confusing the jury, misleading the jury, and unfair prejudice significantly outweigh the probative value of the evidence.¹⁴⁸ The probative value of DTI evidence is significantly low due to inferences necessary to make connections between DTI findings and TBI, as well as several shortcomings related to applying the DTI technique clinically at the level of the individual.

142. Deena S. Weisberg et al., *The Seductive Allure of Neuroscience Explanations*, in 20 JOURNAL OF COGNITIVE NEUROSCIENCE 470 (2008).

143. ROSKIES, *supra* note 134, at 101.

144. In November 2017, famed sports broadcaster Bob Costas' predicted the demise of American football as a sport, stating that the "game destroys people's brains." Tom Schad, *Bob Costas on the future of football: 'This game destroys people's brains'*, <https://goo.gl/MUFuvi> (last visited Feb. 5, 2018); Ryan Basen, *Can Science Solve Football's Concussion Crisis?*, <https://goo.gl/KkJk8W> (last visited Feb. 5, 2018); Sean Gregory, *After Aaron Hernandez, CTE Has Become the NFL's Biggest Problem*, <https://goo.gl/1wbxrt> (last visited Feb. 5, 2018); Christian Red, *The Brains In Football: Meet the doctors trying to solve NFL's CTE issue*, <https://goo.gl/RpAuZL> (last visited Feb. 5, 2018); Khadrice Rollins, *Aaron Hernandez Had the Most Severe Case of CTE for Anybody Under 46*, <https://www.si.com/nfl/2017/11/09/aaron-hernandez-stage-3-cte-most-severe-case-his-age> (last visited Feb. 5, 2018).

145. Steven T. DeKosky et al., *Traumatic Brain Injury: Football, Warfare, and Long-Term Effects*, in 363 New England Journal of Medicine 1293 (2010); SCHAD, *supra* note 144.

146. David B. Arciniegas et al., *Mild traumatic brain injury: a neuropsychiatric approach to diagnosis, evaluation, and treatment*, in 1 NEUROPSYCHIATRIC DISEASE AND TREATMENT 311 (2005).

147. See Jane C. Moriarty, *Flickering Admissibility: Neuroimaging Evidence in the U.S. Courts*, in 26 BEHAVIORAL SCIENCES AND THE LAW 29, 48 (2008).

148. Fed. R. Evid. 403.

IV. ANDREW V. PATTERSON MOTOR FREIGHT¹⁴⁹: A CASE STUDY INTO THE TRENDING ADMISSIBILITY OF DTI

This section will first describe the general jurisdictional trends of admitting DTI evidence in TBI litigation. Using *Andrew v. Patterson Motor Freight* out of the United States District Court for the Western District of Louisiana as a brief case study, this section will analyze and explain this trend.

A. Courts are broadly admitting DTI evidence in TBI litigation

Despite falling short of evidentiary standards, DTI is overwhelmingly being admitted into evidence. Since 2005, at least sixteen jurisdictions have admitted DTI evidence in TBI litigation over objection. Interestingly, DTI evidence has been admitted in 70% of *Frye* jurisdictions,¹⁵⁰ compared to only 22.5% of *Daubert* jurisdictions.¹⁵¹ This stark difference demonstrates the advance in protection against inadmissible scientific evidence offered by *Daubert*. However, it is unwise to read too far into this data as it does not take into account cases that settle prior to judgment.

Andrew v. Patterson Motor Freight, a TBI case out of the United

149. *Andrew v. Patterson Motor Freight, Inc.*, 2014 U.S. Dist. LEXIS 151234 (W.D. La. 2014).

150. New York Supreme Court. *LaMasa v. Bachman*, 8 Misc. 3d 1001(A) *7 (N.Y. Sup. Ct. 2005); Civil Court of the City of New York. *Girgs v. Santagata*, 27 Misc. 3d 128(A) (N.Y.C. Civ. Ct. 2014); Minnesota District Court. *Wills v. Sullivan*, 2010 WL 4522737 (Minn. Dist. Ct. 2010); Minnesota District Court. *Hansen v. Crain*, 2011 Minn. Dist. LEXIS 160 (Minn. Dist. Ct. 2011); Minnesota District Court. *Nelson v. BNSF Ry.*, 2011 U.S. Dist. LEXIS 46208 (Minn. Dist. Ct. 2011); Minnesota District Court. *Nordstrom v. Fleet Farm of Menomonie, Inc.*, 10th Judicial District, County of Washington, Minnesota, File Number 82-CV-11-5842, (January 17, 2014); United States District Court for the Western District of Washington. *Shannon v. Columbia Basin R.R.*, 2013 U.S. Dist. LEXIS 11275 (W.D. Wash. 2013); Pennsylvania Court of Common Pleas. *Rotunda v. Petruska*, 2010 Pa. Dist. & Cnty. Dec. LEXIS 479 (Pa. Comm. Pl. 2013); Superior Court of California. *Gutcher v. Toyota Motor Sales, S-1500-CV-270351* (Cal. Sup. Ct. 2010); Superior Court of New Jersey. *Ferrante v. City of Atlantic City*, Civil Action No. ATL-L-1892-10 (N.J. Sup. Ct. 2014);

151. United States District Court for the District of New Mexico. *Booth v. Kit*, 2009 U.S. Dist. LEXIS 125754 *12 (D.N.M. 2009); Court of Appeals of Louisiana. *LeBoeuf v. B & K Contractors, Inc.*, 2009 La. App. Unpub. LEXIS 324 *42 (La. Ct. App. 2009); Michigan Circuit Court. *Rye v. Kia Motors America, Inc.*, No. 2007-701204-NP (Mich. Cir. Ct. 2010); Colorado District Court. *Whilden v. Kimberly Cline*, 2010 Colo. Dist. LEXIS 908 *1 (Colo. Dist. Ct. 2010); Superior Court of Massachusetts. *Zawaski v. Gigs, LLC*, 2010 Misc. Filings LEXIS 7669 (Mass. Sup. Ct. 2010); Superior Court of Massachusetts. *Wu v. Lauriat*, 2012 Mass. Super. LEXIS 243 (Mass. Sup. Ct. 2012); United States District Court for the District of Massachusetts. *Chiulli v. Newbury Fine Dining, Inc.*, 895 F. Supp. 2d 277 (D. Mass. 2012); Florida Circuit Court. *Hammar v. Sentinel Insurance Company, Ltd.*, Civil Action No. 08-019984 (Fla. Cir. Ct. 2010); Florida Circuit Court. *Sworin v. Harris*, 2014 Fla. Cir. LEXIS 27201 (Fla. Cir. Ct. 2014); United States District Court for the Northern District of Indiana. *Ruppel v. Kucanin*, 2011 U.S. Dist. LEXIS 67503 (N.D. Ind. 2011); Tennessee Court of Criminal Appeals. *Odom v. State*, 2017 Tenn. Crim. App. LEXIS 922 (Tenn. Crim. App. 2017); United States District Court for the Western District of Kentucky. *Roach v. Hughes*, 2015 U.S. Dist. LEXIS 67669 (W.D. Ky. 2015).

States District Court for the Western District of Louisiana, serves as a good case study of the current typical judicial approach to DTI evidence.¹⁵² In *Andrew*, the plaintiff alleged a TBI arising out of a motor vehicle collision with a tractor-trailer.¹⁵³ To support his claim of TBI, the plaintiff offered expert testimony from a neuroradiologist, Dr. Eduardo Gonzalez-Toledo.¹⁵⁴ Plaintiff underwent a DTI and Dr. Gonzalez-Toledo offered the DTI findings as evidence to support his expert testimony that the plaintiff sustained a severe TBI.¹⁵⁵ The Court admitted the DTI evidence offered by Dr. Gonzalez-Toledo over objection by the defense.¹⁵⁶

The defense raised several concerns in objecting to the DTI evidence.¹⁵⁷ First, the defense argued that Dr. Gonzalez-Toledo was not qualified to present DTI evidence as an expert because he was not boarded by a professional organization to garner recognition as a neuroradiologist.¹⁵⁸ Instead, the defense argued, he “self-selected” himself as a neuroradiologist.¹⁵⁹ Next, the defense presented several of the concerns mentioned in section III(b) regarding the scientific reliability of DTI used clinically in an individual case.¹⁶⁰

The Court rejected each of the defense’s arguments regarding Dr. Gonzalez-Toledo’s presentation of DTI evidence.¹⁶¹ The Court did not, however, address the concerns raised regarding the scientific reliability of DTI as evidence. Despite citing *Daubert* as the controlling standard,¹⁶² the Court did not fulfill the role as a gatekeeper by failing to consider these concerns. The Court’s primary reasoning was that the defense should raise these concerns to a jury on cross-examination of the expert witness, Dr. Gonzalez-Toledo.¹⁶³ However, with such complicated scientific evidence consisting of striking images and the considerable uncertainties associated with DTI, merely leaving these concerns for cross-examination significantly risks violation of Rule 403 by confusing or misleading the jury, as well as instilling unfair prejudice in the minds of jurors.¹⁶⁴ All scientific evidence can be as misleading as

152. *Andrew v. Patterson Motor Freight, Inc.*, 2014 U.S. Dist. LEXIS 151234 (W.D. La. 2014).

153. *Id.* at *2.

154. *Id.* at *11.

155. *Id.* at *22-*26.

156. *Id.*

157. *Id.*

158. *Id.* at *12-*13.

159. *Id.* at *12.

160. *Id.* at *22-*26.

161. *Id.*

162. *Id.* at *5.

163. *Id.* at *24-*26.

164. *See supra* section III(B).

it is powerful due to the difficulty involved in its evaluation. This risk of misleading a jury becomes exacerbated when the jury hears the plaintiff's expert presenting the DTI evidence and the defendant's expert opposing the clinical use of DTI, cross-examination of both of these experts aiming at tarnishing their credibility. Scientific evidence and expert testimony require additional judicial maintenance than lay testimony, as demonstrated by the adoption of the *Daubert* standard, and these 403 risks justify, at a bare minimum, more stringent judicial control over widely contested evidence such as DTI than what is being exercised currently.

V. CONCLUSION

Despite DTI clearly falling short of the evidentiary standards required for admissibility of scientific evidence, it is still being overwhelmingly admitted into the courtroom. Based on the trends of DTI being admitted, it seems as if *Daubert* is not serving its purpose in practice. Judges continue to deny *Daubert* motions to exclude DTI evidence, forcing the concerns with DTI to be presented to a jury on cross-examination and greatly increasing the risk of confusing the jury, misleading the jury, and unfairly prejudicing the opponent of the evidence.

The current sophistication and increasing popularity of TBI claims presents a significant challenge to courts in assessing the admissibility of expert testimony and scientific evidence. The development of advanced neuroimaging techniques such as DTI and the emergence of their use in litigation introduce an additional unique challenge to fulfilling the role of gatekeeper imposed by *Daubert*.