

Background

Literature Review/Research Article Prophylactic neck bracing system in helmet clad users by means of the provisionally patented Leatt-Brace[™], a study of the need and viability of eliminating cervical spine injuries in those sporting and other activities that are at risk of producing such injuries.

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For those who participate in sports or activities where a helmet is recommended or mandatory such as: motorcar track/rally, motorcross, motorcycle enduros, ATV sports, mountain biking, snowmobiling, or any other sport, or for those who commute on motorcycles, neck injury remains a threat. This has been recognized by such sports as Formula One motor sport with the adoption of the Hans Device. There is however no effective and practical product on the market at present that will offer all of the above mentioned users an alternative to the risk of suffering a devastating neck injury. There is a large range of protective products on the market for these sports, such as full face helmets, 4 – 6 point harnesses, chest protectors, "back protectors", kidney belts, boots, gloves, elbow and knee guards, not to mention a large range of protective clothing. Surprisingly little has been done however to protect the cervical spine against injury. What has been offered thus far is either ineffective in terms of adequate protection if one looks at the spectrum of neck injury mechanisms, or is effective in certain injury mechanisms but impractical or prohibitively costly in terms of the end user. The literature shows the need for a neck protective device and the lack of a suitable option at present. The author asked a cohort of sportsmen and commuters to name one injury they wished to avoid, the answer was a neck injury. When asked whether they would wear a prophylactic neck bracing system should one be available, that was easy to use, required no modification of equipment and was effective in preventing cervical spine injury, 100% of respondents said they would use such a device.

Aim

The aim of this study is to prove that neck injuries are a real possibility with serious consequences and that there exists the need to develop a prophylactic neck bracing system {PNBS} and that the Leatt-Brace[™] complies with the above mentioned criteria. This article should have appeal to both academics and potential users of this product and as such is written in a way as to be understandable to the man in the street.

Method

A literature search was conducted to assess the incidence of neck injuries and in particular cervical spine injuries suffered in sports or related activities. A search was also conducted on all prophylactic type neck devices on the market, or in development, this included the literature as well as the USA and UK patent office registrations. Once a need for a PNBS was established the design of the Leatt-Brace[™] was offered for scrutiny by the medical profession.

Materials

The pubmed search engine as well as Internet based search engines were used to access the available information and articles on this subject. Reference was also made to medical text. Opinions of drivers and riders were gathered.

Key Words and Terms

PNBS – Prophylactic Neck Bracing System, Enduro – Cross country motorcycle race, Cervical Spine – seven vertebrae of the neck. MVA – motor vehicle accident. Words in brackets () indicate medical terms, words in brackets [] indicate layman’s terms or explanations, words in brackets { } indicate extra information or an abbreviation.

Highlighted areas indicate important points or the author’s opinion.

Results

Results were as follows: approximately 30% of all motorcycle injuries requiring hospital attendance were to the head and neck. Roughly 4-12% suffered spinal injuries, of which 20% had neurological fallout [altered sensation, reflexes, power or tone] and 20% involved the cervical spine. The incidence of cervical spine injury was even higher in the car/MVA group (aprox. 50%) Although controversy exists in the literature it would appear that helmet usage may increase the incidence of cervical spine injury when a helmet weighs more than 1500g. There may be an underreporting of neck injuries as ring base of skull fractures {included in head injury statistics} may be considered as a form of supra-cervical neck injury.

Conclusion:

There is a high degree of risk of cervical spine injury in motorcyclists and MVAs as well as other sports and activities where a helmet is used and where there is a chance of falling at some speed. It is possible to protect against neck injuries in theory, with the use of a PNBS, and that such a system would be used by motorcyclists and other sporting participants and commuters. The Leatt-Brace™ fulfills these criteria. Furthermore, helmet usage without a PNBS may increase the risk of neck injury. A PNBS may decrease the incidence of traumatic brain injury by limiting the range of movement for acceleration/deceleration injuries.

Neck Injuries

There are a large range of potential neck injuries that may be incurred by accident victims, both motor vehicle accidents {MVAs} and others. These may include cervical spine injuries as well as soft tissue neck injuries. Muscle responses of the neck are greater in high speed acceleration of the head on the neck and in victims aware of an impending accident that may explain why low speed falls and rear impact collisions produce significant cervical spine injuries. The mechanism of neck injury may be as a result of one of the following excessive neck movements or a combination of these:

- ♦ **Hyperflexion injuries** – (also known as hyperanteflexion) are the most common type in helmeted users and occur with a forward fall and acceleration of the body over a stationary head.
- ♦ **Hyperextension injuries** – (also known as hyperantiflexion or hyperretroflexion) are the most common mechanism in whiplash type injuries and occurs when the head is pushed backwards and upwards (and may be accompanied by posterior hypertranslation), also suffered in non-motorcar type accidents.

- ◆ **Posterior Hypertranslation injuries** – this occurs when the head is pushed backwards in relation to the neck, this will usually occur with a component of extension.
- ◆ **Lateral Hyperflexion injuries** – sideways acceleration of the head towards the shoulders.
- ◆ **Lateral Rotation injuries** – as occurs when the head strikes an object causing the head to rotate to the side. This will usually occur with a degree of flexion or extension.
- ◆ **Axial Loading injuries** – this may occur when the rider lands directly on the vertex of his/her head in the vertical plane and will seldom occur without flexion or extension. It is therefore necessary for any PNBS to prevent excessive flexion, extension, posterior translation and lateral flexion.

Spinal Injuries

- ◆ In a large study of 1,121 motorcycle injured patients and 2,178 car accident victims who attended hospital, conducted in the United Kingdom and published in 2002, there was an incidence of 11.2% spinal injury in the motorcyclists, with 19.8% of these having neurological deficit and 14.1% spinal injury in the car accident victims. 10.2% of all spinal injuries required spinal surgery. 10.3% of all motorcycle crash victims died and 6.8% died in the car group.
- ◆ In a study of hospital admissions in Pittsburgh over a 42 month period and published in 1989 it was shown that there was an incidence of 1.5% cervical spine injury and a total spinal injury rate of 6.4% in 266 consecutive motorcycle accident victims.
- ◆ The site of trauma greatly influences the severity of hyperextension spinal cord injuries; mandible [jaw] or frontal helmet damage indicates an increased chance of a hyperextension injury.
- ◆ The energy to cause (basilar) skull (ring) fractures from mandibular [jaw] impacts has been calculated to be 13.0 +/- 1.7 J [joules]. The use of a crash helmet has not been shown to reduce this incidence.
- ◆ Cervical spine injuries occurred in 1.3% of all patients in a series of 2,555 patients with facial fractures, this rose to 5.5% of patients with facial injuries arising from MVAs. People wearing helmets have a reduced incidence of facial injuries. However, the same forces are transmitted to the neck (or greater due to helmet weight). The areas involved were C2 (31%) and C6 & C7 (50%) in this study [second, sixth and seventh neck vertebrae]. This may indicate that racing type seat belts (i.e. 4 – 6 point harness) may increase the chance of a lower cervical spine injury as the torso is tightly strapped into the seat and the belts are closely approximated to the drivers lower neck with a free moving head and neck and thus may act as a fulcrum for fracture.
- ◆ Although less than 5% of patients who have suffered a possible neck injury have an injury requiring medical treatment, plain x-rays may be misleading in excluding cervical spine fractures. (In a study of severe neck trauma in 100 consecutive patients, eight fractures of the upper cervical spine were only diagnosed on CT. In seven of these patients, three fractures were found in the occipital condyles, five fractures were of C1 – C2, and only two showed some prevertebral soft tissue swelling. All these patients required stabilisation with a Halo.)
- ◆ In a study of 155 traffic accidents, 66 had neck injuries and of these 14 had injuries to the atlanto-axial motion segment [uppermost cervical spine segment]. These included sprains and fractures..

- ◆ In a series of 1,197 consecutive MVA patients who needed to attend hospital there was an incidence of 15% Soft Tissue neck injuries.
- ◆ In a study in the Sheffield Spinal Injuries Unit there was an incidence of 37% spinal cord injury with neurological fallout without demonstrable bony injury [loss of function without a fracture of the spine on X-Ray].
- ◆ In a study in Thailand of 219 spinal cord injuries, 50.7% were due to MVAs. (23.7% were tetraplegic, 26.5% were tetraparetic, 28.8% were paraplegic and 21% were paraparetic.)
- ◆ In a German study, approximately 20% of all in-car-deaths resulted from neck injuries

Whiplash Injuries

This entity is usually attributed to MVAs and is associated with headache, neck pain and occasionally parasthesia [altered sensation] in the arm and hands. The exact pathology [nature of injury] is not known but probably involves cervical joint capsules (facet joint capsules have been shown to stretch 17%-97% in cadaver sled-driven tests) and ligaments/soft tissue structures (tectorial membrane thickness may be reduced with elongation or rupture of the atlanto-occipital membrane/dura mata complex). Whiplash injuries are as a result of rapid acceleration/deceleration of the head with hyperextension/hyperflexion of the neck and are most commonly as a result of a rear end collision in a MVA. This injury also occurs in other activities such as motorcross, bicycle accidents and contact sports and may be described as neck sprain. It may be associated with lasting clinical syndromes.

In a study of 4,759 consecutive whiplash victims in Canada in one year (1987), 12% had not recovered after six months. Neck injury rates were significantly lower in those cars fitted with self-aligning head restraints {SAHR}. In a study of SAHR fitted to Saab cars there was a 75% reduction in whiplash injuries in rear impact car crashes. Such a device limits hyperextension only. A study in Sweden has shown a 67% reduction in neck injuries from frontal impacts in a computer model using an Experimental Head Restraint Concept {EHRC}, a seat belt for the head limiting hyperflexion injuries. The introduction of an effective PNBS will in theory prevent these types of injury.

Motorcycle Injuries

Motorcycle sporting injuries:

- ◆ In a study of the injuries incurred by competitors at four international six day enduro events featuring 1,787 competitors, 10% suffered injuries of which 15% were severe {n=27}.
- ◆ In a review of injuries sustained by 2,500 competitors on the Isle of Man during the years 1989 to 1991, there were 175 injuries and 16 deaths. {Injuries to spectators outnumbered those to competitors, due to the nature of the track and close proximity of the spectators to the riders through bends!}
- ◆ In a study of 113 deaths of all terrain vehicle {ATV}users in West Virginia from 1985-1997, 66% of the deaths were caused by head and neck trauma.
- ◆ When compared to motorcycles, ATVs have a slightly higher mortality rate but a greater head and neck injury rate of 56% versus 30% for motorcycles in a study of 74 ATV crashes and 169 motorcycle crashes in Puerto Rico published in 2003.

Other Stats:

- ◆ In New Zealand in 1994 the death rate amongst motorcyclists was 3.6 per 100 000 persons per year and the hospitalization rate was 80.4 per 100 000 persons per year.
- ◆ The incidence of body region injury throughout the literature is approximately as follows; head and neck 30%, lower limb 35%, upper limb 25% and abdominal/thoracic [belly and chest] injury 10%. The mortality rate was approximately 7%. Roughly 60% of fatalities are due to head and neck trauma.
- ◆ Studies have shown that engine size has little influence on injury severity.

Injuries recorded at autopsy:

- ◆ Of 73 fatally injured patients of a group of 1082 motorcycle crashes in Thailand there was a high rate of occult [not initially obvious] soft tissue injuries to the neck (carotid sheath, vertebral arteries, phrenic nerve and brachial plexus) indicating that neck fractures are not the only type of injury to this area in motorcycle crash victims. As these were occult injuries, appropriate initial medical treatment may not have been given.

Bicycle Injuries

- ◆ Young age was a factor in the risk of serious injury (<6yrs) in a study conducted on acute injuries in mountain biking in 1993 and is thought to be as a result of early musculo-skeletal development (sled tests at 49kph using a Hybrid-III six-year-old dummy showed full-face contact with the dummy’s chest). With the advent of such sports as Kiddie Cross [motorcross for children] there may be an increased incidence of neck injuries in this population of competitors. This is yet to be proven.
- ◆ In 1983, 520 children were admitted to the Children’s hospital in Philadelphia with bicycle injuries, of these 31% had injuries to the head and neck.
- ◆ Approximately 65% of injuries sustained by competitive off road cyclists occurred as a result of falling over the handlebars {versus 25% from falls to the side}and produced more head and neck injuries {56% versus 8%}.

Helmet Usage

As there is a lot of literature available on the benefits of helmets in terms of injury prevention and in particular traumatic brain injury {TBI}, it was included in the search. This may offer a useful comparison in order to extrapolate the effectiveness of a PNBS in the prevention of neck injuries.

An interesting finding is that the use of a helmet may well increase the incidence of neck injury on the basis of increased head weight and its effect on the inertia of acceleration / deceleration type neck injuries. The weight at which helmets produce a significant increase in neck injuries would appear to be 1500g.

Base of skull fractures {BOS#}, in particular ring fractures in proximity to the foramen magnum (aperture where the spinal cord exits the skull), may be included {suggested by the author}when calculating the incidence of neck (cont/...)

injuries. There is an increased incidence of BOS# in helmeted accident victims, this can be viewed as a "supra-cervical neck injury" and not as a head injury and as such should be considered in the incidence of neck injuries in crash victims as the mechanisms of producing these head injuries are the same for neck injuries. With a PNBS this type of injury should be avoidable.

Other facts concerning helmets:

- ♦ Helmets offered no protection of the junction of the head and neck.
- ♦ It has been shown, via the introduction of helmet laws in various states and countries; that **motorcyclists and other sportsman often need to be told what is best for them in terms of injury prevention** and thus an approach to the use of a PNBS may be through legislation, perhaps starting with competition.
- ♦ In a study of 1231 motorcycle trauma patients in Chicago, 30% of all helmeted patients who received direct trauma to the head still sustained a head injury with a 4% incidence of spinal injury in the helmeted group.
- ♦ In Greece in 1994 it was calculated that 457 deaths could have been avoided through helmet use in that year. Many authors of articles pertaining to head and neck injuries recognize the benefits of helmet protection but still advocate ongoing research into the development and energy absorbing properties of helmets as head injuries still occur with the proper use of a helmet.

Other Sports

This article has concentrated on the possible application of a PNBS in motorcycle and car use, however, many other sports and activities would benefit from neck injury reduction or preventative strategies. These include, amongst others, ATVs/ quads, bicycle/mountain biking, snowmobiling, skiing, Street Luge/other extreme sports, pilots and contact sports such as American football.

Pilots

- ♦ With the advent of high performance aircraft, especially fighter aircraft, there has been an increase in neck injuries and fractures due to the forces exerted on the necks of these pilots by +Gz [gravitational force units].
- ♦ The one year prevalence of neck injuries for F16 pilots was 56.6% and for their F16 career it was 85.4%. Preventative strategies recommended are neck strengthening exercises and placing their heads against the seat prior to loading with +Gz, the same effect would be achieved with a well designed PNBS. C5-C7 was the most common area to be fractured.
- ♦ All studies reviewed on this subject have concluded that other preventative strategies should be sought.

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