CERVICAL SPINE BIOMECHANICS

Understanding of cervical spine biomechanics is important in understanding the mechanism of any injury to the upper cervical spine. Biomechanics is basically a science, which applies physical and mechanical laws to biological structures like muscles, ligaments, joints and various other structures. Since the human spine is populated with many of these structures in a complex web it is possible for changes in these structures or changes in the position of the skull (occiput or C0) on top of the cervical spine to affect the biomechanical abilities of the cervical spine to hold the head vertical and therefore affect normal movement at that level. Also, because of the close proximity of vital anatomy like cranial nerves, the spinal cord, the brainstem, arteries and other blood vessels it stands to reason that any change in cervical spine biomechanics may well have a detrimental affect on these vital structures and hence affect a person's overall health. We are all accustomed to the disastrous consequences for someone who breaks their neck (cervical spine) or who sustains a dislocation of fracture of cervical vertebrae. Certainly dislocations or fractures in the upper cervical spine are invariably fatal or can be neurologically detrimental. What consequences, symptoms or other problems do people experience that do not exhibit any visible (as viewed on basic X-ray, CT scan or MRI) dislocation or fracture of the cervical spine? Nothing? What happens when a person receives a significant blow to the head, which may or may not result in unconsciousness? Nothing? Just because normal radiographic analysis results in a diagnosis of "Within Normal Limits", does this mean that there has been no damage to cervical spine biomechanics? I suggest not.
It's just not plausible that nothing happens to the structures that maintain biomechanical stability. It stands to reason that at the very least ligaments can be stretched briefly and at the other end of the scale stretched beyond their elastic limits or even tear. In these cases it can be the very anatomy of a person, their age and their physical strength that determines whether they are fatally inflicted or just have some minor neck pain. Of course, there are many people in between who have chronic pain and dysfunction for years yet Doctors can find nothing wrong with these people using the tools and methods at their disposal.

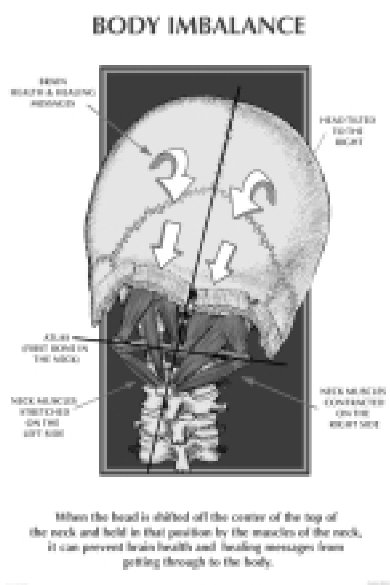
All things, which are influenced by gravity, are normally stable when the centre of gravity is in synchronisation with the forces and weights affecting them. Thus it is clear that a structure like the human spine with the head sitting atop the cervical spine is mechanically stable when the head is directly over the pelvis. A biomechanically stable spine is characterised by a head sitting vertical to the cervical spine and the eyes, jaw, shoulders and pelvis, which are level with the horizon. There should be neither rotation of the head, shoulders, pelvis nor any anterior or posterior lean of the spine from the cervical spine down to L5. Any deviation from the centre will induce axial loading forces, and alter the weight bearing structures throughout the body. No more is this evident than in the cervical spine. Changes in the biomechanical structures holding the skull on to the atlas vertebra will alter the weight bearing capability of the cervical spine. This resultant change in the centre of gravity can cause postural asymmetry, which represents a mechanical and physiological imbalance of the spine. Injury to ligaments attached to the atlas and skull can result in a complete shift of the skull on the atlas. According to White and Panjabi[1] page 283, "the anatomic structures which provide stability for the articulation of the occipital-atlanto-axial articulations are the anterior and posterior

[1] Clinical Biomechanics of the Spine- Second Edition 1990; White and Panjabi

atlantooccipital membranes, tectorial membrane, alar ligaments and apical ligaments." I think we can also add some of the sub-occipital ligaments like the rectus capitis posterior minor (RCPMI) and major, obliquus capitis superior and inferior. The RCMPI attaches to the posterior arch of the atlas, to the occiput and via the Myodural Bridge to the dura mater. Form comments from other authors White and Panjabi note that these authors "believe that the occipital-atlantal joint is relatively unstable, at least in children." What I notice most about sick children I have seen is their inability to hold their head up vertical and their tendency to hold their heads in forward posture. I also notice that some young children have very large heads, almost the size of adults (which weight about 4 to 5kg) yet their necks seem so frail as to seem incapable of holding the head upright on the neck. Are these necks unstable as defined in the literature?

White and Panjabi provide a table of criteria for instability of the C0-C1-C2 complex. Page 285, Table 5-3.

>8°	Axial rotation C0-C1 to one side
>1 mm	C0-C1 translation (as measured in Fig. 5-6A, pg. 286)
>7mm	Overhang C1-C2 (total right and left)
>45°	Axial rotation C1-C2 to one side
>4 mm	C1-C2 translation (as measured in Fig. 5-6B, pg. 286)
<13 mm	Posterior body C2-posterior ring C1 (as measured in Fig. 5-6C, pg. 286)
	Avulsed transverse ligament



The question I think becomes, "If the C0-C1-C2 complex is studied on a particular person and the criteria for 'instability' are not met, does this mean that the person is considered to be 'within normal limits'" and therefore there is nothing wrong with them? Maybe even smaller deviations than the limits in the above table have negative affects on a person's health, which manifest themselves as symptoms I have described in my own case or as suffered by the boy in the following case.

Case: One particular boy who was suffering from headaches for months along with watery eyes, neck pain and restricted range of motion (ROM) of his cervical spine, exhibited forward head posture. Following an upper cervical chiropractic adjustment to his atlas his normal posture was restored, his headaches disappeared, his eyes stopped watering and his ROM returned to normal, and that was all within hours! He has the biggest head I have ever seen on a child with a really tiny neck and he was only 7 years of age. His GP was busily having him CT-scanned looking for a tumour. The boy's mother was over the moon and the boy returned to the sport he loved. The GP was sceptical and figured the boy was going to grow out of the headaches. In other words it was just a coincidence! I guess this is an anecdotal case, although I witnessed it so it is not anecdotal to me. So be it! Send me more sick kids so I see an anecdotal, coincidental procedure performed on them!

What Problems can a Misalignment in the Upper Cervical Spine Cause?

1. The cervical muscles and ligaments in the cervical spine can apply direct mechanical irritation to the nerves passing close to or through these structures. As mentioned elsewhere there can be direct irritation to the brachial plexus by the scalenes at the base of the neck and also to irritation to the phrenic nerve, which runs through then scalenes.
2. There can be direct irritation, compression or traction to vital nerves and blood vessels around the base of the skull, which all pass through foramen in the base of the skull at the craniocervical junction. In particular, the cranial nerves glossopharyngeal (IX), spinal accessory (XI), vagus (X) and hypoglossal (XII), and the carotid and vertebral arteries. It has been reported in [Page 389, "The Cervical Spine – 3rd Edition" – The Cervical Spine Research Society, Editor: Charles R. Clark, Lippincott-Raven Publishers, 1998] that injuries to the craniocervical (C0-C1) junction, have resulted in injuries to cranial nerves; abducent (VI), facial (VII), glossopharyngeal (IX), spinal accessory (XI) and hypoglossal (XII). This was further reinforced in a meeting I once had with Professor Nicholai Bogduk, who told me that they had found people with injuries to all four cranial nerves glossopharyngeal (IX), spinal accessory (XI), vagus (X) and hypoglossal (XII).
3. The vertebral artery passes through the vertebral foramen from C6 to C1 then pierces the posterior atlantooccipital membrane and loops to enter the brain through the foramen magnum. For a picture of the tortuous pathway of the vertebral artery I refer to you [Plate 14 –External Craniocervical Ligaments, "Atlas of Human Anatomy - 2nd Edition, 1999" Frank H. Netter, M.D.] Changes in the position of the skull will tension this membrane and irritate the artery. In addition the artery can be occluded due to a significant rotary component of the atlas in relation to the occiput and/or the axis. For a picture of this I refer you to [Figure 2-4 from Page 13 of "Atlas of Common Subluxations of the Human Spine and Pelvis", by William J. Ruch, D.C.; CRC Press – 1997]. This picture shows occlusion of the vertebral artery by the C1 interior facet. This can have the affect of attenuating blood flow to the brain and the upper spinal cord. Surely this is a source of much dysfunction?
4. There can be direct mechanical stress placed on the spinal cord via the dentate ligaments that tether the spinal cord to the perimeter of the neural canal. There can also be mechanical stress to the dura mater of the brainstem and cerebellum through the Myodural Bridge ligament attachment from the posterior arch of the atlas to the dura mater.
5. One of the results of a shift of the occiput on the atlas and subsequent change in the centre of gravity causes spinal scoliosis. As a consequence of scoliosis can be direct mechanical irritation of the nerves leaving the spinal canal on each side of the spine. On one side the spinal nerve may undergo compression and directly on the other side stretching. Slight stretching and compression of spinal nerves can change the conduction properties of those nerves with resultant attenuation of nervous system signals or amplification in nervous system signals. Since these nerves control various functions in the body, it is not hard to

hypothesise malfunction of organs and other structures due to nerve signal changes.

6. The carotid artery which lies underneath the sternocleidomastoid (SCM) muscle can be compressed or stretched by this and other muscles due to forces acting to maintain the skull on top of the cervical spine and during turning of the head.