Helmet Protection Systems

Rotational Brain Injuries

Mips

March 2021

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Is Rotational Injury An Industrial Risk?

- There are two types of forces the brain can be exposed to at an impact a translational (linear) force and a rotational force
- The majority of traumatic brain injuries sustained are caused by rotational forces
- Both perpendicular and oblique impacts can give rise to rotational motion that causes brain injuries
- The most common accident type on a construction site, resulting in a traumatic brain injury, is the fall of a person not a falling object
- The most frequent accident leading to severe brain injuries is fall from one level to another
- 90% of diagnosed concussions do not involve a loss of consciousness

*All data gathered via Mips and Tozuda

Where Is The Risk

- Construction
- Utilities
- Transport and Infrastructure
- Manufacturing
- Chemical, Oil and Gas

Everywhere!

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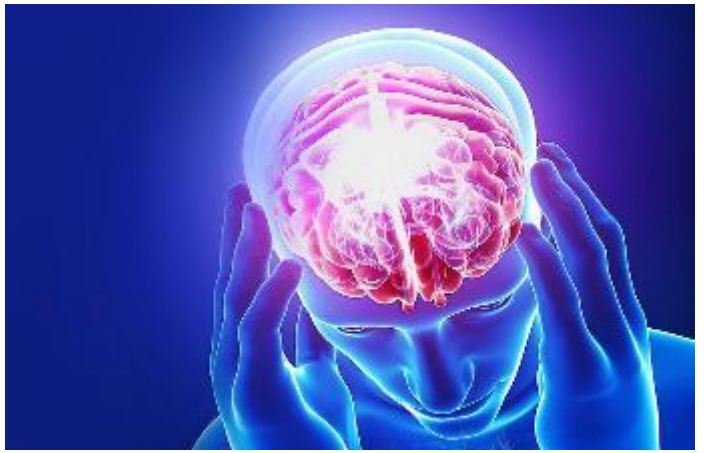
What Is Rotational Acceleration Injury?



A rotational brain injury is the result of a rapid change of the rotational velocity of the head. This rapid change of the rotation of the head can be caused by a direct hit to the helmet or the skull or by an indirect hit to the shoulder leading to a rotational motion of the head. Linear acceleration injuries result from straight line forces that compress or stretch the brain within the skull. In contrast, rotational acceleration injuries result from non-linear forces that twist/shear the brain within the skull* Brain tissue deformation, hence damage is mainly caused by shear rather than compression or tension due to its mechanical properties. Therefore, most traumatic brain injuries are caused by rotational acceleration.

Although linear acceleration injury and rotational acceleration injury can often occur together, there are some important differences. Linear acceleration injury is often associated with focal brain injuries, whereas rotational acceleration injuries more commonly involve both focal and diffuse brain injury*

*Holburn, A. H. S. (1943). Mechanisms of head injury. Lancet, 245, 438–441

Brain Injuries An Explanation?

The principal mechanisms of Traumatic Brain Injury are classified as

(A) Focal brain damage due to contact injury types resulting in contusion, laceration, and intracranial haemorrhage or*

(B) **Diffuse brain damage** due to acceleration/deceleration injury types resulting in diffuse axonal injury or brain swelling*

The Outcome from head injury is determined by two substantially different mechanisms/stages:

(A) The primary insult (primary damage, mechanical damage) occurring at the moment of impact or*

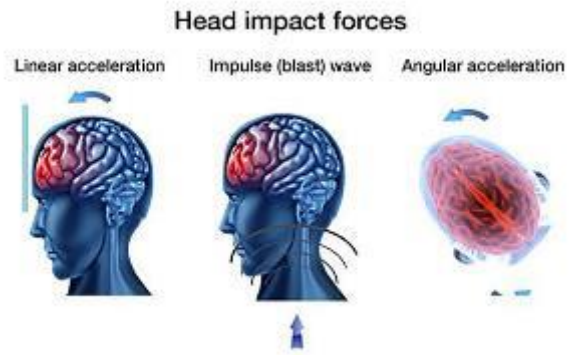
(B) **The secondary insult** (secondary damage, delayed non-mechanical damage) represents consecutive pathological processes initiated at the moment of injury with delayed clinical presentation*

Traumatic brain injury (TBI) still represents the leading cause of morbidity and mortality in individuals under the age of 45yrs in the world*

*Oxford Academic BJA - Pathophysiology of traumatic brain injury

So Can Dropped Objects Cause A Rotational Injury?

To answer this we need to first consider that when an object falls, does it fall straight down? The answer is of course no as its descent is normally affected on its way down, only in very rare cases would it not be effected in some way. Dropped objects fall into 2 categories these are:



Static Dropped Object
Any object that falls from its previous position under its own weight (gravity) without any applied force

Dynamic Dropped Object
Any object that falls from its previous position due to an applied force. For example, a brick falls but hits the scaffolding or re-bounds off some hoarding. This is more common

So that's the first bit answered

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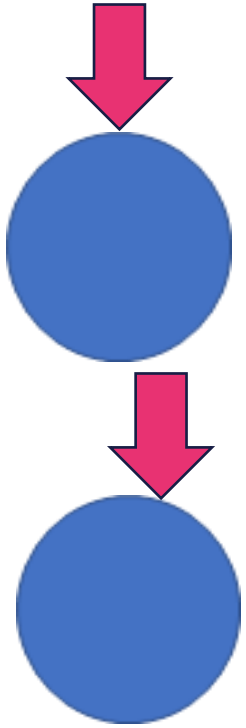
So Can Dropped Objects Cause A Rotational Injury?

So lets consider……when the object hits you what happens?

The impact is perpendicular and strikes you square on the top of your safety helmet….



The hit is dead centre, there will be very limited rotational forces (if any) to the head/brain

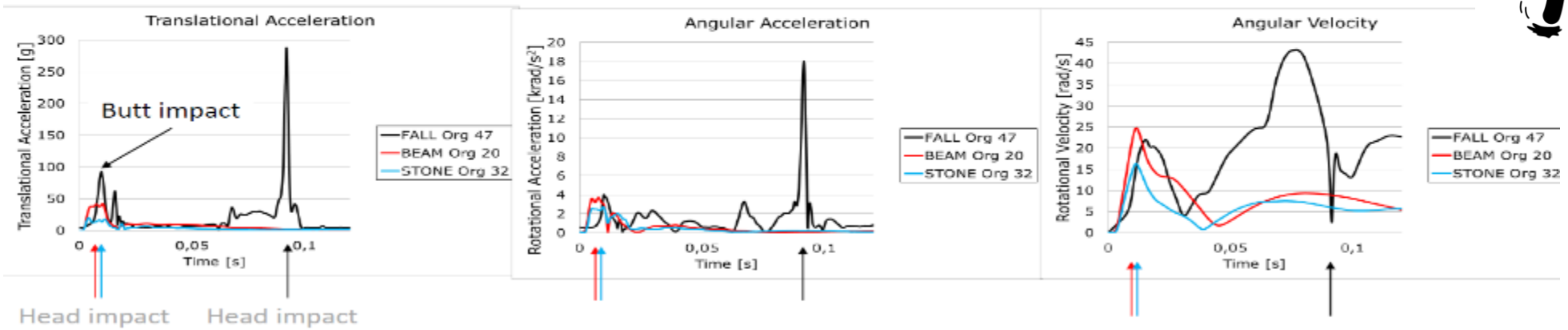
The hit is off centre (in any direction), now rotational forces are introduced to the head/brain.

So lets now look at falls

What Happens When You Fall Wearing A Hard Hat?

It is almost nine times more frequent to acquire a long-term injury from a fall than to get the same injury outcome from a falling object
So we can understand more we need to look at the acceleration in three impact scenarios

Experimental results from the different impacts



Head impact for **beam** and **stone**

Head impact for **fall** accident

The brick was dropped from 3.7m and weighed 4kg.
The fall is **only** from 1m above ground

What Happens When You Fall Wearing A Hard Hat?

From this we can see that the helmet does help slightly and if it had a liner inside maybe a bit more but the translational acceleration, angular acceleration and angular velocity are very high leading to an increased risk of rotational brain injury due primarily to the fact that the impact may have been oblique rather than perpendicular or a combination of both

So what is a perpendicular impact?

This is a direct/straight impact of which the linear kinematics motion will be the exact opposite direction, this is the typical EN397 test.

So what is an Oblique impact?

An oblique impact simply makes contact at an angle and of which the kinematics motion will include a rotational element

Lets look at an illustration that will help to explain this

What Happens When You Suffer Head Trauma

Falls From The Same Level or One Above

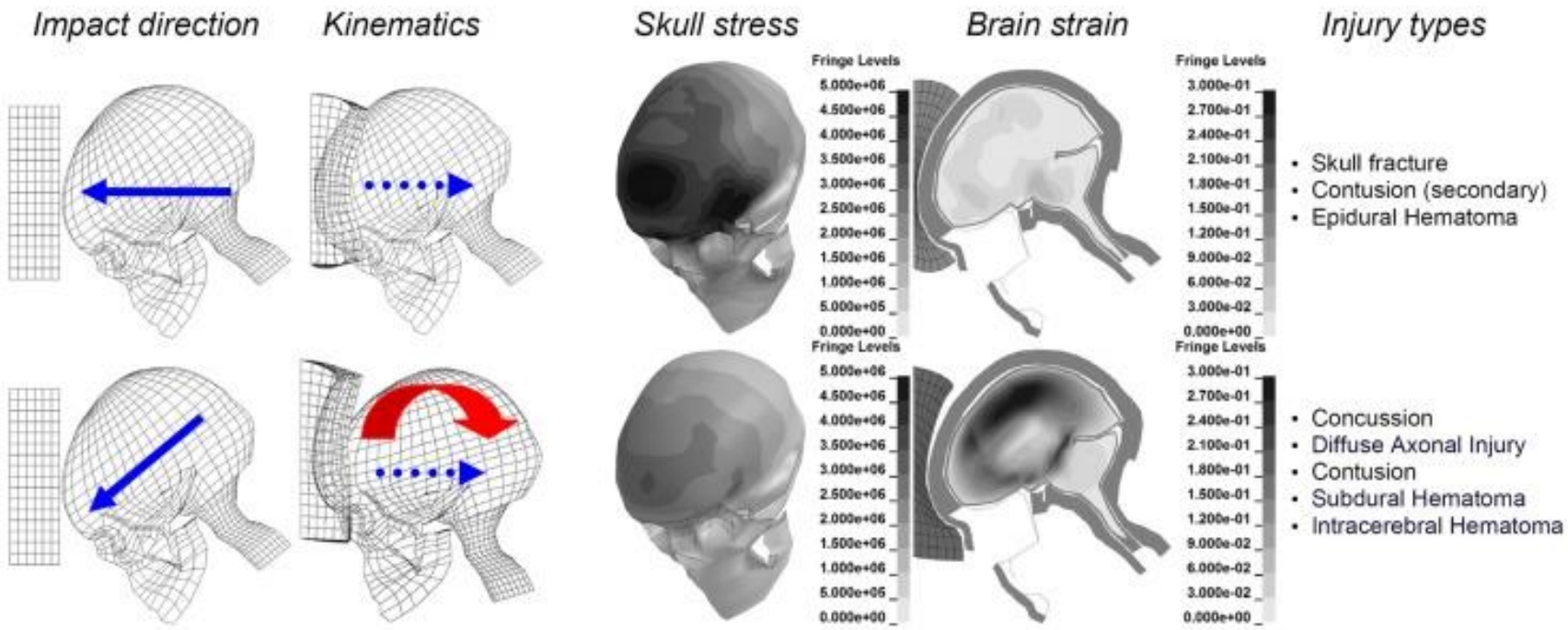


Illustration of the biomechanics of an oblique impact (lower), compared to a corresponding perpendicular one (upper), when impacted against the same padding using an identical initial velocity of 6.7 m/s

*Linear kinematics involves the shape, form, pattern, and sequencing of linear movement through time, without reference to the forces that cause or result from the motion

So What Does This Mean For Safety Helmets?

Safety helmets are fairly good at absorbing linear impacts, such as the EN397 impact test. If the safety helmet you are wearing has a liner then this is improved slightly. The problem arises when you have an impact and experience rotational acceleration. The helmet then slides across the head grabbing the skull and rotating it along with the directional force of the impact. This can of course as we discussed earlier not only occur as a result of slips, trips and falls from the same level or one above but also from dropped objects striking you. This can include side swipes from machinery say a digger operator turning suddenly and striking you with the bucket.

So why have I not heard about this before?

The foundation for understanding human behaviour and brain injury can be attributed to the case of Phineas Gage (1848) and the famous case studies by Paul Broca. The first case study on Phineas Gage's head injury is one of the most astonishing brain injuries in history. As time has passed we have learnt more and more of not only how the human brain functions but how it behaves under stress and of course during and after impacts. This coupled with an understanding of safety helmets and their behaviour in impacts has brought us to this point.

We must of course also consider…..

When An Incident Has Occurred What Is The Effect On Our Mental Health

While an incident can cause horrific physical injuries, it also can inflict serious psychological damage. In addition to chronic pain and scarring, workers also might experience depression, anxiety and other psychological symptoms

So Let's Summarise?

The majority of traumatic head injuries that people sustain are caused by rotational forces that are commonly generated as a result of the helmeted head of a person having a glancing oblique or perpendicular impact with a hard surface or another unrelenting object

For impacts involving a pure translational force, the helmeted head of the person undergoes rapid acceleration or deceleration movement in a straight line without rotating about the brain's centre of gravity which is located in the pineal region of the brain (Halliday, 1999). Those Such forces, helmets are well designed for and the brain is fairly well designed to absorb these without being damaged.

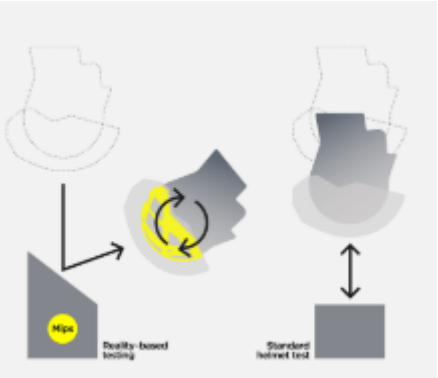
For impacts involving a rotational force, the helmeted head undergoes rapid rotational acceleration or deceleration about the brain's centre of gravity. The majority of impacts involve a combination of translational and rotational forces and as a result the head will rotate around its point of articulation
Remember Newton's 3rd law of motion for every action there will be an equal or opposite reaction

So how can we reduce the risk?

Redirecting rotational energies

This risk was established a while back by a company called Mips who is very well known in the sport industry and whose vision is to **Reduce head injuries, Save more lives**

Centurion Safety Products and Mips have partnered to develop the worlds first Multi-directional Impact Protection System for an industrial helmet that has a cradle.



For certain impacts this can help redirect harmful rotational forces that are otherwise transferred to the head in the event of an incident.

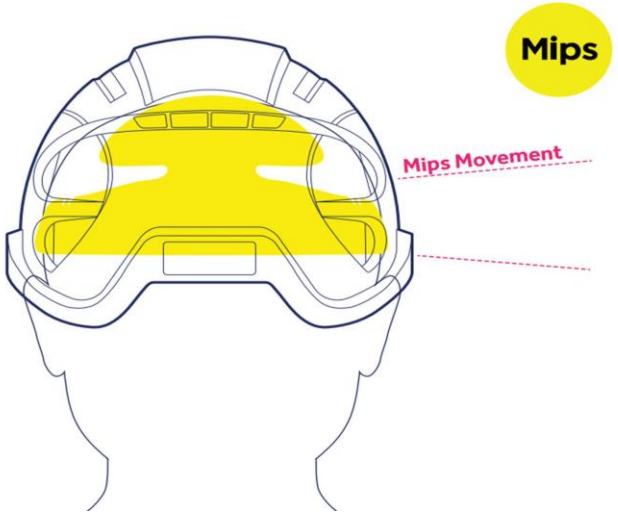
Injury statistics show that when you fall and hit your head, it's most common to fall at an angle, compared to a linear fall.

Falling at an angle creates rotational motion and science has shown that our brains are very sensitive to rotational forces. In an angled impact, these forces may transfer to your head. The Mips Low Friction Layer can redirect rotational motions.

So how does it work?

Redirect rotational energies

The human brain is amazing but fragile. During an angled impact, rotational motion can cause strain to the brain tissue, which may lead to severe brain injuries. When you have suffered concussion or even more serious damage to the brain, rotational motion to the brain is the most likely cause.



The Mips Low Friction Layer allows the head to move inside the helmet (10mm – 15mm relative motion in all directions) which can redirect the harmful rotational motion otherwise transferred to the head.

Questions?

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