Mips

TECHNICAL BULLETIN

ROTATIONAL HEAD INJURY AND MIPS

140
A BRITISH BRAND
SINCE 1879

CENTURION®
WHEN CLARITY COUNTS

INTRODUCTION

Safety helmets and hard hats have been protecting people for thousands of years. They were first seen around 2500BC protecting soldiers from sword blows or arrow strikes but became much more common around 900BC when they were worn by Assyrian soldiers and made of thick leather or bronze. Nowadays, these common place (more often plastic) items offer you protection from impacts whilst at work or play. However, as we begin to understand head injuries and their mechanisms more, we are increasingly asking ourselves the question, is this protection alone good enough? 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 on not only how the human brain functions but also how it behaves under stress and of course during and after impacts. This coupled with an understanding of safety helmets and their behaviour when struck has brought us to this point.

IS ROTATIONAL HEAD INJURY A REAL RISK?

To understand this let us look at some key facts: -

- There are two types of forces the brain can be exposed to at an impact a translational (linear) force and a rotational force.
- Most 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

WHAT IS ROTATIONAL BRAIN 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*

SO, CAN DROPPED OBJECTS CAUSE A ROTATIONAL HEAD 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 is it not affected in some way. Dropped objects reside in 2 categories:

Static Dropped Object

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

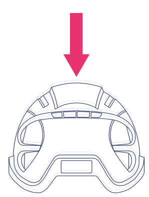
Dynamic Dropped Object

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.

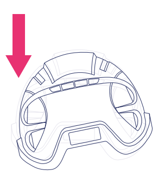
So that is the first bit answered.

So, let us consider what happens, when a falling object hits someone whilst wearing a hard hat?

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.

WHAT HAPPENS WHEN YOU FALL WHILST 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. When it comes to falls, wearing a safety helmet does help reduce the impact, and if that helmets has a liner inside it might further reduce the chance of injury. However, the translational acceleration, angular acceleration and angular velocity are normally very high in fall situations and can lead to an increased risk of rotational brain injury due to the fact that the impact may have been oblique rather than perpendicular or a combination of both.

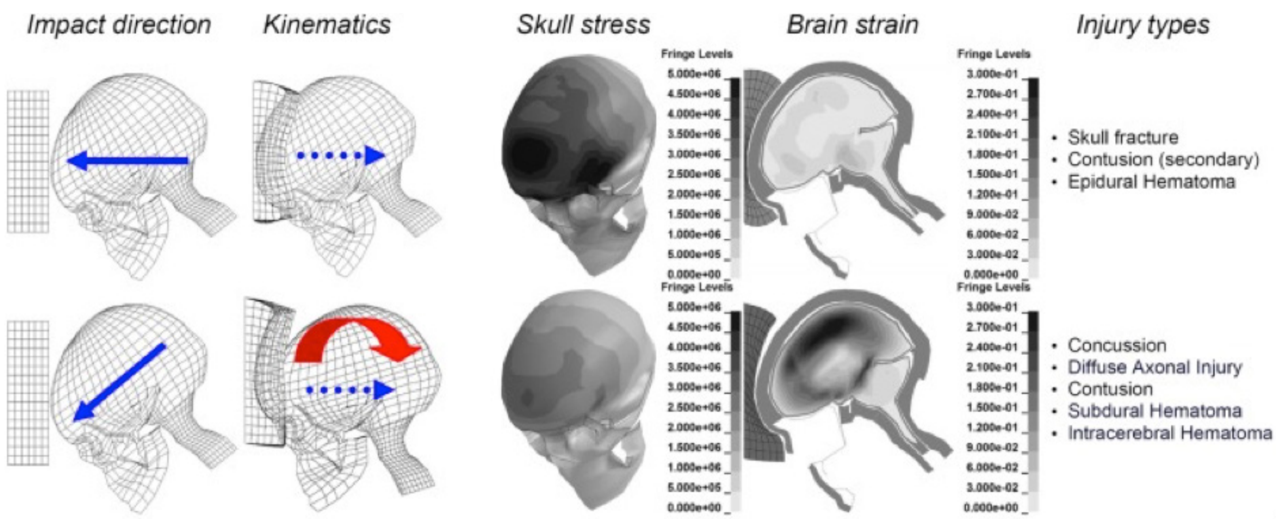


Illustration of the biomechanics of an oblique impact (lower), compared to a corresponding perpendicular one (upper), when impacted against the same padding using an identical initial velocity of 6.7 m/s (Kleiven 2007)

SO, WHAT DOES THIS MEAN FOR SAFETY HELMETS?

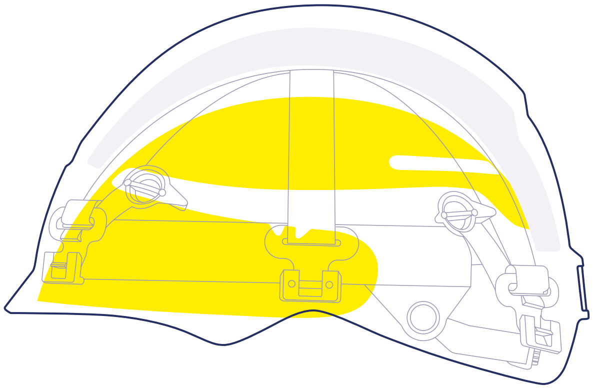
Safety helmets are relatively good at absorbing linear impacts, such as the EN397 impact test. If the safety helmet you are wearing has a liner, then this is improved slightly. The problem arises when you have an impact and experience rotational acceleration. The helmet then slides across the head grabbing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

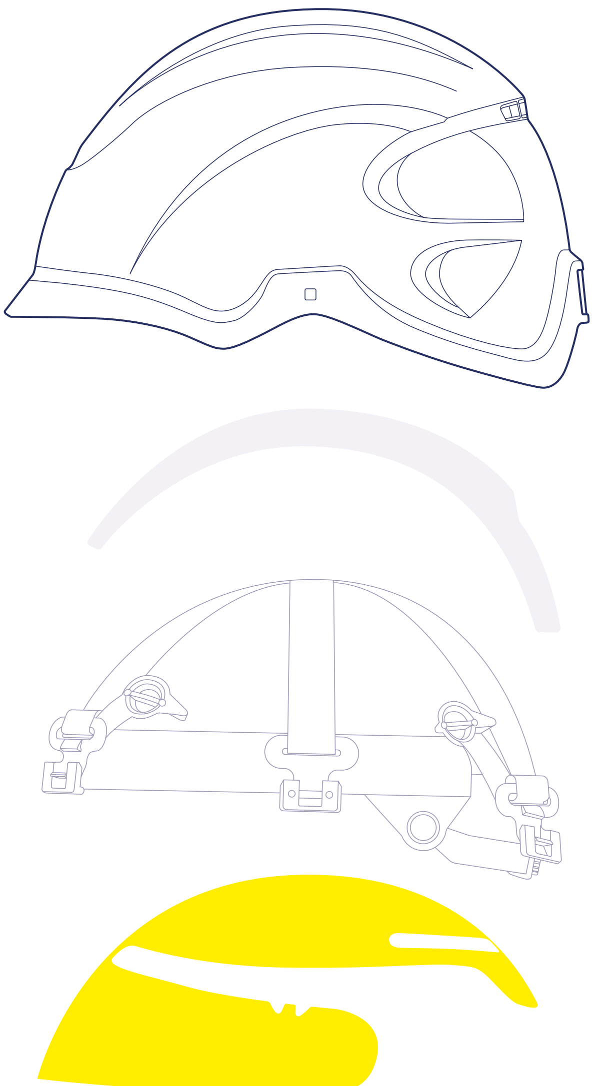
SO, LETS SUMMARISE TECHNICALLY.

Most traumatic head injuries that people sustain are caused by rotational forces that are commonly generated because of the helmeted head receiving a glancing oblique or perpendicular impact with a hard surface or another unrelenting object.

For impacts involving a pure translational force, the helmeted head 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). Most modern safety helmets are well designed to cope with such forces and the brain is reasonably able to absorb these types of impacts 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.





SO, LET'S SUMMARISE LOGICALLY.

Another way to explain this is to look at the Kinetic Energy (Ek). Ek=mv2/2.

Example 1:

You fall and hit your head on the ground. "m" is the mass of your head, which is constant, but the velocity (v) will be lower after impact, so the Ek energy will be reduced by the impact. However, Einstein says energy cannot vanish, so it has to go somewhere. Some has turned into friction energy between the head and the ground, but some has also been absorbed by your head and brain and can cause stress on the brain. Looking at the formula it makes sense to reduce the speed of the head as little as possible at impact, so the energy is preserved as kinetic energy and not energies that damage your head. It is better that less sensitive parts of your body reduce the speed and absorb these dangerous energies rather than your head.

Example 2:

A brick falls from above and hits your head (somewhere which is not in the center of your helmet). It is clear that when the brick hits the helmet your head will absorb some of the energy, but if we can preserve more energy in the brick and keep the velocity the same or higher, then less or potentially none of the energy will be absorbed by your head.

SO, WHAT IS THE SOLUTION?

Redirecting rotational energies

This risk was established some time ago 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 world's first Multi-directional Impact Protection System for an industrial helmet that has a cradle.

For the types of impacts we have been discussing, this can help redirect harmful rotational forces that would otherwise be transferred to the head in the event of an incident.

Injury statistics show that when you fall and hit your head, it is 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.

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 harmful rotational motion that would otherwise be transferred to the head.

CENTURION MIPS PRODUCTS – CONTACT

If you would like further technical information, or any clarification regarding our Mips system then please contact:

techsupport@centurionsafety.co.uk or go to:

https://centurionsafety.eu/

140
A BRITISH BRAND
SINCE 1879

Centurion Safety Products Ltd
T: +44 (0) 1842 754266
F: +44 (0) 1842 765590
A: 21 Howlett Way, Thetford,
Norfolk, IP24 1HZ, United Kingdom
centurionsafety.eu

Distributed in North America by:

MPS Inc.
Toll free: 800-852-6529
Local or Intl: 309-852-6529
P.O. Box 484
Kewanee, IL 61443
mail@go-mps.com
go-mpsinc.com