



UNDERSTANDING HEAD AND NECK TRAUMA

Or, why helmets *increase* the danger!

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HEAD AND NECK TRAUMA

Trauma is a type of injury which effects the body by external force being applied in a violent and sudden manner. When dealing with motorcycle accidents, it's important to understand the types of forces which a rider is subjected to, the body parts affected by these forces, and how the body reacts to certain inertia or 'g-forces'.

It has been suggested by NHTSA that helmets might prevent neck injury. This was prompted by testimony before the Tennessee Transportation Committee when I stated that helmets could cause cervical spine injury due to their weight. In order to rebut these remarks, a regional spokesman for NHTSA testified that more people receive neck injury without a helmet than those wearing helmets. Therefore, he concluded, without any foundation or authorities, that helmets might prevent neck injury. This of course is utter nonsense.

First, let's define the different types of trauma.

- 1. Penetrating trauma
- 2. Blunt trauma
- 3. Acceleration/deceleration trauma

Penetrating trauma is an object entering the body or head due to an object striking the body, or the body being placed in motion and striking an object which then penetrates the body.

Blunt trauma occurs when an object strikes the body or head with force causing a compression of body tissues which results in injury.

Acceleration/deceleration trauma occurs when the body is moving and strikes

another moving or stationary object. This results in a change of motion for the body, or a complete stop of motion, which causes stretching and tearing of body tissues.

When considering the way the FMVSS 218 standard tests helmets, it's clear that these tests in no way simulate an actual crash situation. The headform in the helmet has no neck or neck sensors and the helmet is stationary with a weight dropped on it (compression) from an elevation.

To properly simulate a crash, a full form human crash test dummy should be used (or perhaps the regional spokesman for NHTSA), whereby the dummy is moving at a certain speed and then comes to an abrupt halt or strikes a stationary object (acceleration/deceleration).

'G-Forces'

'G-forces' are what determines the extent of injury to the head or neck in many motorcycle accidents. When a body is stopped (due to crashing into a stationary object) or is hurled into space with a three pound helmet flexing the neck, the force of gravity causes the body to weigh many times its actual weight. For example, a male human head, without helmet, weighs about 10 pounds. If subjected to 10 'G's', that head briefly weighs about 100 pounds, passing that stress and load onto the neck. Consider adding a 3 pound helmet, and you begin to appreciate the forces your neck has to contend with.

Going a little further, using a full form human dummy, developers of the Head and Neck Support (HANS) device found that the head briefly experiences 25 'G's' and weighs about 250 pounds in a 35 mile-per-hour impact. With those forces in play, the delicate human brain bounces around in side the skull (coup/contrecoup) with a force equal to weighing 75 pounds. A normal brain weighs about 3 pounds. Combined with this is the fact that the rotation of the head and neck during one of these crashes causes severe tearing and stretching of the tissues of the brain and brain stem. No helmet can prevent this collision of the brain within the skull.

It has been suggested that race car drivers exceed speeds of 200 miles-per-hour and walk away from crashes because they had a helmet on. Again, this is a half-truth, manipulated statement by pro-helmet forces. the truth is race cars are no longer built out of strong, resilient materials. Modern technicians have

learned that in order to protect the driver, the race car must crush and disintegrate during a crash. This allows for a more gradual, extended period to distribute the force of the crash and decelerate the 'G's'. With a deformable structure construction, akin to airplane design, the chassis and body of the car takes up most of the 'G' forces, according to Rick Amabile in his book, *Inside Indy Car Racing: 1990*. Besides the chassis design, the internal cockpit of the cars is better designed also. Direct blows to the driver are minimized through a safety system integrating a seat angled backwards at 45 degrees and a six-point safety harness system. The weak link in this equation, again, is the neck.

The neck was listed on 31.5 percent of incident reports in races. The Sports Car Club of America (SCCA) performed some analyses on their races and found 17 percent of the injuries sustained were neck injuries. This led to the development of the HANS device, which supports the head and neck, helping prevent whiplash and rotational injuries. This device was developed by Biomechanical Design Inc., of East Lansing, Michigan. The importance of this type of device becomes very evident when one considers that according to one of the nations largest insurers of motorsports events, North American Racing Insurance (NARI), 93 percent of all driver injuries were caused by direct blows or sudden, twisting, deceleration forces applied to the body.

The mere fact that a racer is wearing a helmet has little or no impact on his survivability without the other safety engineering factors in place. With a complete safety engineered race car, the National Safety Council puts driving one of these units in the same hazard range as swimming and alpine skiing. In fact, according to their charts, a modern race car driver is at less risk than a scuba diver or mountain climber, and much less at risk than a parachutist or hang glider.

The problem with motorcycle design is we don't have the safety cockpit that would afford us the room and time for a disintegrating chassis to take up the 'G-forces' for us. And we don't have anything padded in front of us to reduce the loads reaching our neck, such as a break away steering wheel or padded dash panel. To say race car drivers walk away from crashes because they wear helmets is absurd. Several Indy car racers recently died of closed skull trauma to the brain, due to the exact twisting and tearing actions we said were caused by acceleration/deceleration, which helmets cannot protect against. Yet we don't hear NHTSA explain or comment about these cases.

According to SCCA data, the neck is the most often injured body part (31.5 percent), followed by the back (19.5 percent), and then the head (15.8 percent). Severe centrifugal forces exert tremendous shearing pressures on the brain.

This causes the brain to impact on the inside of the skull, or tear at the medulla at the brain stem. Developers of the HANS used crash test dummies in their testing procedures and found the head can briefly encounter 25 'G's', amounting to about 250 pounds, in a 35 mph impact. Gravitational forces are dependent on speed, and a doubling of speed quadruples the 'G-forces'.

To determine the number of 'G-forces' in a collision, the formula is:

$G's = .0333 \times (M.P.H. \times M.P.H.) \div \text{Distance}$. In other words, multiply the square of the vehicle's speed, in mph, times .0333 and divide it by the stopping distance in feet. This is for a direct, head on collision, and the formula is more complex in angular collisions due to the fact that the kinetic energy is expanded over a longer period of time, resulting in lower 'G-forces'.

Collision, collision, collision

There are actually three collisions occurring in a crash:

- 1. Vehicle vs whatever it contacts with
- 2. body vs whatever it contacts with
- 3. body tissues and organs vs body tissues and organs

Once your vehicle strikes another object, you have suffered a collision. At that point your body is slammed into some stationary or moving object, or perhaps ejected and is thrown to the ground. At that point, your internal organs, including the brain, began a collision course of their own. Brain injury can occur without any impact to the head, whether helmeted or not. If the body comes to a sudden stop, including the head and skull, the brain continues to move and slams into the inner skull wall. Brain tissue and blood vessels can shear in this violent, twisting action. The skull, even without a helmet, can withstand hundreds of 'G's', but the brain cannot. Other internal organs, especially the heart and aorta, are subjected to these tremendous forces, and often rupture or tear. To give a graphic example, a 160 pound man will strain at his seat belt with a weight of 6,400 pounds at a 40'G' deceleration. Now you might understand why so many people die from ruptured or torn aortas in crashes. There is basically little connective tissue to anchor the heart, since it has to palpitate and move during its rhythmic beating.

'G-Force' Tolerance: Head vs Neck

It is believed that the head can withstand 300 'G-forces', which is higher than other body parts. The deceleration of 'G-forces', movement of the head and duration of the incident all determine the amount of injury the head will sustain. It is common to have skull fracture and no brain injury, and brain injury and no skull fracture. Helmets are designed to distribute the force of the impact over a wide surface in order to reduce the amount of 'G-forces' reaching the brain. The force of inertia in a crash can cause brain injury even without an impact to the head, thus a helmet cannot protect against this event. Brain tissue and blood vessels can be torn by inertia when the head rotates, common occurrence amplified with helmet use. The weight of the head and helmet pulling at the neck can be sufficient to fracture the skull. Known as basal skull fracture (hangman's noose analogy), these injuries can often be fatal.

According to NARI, the neck is the most often injured body part in their studies. This might account for the fact that the NHTSA regional spokesman said there are more neck injuries without helmets than with, thus leading him to his erroneous conclusion that helmets might prevent neck injury. Tests using human cadavers found that the neck can tolerate about 42 foot-pounds of backward whiplash force before injuries began to occur. The muscles in the rear of the neck are stronger than those in the front, thus a forward rotating head will allow the neck to withstand about 140 foot-pounds of force. Of course, these are ideal positions, direct forward or backward movement. In a real crash, the head is bounced in all sorts of directions, and the neck is less tolerant of sideways acceleration/deceleration. In these instances, the neck can handle about 33 foot-pounds of force.

How strong is the unhelmeted head? The amount of force a head can withstand depends on several factors, including the location of the impact, the size of the object striking the head and the density of the individual's bone tissue. The frontal bone (forehead) can withstand on average, 1,000 to 1,600 pounds of force. The temporo-parietal (sides of head) bones can tolerate around 700 to 1,900 pounds of force. The back of the skull can handle around 1,440 pounds of force. The bones of the face and cheek are less tolerant, standing forces of only 280 to 520 pounds.

Remember, the brain cannot withstand the same forces the skull can, and even a helmet cannot prevent dangerous forces from reaching the brain or the brain moving within the skull cavity.

When we said that the forward rotating head can transmit energy loads to the neck, and the neck can tolerate about 140 foot-pounds of force? Well, when the engineers conducted tests on their HANS safety restraint system, they used a full human form crash test dummy. With the HANS restraint system in place, the dummy was held in position during a frontal impact collision, resulting in neck loads under 130 foot-pounds. When tested without the restraint system in place, the dummy's head rotated forward in the simulated 40 mph test collision, and the neck received loads of nearly 1,000 foot-pounds. The dummy was helmeted, and I suggest that if the spokesman for NHTSA really believes helmets can prevent neck injury, he climb onto the test sled, put on a helmet and see how his neck handles 1,000 foot-pounds of pressure.

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