PERSPECTIVE

Protecting the neck

Better data and technology could prevent many devastating injuries, says **Peter Cripton**.

In August 2013, at a high-school American football game in a suburb of Atlanta, Georgia, a 16-year-old player made a tackle — but he didn't get up. He broke his neck and never regained consciousness, and was later pronounced dead in hospital.

A traumatic injury can occur when an impact to the body is transmitted to the neck. If a football player makes a head-first tackle, his neck is compressed between the head and the still-moving torso. The impact transmits large forces through the neck region of the spine. If the load on the spine exceeds its strength, vertebrae can break, one vertebra might slide over another, or both may happen

Changing behaviour can often prevent such injuries. Coaching methods and rule changes in football, ice hockey and rugby have made great progress in preventing head-first impacts and spinal cord injuries. Football players are told to tackle with their heads up, and hockey players should not be checked from behind as this could launch them headfirst into the boards.

In addition to safer behaviour, I believe that a combination of more data and developing technology can prevent some catastrophic injuries. For example, there is evidence that a standard helmet protects the head but not the neck. In one impact study done in my lab, neck injuries in simulated head-first impacts with snow, of the sort that could happen when snowboarding, were equally likely with or without a helmet, although helmets markedly reduced the potential for head injury[1].

> HOW THE NECK BENDS IN AN IMPACT PLAYS A CRUCIAL ROLE IN THE LIKELIHOOD OF RECOVERY. BUT THIS RAISES OTHER IMPORTANT QUESTIONS.

These conclusions were not new. Voigt Hodgson, who explored biomechanics at Wayne State University in Detroit, Michigan, in the 1980s and 1990s, had similar results in his study of bicycle helmets in simulated head-first impacts with pavements. Biomechanical tests and real-world observations of people injuring their neck in head-first impacts consistently show that standard helmets cannot prevent most neck fractures.

Designing a better helmet for neck protection requires engineers to think differently about the physics of impacts.

IMPACT FACTORS

To see whether technology can reduce the risk of neck injuries, I explored the helmet and neck injury studies that have been published, and worked with Tim Nelson — one of my former graduate students and now an engineer at MEA Forensic Engineers & Scientists in Vancouver, Canada — to reduce impacts to the neck by improving helmet design. The problem is extremely complex. The likelihood of a neck injury when wearing a helmet in a head-first impact depends on many variables, including the velocity, the angle of the impact relative to the neck, and the magnitude of the incoming force. The engineering problem is to find a way to reduce the stress on the neck.

This thinking led us to develop the Pro-Neck-Tor helmet. It looks like a normal helmet and functions as one with respect to impacts to the head. The differences lie inside. The Pro-Neck-Tor helmet consists of two shells. During a head-first impact, the helmet's double-shell design lets the head rotate a little, turning the impact into a small amount of flexion or extension. This allows the neck to 'escape' the momentum of the oncoming torso, which helps to prevent a broken neck. We estimate that in football, for example, this helmet could prevent more than 75% of the broken necks that occur.

Other approaches to preventing catastrophic neck injuries include the Leatt-Brace, which mountain-bikers and motocross riders wear. It provides a mechanical block between the torso and the chin in front, and the torso and the back of the head behind, to prevent hyperflexion and extension when a rider falls and hits the front, back or side of the head. Similarly, the HANS (head and neck support) device used in motorsports reduces neck tension in high-speed head-on crashes by tethering two straps to either side of the helmet and helping to keep the head upright. This prevents hyperflexion and large tensile forces in the neck, which can fatally injure racing-car drivers.

REALISTIC DATA

To build devices that prevent even more neck injuries, we need more data. We developed the Pro-Neck-Tor helmet because we know that how the neck bends during an impact plays a crucial role in the likelihood of injury. But this raises other important questions, such as: how does the alignment of the cervical spine vary when we prepare for an impact or end up upside-down when a car rolls over?

To find out, my colleagues and I measured how being upside-down changes the cervical-spine alignment and neck-muscle activity[2]. We found that the neck was more curved when the subjects were upside-down than when they were the right way up. We have also measured the way the spine changes posture when someone tenses up to prepare for an impact, and are in the process of publishing our data. Knowing the posture of the cervical spine in someone preparing for impact will guide us in optimizing the design of the Pro-Neck-Tor, because this is the spine's posture when it starts to bend during a head-first impact. Such data will also enable us and other designers to develop more realistic tests to evaluate devices to protect the spine, and better computer models of what happens to the neck.

Together, a combination of data and engineering can lead to improved devices that reduce the risk of an injured or broken neck. ■

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2. Newell, R. S. *et al.* *J. Biomech.* doi: 10.1016/j.jbiomech.2013.08.013 (2013).