All the images and examples used in this article relate to injuries sustained by the passenger in the Toyota roll-over, case study.

The bones in the affected areas will often look as though they have been hit or crushed by 2.3 tonne. This is reflective of what happens to the body when it is encapsuled in a 2.3 tonne vehicle that is rolling, flipping and bouncing out of control at about 100 kilometres per hour.

The number of injuries, their nature and severity will depend upon the event that cause the trauma to the vertebrae. Vertebrae injuries can cause pain, can cause disability can paralyse and can cause death.
BROKEN NECK, BROKEN BACK, VERTEBRAE FRACTURE

This article focuses on spinal injuries from trauma. The content is selective and only highlights some aspects about spinal trauma.

A broken neck is when one or more of the cervical (neck) vertebrae are broken or fractured.

There are seven vertebrae in the neck.

A broken back is when one or more of the lumber or thoracic (back) vertebrae are broken or fractured. There are twelve thoracic vertebrae and five lumber vertebrae in the back.

Vertebrae can be broken or fractured from trauma when too much pressure or weight is forced upon the vertebrae. It takes extreme or unnatural pressure to fracture or break a vertebrae. You can run, jump, lift heavy objects and fall without fracturing or breaking a vertebrae. The human body can withstand a lot of stress before a vertebrae or any other bone bends or breaks.

Vertebrae can be broken in sports like: football or rugby, being hit by a hockey stick, martial arts and fighting, falling from a race horse, skydiving, mountain-climbing, skating, bike riding, rodeo events, stunt riding, motor cycle or motor car racing.

Other common causes are: Falling down stairs or off a ladder, falling from a tree, or a roof, falling awkwardly from a height, being hit by a hard object or from motor vehicle accidents.

Other factors to consider which affect injury are a persons body proportions and body weight, muscle strength and fitness, the health of the bones or bone mineral density. Symptoms from an injury will vary from one person to the next. Generalising too much or trying to simplify a broken neck or vertebrae injury can result in misdiagnosis. Someone who is fit and active and healthy may be more resilient to an injury and might make a better recovery. Inactivity and poor diet can lead to weaker bone strength.

The vertebrae supports the body, accommodates flexibility and movement and protects the spinal cord. A broken vertebrae does not mean being paralysed. If the spinal cord is compressed or damaged then paralysis can occur. There are many different scenarios which can result in spinal cord damage and paralysis, too many to examine.
SPINAL CORD
Fracturing or breaking the outer part of the vertebrae will not cause paralysis if the spinal cord is intact and undamaged. Fractures close to the spinal cavity can encroach into the spinal canal or reduce spinal space. Paralysis or neurological symptoms can occur if the cord is compressed.

SPINAL CORD COMPRESSED
The spinal cord may be squashed or compressed a bit without causing paralysis. There will be a threshold when the cord can not tolerate any more compression. When the spinal cord is compressed to its limit or threshold, body movement or position can initiate or exasperate neurological symptoms. Bending, sitting, walking, jumping or a jolt may exasperate or initiate symptoms. Lying down might elevate symptoms sometimes.

SPINAL HEADACHE
When the cervical spinal cord is compressed to its threshold or limit it can cause a spinal headache. Compression of the spinal cord can obstruct and restrict the flow of cerebrospinal fluid between the spinal cord and the brain. This can cause a headache. The headache may increase or decrease depending on the body's position. The headache is sometimes called a positional headache. The headache will generally subside while lying down.

BRACING
When somebody is dead or unconscious the body is as limp as a rag-doll. A person who is alive and conscious can brace themselves during an accident or when a vehicle is rolling. Different injuries can occur as a result.

Example: There is a lot of weight in someone's legs. If someone is dead or unconscious during a high speed vehicle roll-over their legs can be flung around placing extreme pressure on the lower lumbar vertebrae. This can result in compression fractures, vertebrae space reduction and disc herniations in the lumbar vertebrae.

COMPRESSION FRACTURE
Compression fractures happen when too much pressure is placed on the vertebrae. Compression fractures can change the shape of the vertebrae. Sometimes the fractured bone will burst. Often small pieces of bone will break or shatter off. They resemble teardrops so are called teardrop fractures.

BONE SPURS, DISC HERNIATION
Compression and bone damage near the spinal cavity can cause bone spurs inside the spinal cavity. It can also cause bone and discs to herniate into the cavity. Any encroachment upon the cord can cause paralysis.
DISLOCATION
Dislocation is when the vertebrae separates. A complete dislocation is when the vertebrae separates completely. Complete dislocation is caused by extreme trauma like high speed motor vehicle accident. Complete dislocation is common when a vehicle’s roof folds in. When the head space disappears in a roll-over a person’s cervical vertebrae can be torn off, totally separating from the thoracic vertebrae. When this happens it exposes the spinal cord which becomes completely unprotected.

The person is likely to be paralysed or killed. If the cervical spinal cord is cut or severely compressed it can stop the neural link between the brain and the heart. Death is instant. The brain and heart both stop simultaneously.
A Toyota Landcruiser rolled many times at about 100 kilometres per hour in the Gibson Desert in outback Australia. The Toyota roof folded in breaking the passengers neck.

Vehicle photos taken at the wrecking yard 3 months after the accident.

When the roof folded in, the passengers neck hyperflexed beyond normal range crushing the cervical vertebrae.

Front of cervical vertebrae is severely compressed

Vertebrae buckles

Vertebrae eventually dislocates at T1

HYPERFLEX
Over-extend in forward direction

A CASE STUDY
CERVICAL VERTEBRAE  

COMPRESSION FRACTURE  

Intervertebrae spaces are reduced

Compression fractures

Teardrop fractures

Bone is broken off the vertebrae spinous process at C7.

The vehicles weight crushes the (neck) cervical vertebrae as the Toyota is rolling.
Damaged vertebrae bone and squashed discs encroach into the cavity from different sides.

Vertebrae from C3 to C7 are crushed against one another fracturing them. This alters the shape of the vertebrae and reduces their height.

The spaces between the vertebrae are reduced. As a result discs herniate out. Four of the discs herniate into the spinal cavity.

Back of neck.

Pieces of bone are smashed off the vertebrae spinous process at C7.

Bone is also smashed off at T1  
T2  
T3
Neck was also crushed at the back. This causes additional encroached into spinal cord.

Neck was also crushed at the back. This causes additional encroached into spinal cord.

Spinal cord is being crushed here.

The width of spinal canal is normal here.

The width of spinal canal is too small and narrow here.

This disrupts the spinal cords functioning, compression of spinal cord here also restrictly the flow of cerebrospinal fluid to the brain causing a spinal headache.

More than 2 tons of weight (Toyota) was pushing down my head and neck.
DISC HERNIATION  CERVICAL VERTEBRAE  BONE SPURS

Front of neck.

Vertebrae discs herniate or enter into spinal canal.

Back of neck.

Crushed vertebrae encroaching into spinal canal.

Bone spur.

Bone spurs inside canal.

Bone spurs inside the cavity can cause neurological symptoms and paralysis.

They can also perforate the spinal cord. This can cause loss of cerebrospinal fluid to the brain. This can be fatal.
DISC HERNIATION
COMPRESSION FRACTURES
COMPRESSED SPINAL CHORD

Cervical Vertebrae

Damaged bone from crushed vertebrae encroached inside spinal cavity (foramen). This compresses the spinal cord.

Cervical Vertebrae
Disc herniating into cervical spinal canal.

Spinal cord is compressed, its shape has altered.

Spinal cord being compressed by herniating disc.
Neck has buckled and was almost about to dislocate here, it dislocated at T1-T2 instead. Cervical Vertebrae has been crushed. Vertebrae bones are compressed together. Bones ground against one another whenever my neck moved. Nearly every neck vertebrae is fractured. Fracturing has also occurred inside the spinal canal, compressing spinal cord.
TUG OF WAR

Have you ever tried having a tug of war with a 2.3 ton Toyota Land-cruiser. The Toyota is bound to win. In this contest the Toyota Land-cruiser was upside down and airborne, travelling at 100 kilometers an hour and bouncing on its roof above my head. I was seat-belted into the front car-seat.

The contest required me to resist and push back against the Toyota with my head, only using my neck muscles. Losing the contest meant having my head torn off, or having my head pushed down into my chest cavity. Death awaited either way. I resisted the Toyota as much as I could. I tried to lock my neck muscles. Everything in my neck including bone was being crushed while the Toyota’s entire weight pushed against my head. The neck muscles are attached to the back vertebrae at T1. The contest finished with my vertebrae dislocating (torn off) at T1. I was taken out immediately, death was instant.

This C.T. /CAT scan of my neck is a result of the contest. This image was taken seven weeks after the accident. If a picture were to have been taken immediately after the accident, it would have looked worse because of the dislocated vertebrae at the time.
VERTEBRAE DISLOCATION

When a vehicle roof folds in during a roll-over it can push down on the head or neck of the person underneath. A Toyota Landcruiser weighs 2.3 tonne which can break a vertebrae completely in half. The Toyota bounced on its roof folding the roof down directly above the passenger. After initially crushing the cervical vertebrae, the vertebrae dislocated completely at T1. This exposed the spinal cord. When the vertebrae separated death occurred instantly. A vehicles weight on a spinal cord can cut the neural link between the brain and heart. If the person survives they are often paralysed.
UPPER BACK VERTEBRAE
Thoracic vertebrae (T1)
FRACTURED
When the roof folded in, I tilted by head down forward. Instead, of crushing my skull, the roof pushed down on my neck crushing it. I took the brunt of more than two tonne of weight.
LUMBAR VERTEBRAE DISC HERNIATION COMPRESSION FRACTURE

When a person is dead or unconscious they cannot brace themselves or flex their muscles during a vehicle roll-over. Their body will be limp. Limbs not restrained by a seatbelt like arms, legs and head with thrash around loosely. This can cause further injury. There is a lot of weight in a person's legs. During a high speed rollover this can cause injury to the lower (lumber) vertebrae. It can cause compression fractures, reduce height in between vertebrae, discs can herniate and the spinal cord can sustain injury.
The passengers seat was crushed every time the roof pushed down on the headrest. An object permeated the seat. This punched hard into the passengers back smashing off more pieces of vertebrae. Some vertebrae shattered or fractured. These blows had over 2 tonne of weight behind them every time the roof hit the ground while rolling. A hard hit to the spine at T4-T5 smashed the vertebrae but also kick-started the passengers heart. The Toyota Landcruiser finishing on its roof about 100 metres away from where it left the road.

2.3 tonne of weight pushed down on the head-rest.

When the roof pushed down on the head-rest an object permeated the seat, punching hard into the passenger back.

These hits broke and shattered the vertebrae. One blow kick-started the passengers heart.

Passenger was crushed and hit by:

**ROOF**
- Broken neck
- Broken back
- Herniated discs
- Vertebrae dislocation
- Bone spurs in spinal canal

**SIDE WINDOW**
- Fractured skull

**SEAT**
- Broken back

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Drivers seat head-rest       Passengers seat head-rest
Toyota Landcruiser landed on roof.
The roof folded in.
Hitting the vertebrae spinous process with a force of two tonne or more is similar to hitting a brick with a block brick hammer. The vertebrae can shatter all the way through just like a brick does.

A heavy blow in the back smashes bone of the vertebrae spinous process.

An extremely hard sudden hit in the spinous process can shatter the vertebrae.
Pictures of the wrecked vehicle 3 months after it was taken to wrecking yard.
Passengers side