

The whiplash injury

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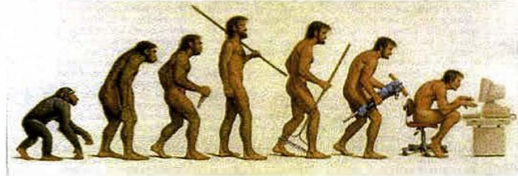
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Introduction



The erection of man and evolution from „Homo erectus“ to „Homo sedens“

“Vertebral column”
Term from the time of
descriptive anatomy

better to be called the
human axis organ,
central organ of the human body

Human axis organ I Functions

- Carries the human head with brain and the most important sensory organs
- Carries the human body
- Responsibility for movements of the head in all dimensions, axis organ of human body
- Fixation of shoulder girdle and the upper extremities
- Fixation of pelvis and the lower limbs
- Fixation of inner organs:
 - chest with cardio-respiratory organs
 - abdominal organs

Human axis organ II Regulation for posture and turning movements midbrain-pontine centre

- Responsible for
 - Adaptation of the human body in the gravity field
 - Basis for all movements of the human body in the gravity field
 - Readaptation of the body position by the postural and turning reflexes due to the vestibular apparatus and the proprioceptive system, receptors in cervical spine, lumbar and thoracic spine, foot sole

Phylogenetic development of the axis organ, the vertebral column

- Tunicata, external skeleton
- Development of Chorda dorsalis (amphioxus)
- Development of cartilage fish
- Development of the vertebral column
 - Horizontal position of the vertebral column
 - bone fish, amphibians, reptiles
 - arch bridge construction, partial development
 - terrestrial tetrapods (mammals, aquatic mammals)
 - arch bridge construction, full development
 - Vertical position of the vertebral column
 - human being
 - lattice tower construction

Tetrapods arch bridge construction

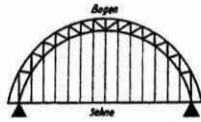


Abb. 6. Schema des Konstruktionsprinzips der Säugerwirbelsäule. Nach SLATJER

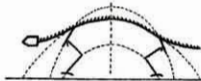


Abb. 4. Schema der Wirbelsäule eines primitiven Säugetieres. Nach BÜCKER

- Bow consists of two parts: upper belt and lower belt
- Upper belt: vertebral arch, spine of vertebra, ligamenti, back muscles
- Lower belt: vertebral body, vertebral disc, ligamenti, short and long tendons, muscles
- bow string: cranial fixed by the ribs (chest), caudal fixed by abdominal muscles

Tetrapods scheme of the arch bridge construction

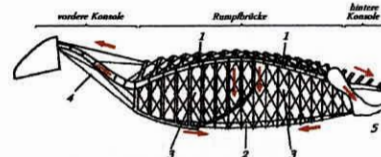


Abb. 7. Schema des Konstruktionsprinzips der Wirbelsäule beim Vierfüßler: 1. Wirbelsäule in Form einer flachen Kypheose; 2. Sehne in Form der langen ventralen Rumpfmuskeln; 3. Querstreben in Form der Rippen und schrägen Rumpfmuskeln

- Flat kyphosis of spine (1)
- Bow string long ventral trunk muscles (2)
- Ribs (chest) and diagonal trunk muscles (3)
- Anterior console (4)
- Posterior console (5)

Vertebral column in tetrapods

- Thoracic and lumbar spine
 - Fixation of the extremities for standing and locomotion
 - Support in jumping
 - Fixation of ribs and the diaphragm for respiration
 - Fixation of inner organs
- Cervical spine
 - Carrying the head with brain, sensory organs including vestibular apparatus
 - Responsible for free movement of the head
 - Receptors for gravity (neck muscles, tendons, cervical joints)
- Tail, used for balance
 - special motion receptors
- Balance, continuously regulated by postural and turning reflexes of the midbrain centres

Tetrapods

Spine maximal integrated in the running movement, galloping dog - high speed possible

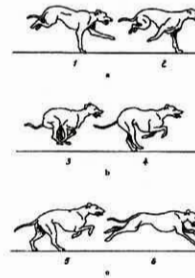


Abb. 8a—c. Bewegungsfolge eines galoppierenden Hundes mit maximaler Beteiligung der Wirbelsäule.

'Great' vertebrates tetrapod and bipeds in normal gravity



Vertebral column change in special biotops passager lordosis in the lumbar region



Lithocranium Walleri

- a) Arch bridge construction
- b) Lordosis during ingestion

Abb. 11a. Gaffelganzelle (Lithocranium Walleri) im Stand. Nach BÜCKER.
Abb. 11b. Aufgerichtete Gaffelganzelle (Lithocranium Walleri). Nach BÜCKER. — Man beachte die jetzt obere Lende.

Lift-grasp-climbing position neck and lumbar lordosis development of dome construction of vertebral spine



Arch bridge construction
changing to lattice tower construction

Abb. 12. Lordose (schematisch) beim Aufrichten im Zuge des Stemm-Greif-Kletterns.

Quelle: T. Koch: Phylogenie der Wirbelsäule. In: Neurologie der Wirbelsäule und des Rückenmarks im Kindesalter, 1964

Lattice tower position



a)



b)

- a) Human: lattice tower position
- b) Gorilla: lattice tower position, rest of vault bridge construction

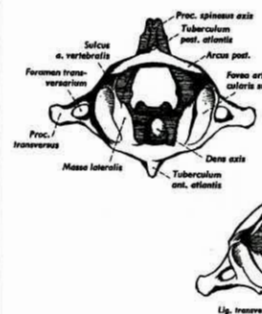
Special function of cervical spine turning movements in 3 dim. Development of the Atlas-Axis-system

Three steps:

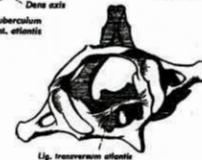
1. development of 2 condyles on os occipitale (amphibias),
2. development of a second level, the atlas-axis-joint, rebuilding of dens by loss of the first disc (tetrapods),
3. special axis-dens-system, great autonomy, but highly vulnerable (man)

Atlas-Axis-system, different positions

Atlas and axis, cranial view



Atlas and axis, view from dorsolateral



Turned atlas, fixed dens axis

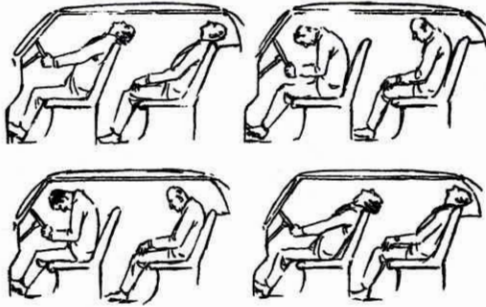
Vulnerability of the human vertebral spine incompleted development of lattice tower position, high vulnerability of axis-dens-system

- overloaded due to unphysiological position (industrial life), typical symptoms of cervical spine and lumbar region (Mumenthaler, Schliack)
- psychological factors, influencing regional dysfunction of vertebral spine, mainly upper part
- motion trauma of cervical spine (whiplash injury), mostly including the other parts of vertebral spine (typical acute symptoms, sometimes long-lasting dysfunction, sometimes defect states)

Whiplash Injury Causes

- Rear-end automobile collision
- Sports injury (ice skating, skiing, etc.)
- Contact sport injury (rugby, boxing, wrestling, etc.)
- Falling on slippery or icy roads on the back of the head (combination with traumatic brain injury possible)

Schema of a whiplash injury Rear-end-automobile collision



Source: Schematic hand painting by A. Gerstenbrand, modified after A. Dagradi

Whiplash injury Fall on the back of the head

Es rißt der Strahl, von Blut geteet;



Sieh! Wie er ruft: „Ich bin geteet!“
Mit diesen Worten fällt er nieder



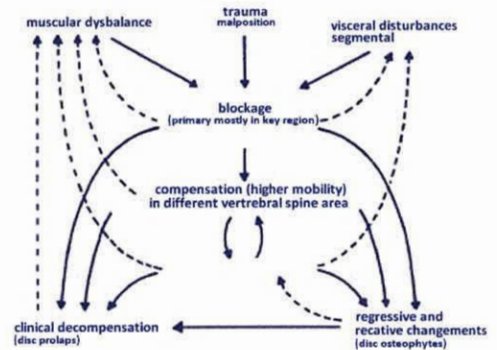
Und stieß die schmerzgelähmten Glieder.
Sach! Wie er ruft: „Ich bin geteet!“
Sie kommt und schreit mit Angeschrien:
„Ach! Wie! Ich! Ich! Ich!“

Original drawing of Wilhelm Busch

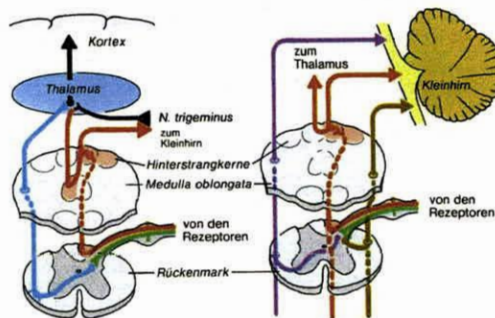
Whiplash Injury Pathophysiology

- Acceleration/deceleration movement of the neck
- Abrupt extension of the whole neck structures (muscles, tendons, discs)
- Small hemorrhages in the neck tissue
- Extension of neck vessels
- Vertebral bone mini fractures possible (rare cases)

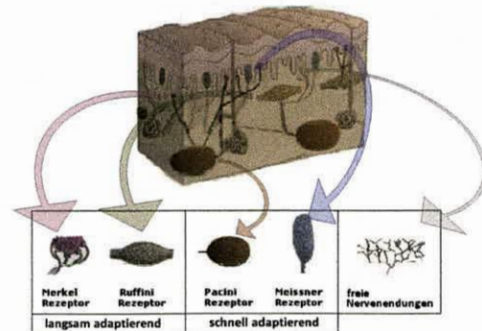
Pathogenesis of vertebral disturbances, reflectoric reactions



Connection of the proprioceptive system to the cortex and to the cerebellum



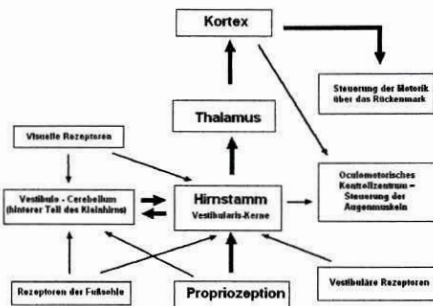
Receptors in foot sole



Scheme of proprioceptive connections to the cortex

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graph TD
    Kortex[Kortex] --> Thalamus[Thalamus]
    Thalamus --> Kortex
    Kortex --> Motorik[Steuerung der Motorik über das Rückenmark]
    Thalamus --> Hirnstamm[Hirnstamm  
Vestibulär-Kern]
    Hirnstamm --> Kortex
    Hirnstamm --> Oculomotor[Oculomotorisches  
Kontrollzentrum -  
Steuerung der  
Augenmuskeln]
    Oculomotor --> Hirnstamm
    Hirnstamm --> VestibuloCerebellum[Vestibulo - Cerebellum  
(hinterer Teil des Kleinhirns)]
    VestibuloCerebellum --> Thalamus
    VestibuloCerebellum --> Hirnstamm
    Hirnstamm --> Receptors[Rezeptoren der Fußsohle]
    Receptors --> Hirnstamm
    Hirnstamm --> Propriozeption[Propriozeption]
    Propriozeption --> Hirnstamm
    Hirnstamm --> VestibularReceptors[Vestibuläre Rezeptoren]
    VestibularReceptors --> Hirnstamm
    Hirnstamm --> VisualReceptors[Visuelle Rezeptoren]
    VisualReceptors --> Hirnstamm
    VisualReceptors --> VestibuloCerebellum
  
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Whiplash Injury Pathophysiology

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Whiplash injury

Course of movement

The diagram illustrates the sequence of neck movements during a rear impact. It consists of four side-view illustrations of a human head and neck. 1. 'initial position' shows the head in a neutral, upright posture. 2. 'spine straightening' shows the head tilted slightly backward as the spine begins to align. 3. 'max. retraction' shows the head tilted significantly backward, with the neck muscles taut. 4. 'extension' shows the head tilted forward, following the initial backward motion. Below each illustration is its corresponding label.

initial position spine straightening max. retraction extension

Figure 1: Occupant kinematics during rear impact.

Source: M. Darok et al: Neck Injury Criterion Validation Using Human Subjects and Dummies. In: Frontiers in Whiplash Trauma, Vol. 38, IOS Press, 2000

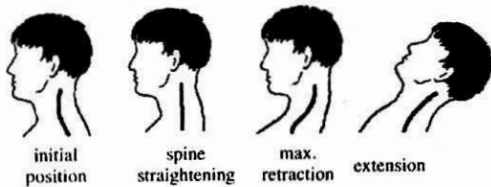


Figure 1: Occupant kinematics during rear impact.

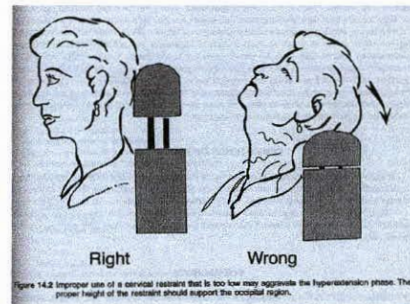
Source: M. Darok et al: Neck Injury Criterion Validation Using Human Subjects and Dummies. In: Frontiers in Whiplash Trauma, Vol. 38, IOS Press, 2000

Whiplash Injury in case of too low position of neck rest

The diagram consists of two line drawings of a person's head and neck in profile, facing left. In the 'Right' illustration on the left, the neck is supported by a dark, rectangular rest that is tall enough to support the back of the head (occipital region). The neck is in a neutral, upright position. In the 'Wrong' illustration on the right, the neck rest is significantly shorter, leaving the head unsupported. The head is tilted sharply backward (hyperextension), and a curved arrow indicates the subsequent forward motion (hyperflexion), which is the mechanism of a whiplash injury.

Figure 14.2 Improper use of a cervical restraint that is too low may aggravate the hyperextension phase. The proper height of the restraint should support the occipital region.

Source: B. Swerdlow: Cervical Acceleration/Deceleration Syndrome (Whiplash).
In: Whiplash and related headaches. CRC Press, 1999



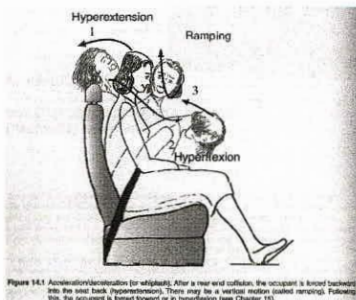
Source: B. Swerdlow: Cervical Acceleration/Deceleration Syndrome (Whiplash).
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Whiplash injury

Course of movement

Figure 14.1 Acceleration/deceleration (or whiplash). After a rear-end collision, the occupant is forced backwards into the seat back (hyperextension). There may be a various motion (dashed markings). Following this, the occupant is forced forward or in hyperflexion (see Chapter 15).

Source: B. Swardlow: Cervical Acceleration/Deceleration Syndrome (Whiplash). In: Whiplash and related headaches. CRC Press, 1999



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Whiplash injury

Symptoms

- Acute phase
 - Neck pain
 - Neck stiffness
 - Pains by head rotation
 - Mostly starting after a few hours
- Post-acute phase
 - Symptoms of a upper cervical syndrome
 - Headaches
 - Cervicalgia
 - Vertebrogenic vertigo
 - Additional symptoms
 - Pseudo-radicular symptoms in upper extremities
 - Low back pain (lumbalgia)

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Whiplash injury Obligatory course

- Acute phase:
 - Improvement after 4 to 10 days
- Post-acute phase:
 - Complains during 6 to 10 weeks
- Rest state:
 - Up to 3 months, sometime to 10 months
- Defect state:
 - Transition to upper cervical syndrome

Upper cervical syndrome

- Combined symptoms
 - Cervicogenic headache
 - Cervicalgia
 - Migraine cervicale (old terminology)
 - Cervicogenic dizziness
 - attacks of vertigo, spontaneous or due to quick head movement
 - in addition:
 - middle and lower cervicale syndrome
 - cervico-dorsalgia, dorsalgia, lumbalgia
 - combination with pseudo-radicular symptoms

Whiplash injury Additional diagnostic methods

- X-ray of cervical spine
- Functional X-ray exposure of cervical spine
- X-ray of thoracic and lumbar spine
- MRI of cervical spine (severe cases)
- Manual therapeutic examination methods
- In the later course neuro-orthopaedic examination

X-ray cervical spine

female patient, 47^a

Upper cervical syndrome after whiplash injury



a) Retroflexion, blockage upper part, dysbalance occipito-atlanto-axial joint



b) Anteroflexion, blockage in upper part and lower part of cervical spine

Whiplash injury Treatment

- Ice application in the first 24 hours
- Bed rest for 24 hours to 5 days
- Cervical collar
- Muscle relaxing medication
- In cases of severe pains analgetics
- Gentle active movements beginning after 2 to 5 days
- Systematic physiotherapy after 10 to 20 days depending to the pain state
- Local infiltration with xylocaine in cases of severe muscle tension

Summary

- Whiplash injury is a common traffic trauma (rear-end automobile collision)
- Whiplash injury occurs in sport accidents and falling backwards
- Typical acute symptoms mostly occurring some hours after accident
- Typical post-acute symptoms
- Great differences in the defect states, chronic course
- Combination with psychosomatic symptoms in some cases
- Medico-legal aspects, difference in various countries
- Diagnosis 'whiplash-injurie' has negative resonance assurance compensation