verdict
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by John C. Gardiner, PhD PE

Litigating Head Injury Cases and Understanding the Role of Motorcycle Helmets

Despite a mandatory helmet law in the State of California, questions often arise during forensic investigations concerning motorcycle helmets and their relationship to head or brain injury. Attorneys litigating cases in which such an injury is alleged to have occurred may face issues such as a plaintiff's comparative fault for not wearing an appropriate helmet or a helmet manufacturer's potential fault for failing to give proper instructions regarding the use of the manufacturer's product. In such circumstances, attorneys might find it useful to methodically break down the factual analysis, and examination of witnesses according to this simple line of reasoning:

- Was a helmet being worn?
- Was the helmet approved for motorcycles? and
- Would a helmet (or better helmet) have reduced the injuries?

Though each case is different, the analytical approach is often similar. First, the motorcycle helmet that the plaintiff was wearing (or claims to have been wearing) at the time of the accident is examined along with and the motorcyclist's injury information. This information is combined with data from the scientific literature and possibly full-scale impact tests to answer each of the three questions.

Was a helmet being worn?

Although helmet use is frequently documented by witnesses and/or responding emergency personnel, many cases do occur in which helmet use is ambiguous. Most analyses begin with a detailed inspection of the helmet and a thorough review of the motorcyclist's medical records. Both sources yield valuable information needed to determine if the helmet was worn.

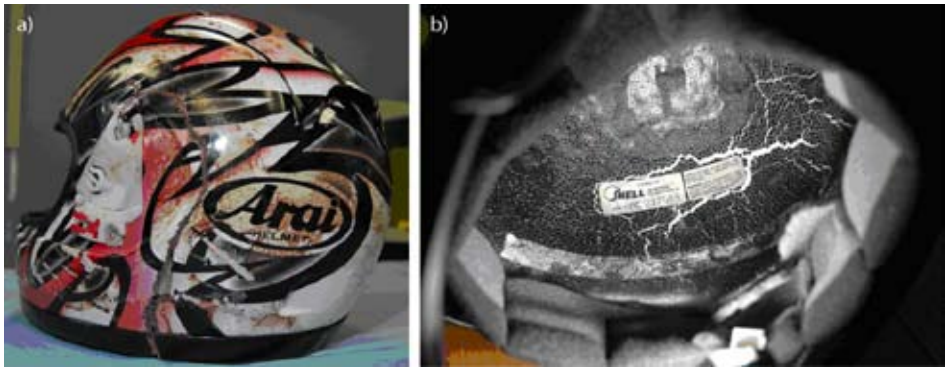

Figure 1. Typical motorcycle helmet (a) exterior and (b) interior damage following an impact.

The helmet inspection focuses on the three layers of a typical helmet: the shell, the energy-absorbing liner, and the comfort liner. The shell is the hard exterior of the helmet and is often made of fiberglass or a polycarbonate compound. Its job is to provide structure to the helmet, slide along the road surface without catching, and resist penetration. Typical damage to the shell includes scratches to the paint and cracks to the shell itself *(Figure 1a)*. Immediately inside the shell is usually an energy-absorbing liner. Some non-approved helmets do not have an energy-absorbing liner. The energy-absorbing liner is made of polystyrene—the same material used for Styrofoam coffee cups, though of better quality and higher density. Damage to the energy-absorbing liner usually consists of cracks or crushing *(Figure 1b)*. The comfort liner is the innermost layer and generally consists of soft form-fitting foam lined with a durable fabric. Its role is to make the helmet comfortable, although blood or tissue left on the liner may provide important clues regarding helmet use.

From the medical records, the type and location of the head injuries sustained by the motorcyclist are determined. As with helmets, the head can be viewed as a structure with three layers: the tissues outside the skull (called extra-cranial tissues), the skull itself, and the brain. Injuries to the extra-cranial tissues include lacerations, abrasions, contusions and localized swelling. Although extra-cranial swelling can be very important for determining helmet use and the site of head impact, extra-cranial swelling is rarely mentioned in radiology reports due to the limited clinical significance of extra-cranial injuries relative to injuries to the brain and skull. As a result, it is often valuable to have films (particularly CT or MRI scans) reviewed by a radiologist specifically for extra-cranial trauma. Skull injuries are usually fractures and vary from linear fractures spanning a wide arc to small depressed fractures from concentrated loading. Some fractures can occur away from the head impact site, and therefore the fracture site does not necessarily indicate impact site. Brain injuries include primary neural tissue damage (e.g., contusions or diffuse axonal injury) and secondary damage (e.g., brain damage from a ruptured artery). Other than some contusions, the location of the brain injury alone is often not helpful in isolating the direction or site of the head impact.

Armed with knowledge of both the helmet

MEA Forensic Engineers & Scientists Inc, 23281 Vista Grande Drive, Suite A, Laguna Hills, CA 92653
T:949 855 4632 1 877 855 5322 F: 949 855 3340 www.meaforensic.com

damage and the head injury, the two can then be compared to see what does and does not match. Specifically, we look for injuries that are either consistent or inconsistent with helmet use, and helmet damage that is either consistent or inconsistent with helmet use. Two examples will help clarify the process.

A simple case involves a rider with a large horizontal laceration above his right ear following a crash. This area of the head is covered by all approved helmets and would not normally be exposed to a laceration if the rider was wearing a helmet. The lack of scratches on the shell of the helmet the motorcyclist claimed to be wearing, combined with the absence of blood on the comfort liner, indicates that the helmet was likely not being worn at the time of the crash.

A more complicated case involves a damaged helmet found some distance from the motorcyclist following a crash. The motorcyclist was unconscious at the scene and was ultimately diagnosed with a closed head injury despite no definitive radiological findings. We were initially asked how the head injury was caused and whether a helmet would have prevented the injury; however, the question in this case ultimately boiled down to whether the helmet was in place when the injury occurred. Inspection of the energy-absorbing liner showed a compressed and cracked liner immediately inside a cracked area of the shell. This evidence indicated a relatively large impact to the helmet with the head still inside the helmet. Combined with no medical evidence suggesting more than one head impact, it appeared that the helmet had come off during the crash, but after an impact that could have caused the head injury. Since the helmet strap was not damaged, it appears that the helmet was worn but was likely not properly fastened at the time of the collision.

These are just two ways that helmet use can be assessed from the evidence reviewed after a crash. Clearly, all cases require an individual evaluation.

Was the helmet approved for motorcycles?

Identifying if a helmet is approved for motorcycle use should be as simple as looking for an "approved" label in or on the helmet. Unfortunately, it is not.

There are four common types of helmets seen on motorcyclists in North America. They are full-face helmets, open-face helmets (or three quarter shell), shorty helmets (or half shell) and beanie helmets (or skullcap style or German Army style) *(Figure 2)*. Both the type of helmet and the helmet construction and performance dictate whether a helmet is approved for motorcycle use. An approved helmet must cover a minimum prescribed area of the head, have both a shell and an energy-absorbing liner, and pass a series of tests (e.g., environmental, retention and impact tests). The specific test criteria vary with the intended use (e.g., football, horseback riding, bicycle, motorcycle, etc.) and the criteria for motorcycle helmets is the most demanding. If a helmet meets these criteria, it can be labeled as an approved helmet. Labels from either the US Department of Transportation (DOT) and/or the Snell Memorial Foundation (Snell) are placed on the inside and outside of the helmet *(Figure 3)*.

Although the presence of a DOT and/or Snell label on the helmet is supposed to signify an approved helmet, fake DOT and Snell decals are readily available and are even sold on eBay®. Although one eBay® seller states, "These stickers are a novelty item and not to be used to circumvent any laws regarding safety equipment," this quote provides a pretty clear picture of how these stickers are being used. It is therefore important that the helmet be thoroughly examined—independent of any labels—to ensure it is an approved helmet.

Figure 2. Four common motorcycle helmet styles: a) beanie or skullcap, b) shorty , c) open-face, and d) full-face.

Non-approved helmets, also referred to as beanies, skull caps, or novelty helmets, have been estimated to make up about 10 percent of the helmets in locations where they are illegal. Non-approved helmets have been reported to produce head injuries more than twice as frequently and twice as severe as approved helmets, a finding that leads into the next question.

Would a helmet (or better helmet) have reduced the injuries?

The hard outer shells of motorcycle helmets prevent lacerations and abrasions to the extra-cranial tissues covered by the helmet. The combined shell and energy-absorbing liner prevent many skull and brain injuries by distributing the impact over a larger area of the head and decreasing the peak acceleration experienced by the head. As the energy-absorbing liner crushes during an impact, it molds to the head (generating a larger contact area) and extends the time the impact force is applied to the head (reducing the peak acceleration experienced by the head).

Since all motorcycle helmets—approved and non-approved—have a shell, they can all prevent some injuries to the extra-cranial tissues. Full-faced helmets cover more of the head than shorty or beanie helmets, and therefore protect larger areas of the head from lacerations and abrasions.

The energy-absorbing capacity of the liner is what really differentiates helmet quality. Beanie style helmets with no energy-absorbing liners provide essentially no impact attenuation. Recent motorcycle helmet drop-testing performed by our company has shown that while most approved helmets keep head accelerations below 300 g during drop tests from about 10 feet, beanie helmets can exceed 300g after dropping only 7 inches. This low drop height equates to an impact speed of only 4 mph—considerably less than the head impact many

motorcyclists are likely to experience in a crash. This means that motorcyclists wearing beanie helmets are putting themselves at greater risk for head injuries in all crashes, even those that would be considered minor.

Amongst approved helmets, some helmets provide impact attenuation well-above the levels required by the standards *(Figure 4)*. The performance of other approved helmets deteriorates rapidly above these standard levels. This decrement in performance appears to be related to a full compression or "bottoming out" of the energy-absorbing liner during the impact and will likely occur in all helmets at some impact severity.

The ability of helmets to reduce the severity of head impacts during a crash naturally leads to questions of whether a helmet would have reduced the head injury severity of a rider who was not wearing a helmet, or whether an approved helmet would have reduced the head injury severity of a rider who was wearing a beanie style or other non-approved style helmet. To answer these questions, the exposure of the head during the actual crash is compared to the exposure had the rider been wearing an approved helmet. If an approved helmet reduces the peak head acceleration below the tolerance level of the injury sustained by the rider without a helmet or with a non-approved helmet, then it can be concluded that an approved helmet would have prevented the injury.

To conduct this type of helmet analysis, the speed at which the head and helmet struck the ground or some other object during the crash generally needs to be known. To obtain this speed information, a reconstruction of the crash often needs to be performed before helmet effectiveness may be analyzed.

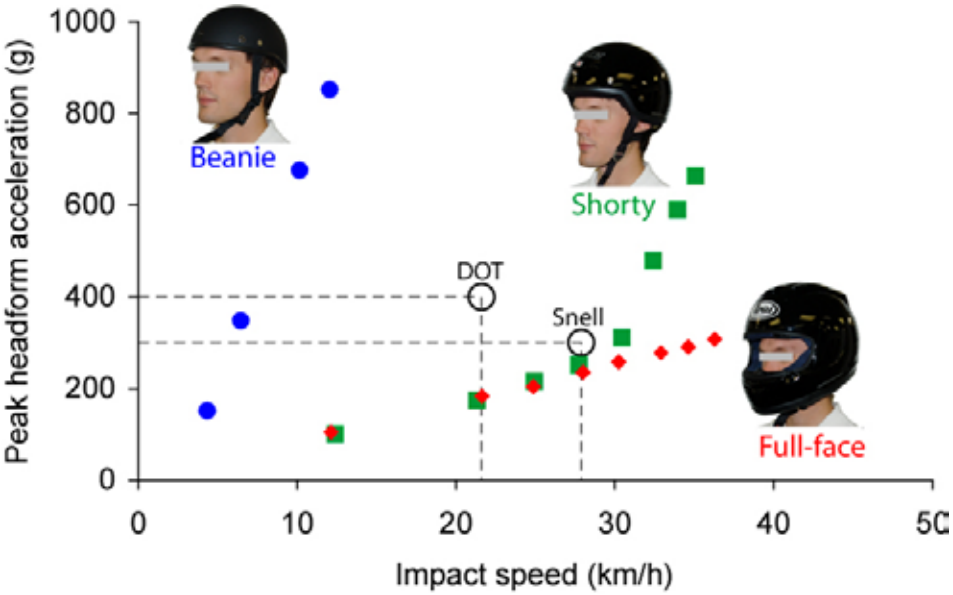

Figure 4. Helmet performance at various impact speeds. The dashed lines indicate the impact performance requirements of the DOT and Snell standards.

Once the crash is reconstructed, the exposure of a rider's head in a collision can often be obtained from published test data or peer-reviewed literature; however in some cases, it can only be obtained through case-specific testing. As part our company's ongoing helmet research, the permanent deformation of the energy absorbing liner was measured after each test impact. The preliminary findings of the study indicate that there is a helmet-specific relationship between impact speed and the depth of permanent foam deformation. This result is encouraging as it indicates the severity of a helmet-to-surface impact can be determined after a collision through careful documentation of the helmet damage. Further research into this assessment technique is ongoing.

Conclusion

Motorcycle helmets can prevent brain, skull and superficial injuries to the head. Not all motorcycle helmets, however, provide equal levels of protection. By examining the helmet, reviewing the motorcyclist's medical records, reconstructing the impact exposure, and relying on published and case-specific test data, liability questions that arise regarding helmet use, compliance, and injury reduction potential can be answered.

John Gardiner, PhD PE, is a member of the Injury Biomechanics group in the Orange County office of MEA Forensic Engineers & Scientists. Dr. Gardiner conducts investigations to assess injury mechanics in cases involving automobile collisions, falls, and sports injuries.

Figure 3. Examples of motorcycle helmet labels that are put on helmets to indicate that the helmet meets a particular standard.