Anatomy part 1
coupled motion in the cervical spine
- mainly reciprocal coupling between axial rotation and lateral bending, caused by the morphology of:
  - facet joints
  - endplates
  - vertebral processes
  - intervertebral discs

(Trommsdorff and Albrecht, 1987; Albrecht and Trommsdorff, 1990; Kerst et al., 1990)

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**segmental versus regional coupled motion (CM)**

**Segmental CM**
- upper cervical spine: mainly contralateral CM
- middle and lower cervical spine: mainly ipsilateral CM

**Regional CM**
- global result of all segmental CM (i.e. sum)
- mainly ipsilateral CM

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C0 – C2 but as well in ± 13% in cerv. spine

right

contralateral coupled motion

left
The effect of ageing on the range of main motion and coupled motion – healthy volunteers (n=56)

Left-right asymmetries: more than articular tropism
• Lateroflexion C0 – C1 = Homolateral rotation of C2
• Rotation C0 irt. C1-C2 gives heterolateral flexion of C0 – C1 (alare)
• Dorsal flexion of C1 = forward tilt C2
Penning:
The C0 - C2 complex compensates the coupled rotation of the lateral flexion of C3 – C7

Dr. Cramer:
heterolateral combination „such bsstsh!“

MOVEMENT CENTER C0 C1

Flexion extension C0 - C1 = 29°
Lateral flexion C0 - C2 = 8°
Rotation C0 - C1 = 2°

axial rotation at C0-C1?

P. van Roy, E. Barbaix, J.P. Clarijs 2005
Rotation between atlas and occiput is physiologically not possible, except post-traumatic and during passive examination.

After trauma the physiological limits are surpassed and a reason occurs for blockage.

Lots of asymmetries in the condyle are created naturally but can also be created by rotation shifts and by disfunction. (KISS children)

When an atlas joint becomes fixed (arthrogenic or muscular) the rotation of the atlas takes place in this joint.

X rays will show this and should be accompanied by palpable segmental investigation.

(Penning – Gutmann)
MOVEMENT CENTER C1 - C2
Flexion extension C1 - C2 = 16°
Lateral flexion C0 - C2 = 8°

LATERAL FLEXION CENTER C0 - C2
Lateral flexion C0 - C2 = 8°
Manual fixation versus locking during upper cervical segmental mobilization

Manual Therapy, Volume 12, Issue 4, Pages 342-362
E. Cattrysse, J. Baeyens, J. Clarys, P. Van Roy

Sideways gliding of the C1 in the direction of the lateral flexion C0-C2

21 healthy children
Range 3: 11.5 jaar
18 kinderen 180° rotatie!
3 kinderen slechts 90°

Characteristics C1-C2 at rotation
- 0-23° → C1 moves without C2
- 24-65° → C1 moves with C2 but C1 moves faster
- >65° → C1 and C2 synchronicity

Also, four patients who had serial motion studies during the delay period showed clear worsening in the pathological stickiness in C1C2 rotation.

In addition, chronic rotatory deformity led to progressive occiput -C1 separation or laxity teleologically to compensate for a skewed visual axis.

The mean occiput – C1 separation angle for chronic patients was 31.2 degrees versus 5 degrees for acute patients and less than 3 degrees for normal children.
fl. – ext. axis of rot. in C0 condyles
rotation C0 – C2 axis of rot. in dens

Figure 4. Illustration of one upp. cerv. spine model (atlantoaxial level) and helical axis location for three different discrete positions of axial rotation

Dugailly et al. Erasmus Brussels 2005

<table>
<thead>
<tr>
<th></th>
<th>D15.0°</th>
<th>D30.0°</th>
<th>D45.0°</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>2.7±1.2</td>
<td>3.4±1.6</td>
<td>2.8±1.5</td>
</tr>
<tr>
<td>y</td>
<td>5.6±1.4</td>
<td>5.8±1.6</td>
<td>5.3±1.5</td>
</tr>
<tr>
<td>z</td>
<td>0.8±1.5</td>
<td>0.7±1.5</td>
<td>0.4±1.2</td>
</tr>
</tbody>
</table>

WOLFF: C1 C2 86° ROTATION?
The post-contrast studies showed an enhancing internal vertebral venous plexus (IVVP), which almost completely occupied the extradural space at the atlanto-axial level. During atlanto-axial rotation blood displacement in the IVVP allows major deformations of the extradural space. This prevents dural sac impression.

**Results of movement**

<table>
<thead>
<tr>
<th>Region</th>
<th>Flexion-extension</th>
<th>Rotation</th>
<th>Lateral flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C0-C1</td>
<td>29°</td>
<td>2°</td>
<td>8°</td>
</tr>
<tr>
<td>C1-C2</td>
<td>16°</td>
<td>81°</td>
<td>2°</td>
</tr>
<tr>
<td>Complex</td>
<td>45°</td>
<td>83°</td>
<td>10°</td>
</tr>
<tr>
<td>LC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C0-C1</td>
<td>29°</td>
<td>2°</td>
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</tr>
<tr>
<td>C0-C1</td>
<td>29°</td>
<td>2°</td>
<td>8°</td>
</tr>
<tr>
<td>Total</td>
<td>136°</td>
<td>145°</td>
<td>38°</td>
</tr>
</tbody>
</table>

These are the degrees through the total range of movement in adults. The high cervical complex does almost ½ of the work. The exception is lateral flexion.
CERVICAL LIGAMENTS

Paradoxal extension C0-C1
(inversion)

When the cervical column nears end position flexion sternum and nuchal ligament cause extension C0 - C1.

It occurs only at whole cerv. spine flexion (when the chin meets the chest)

(in a function test this is obvious)

Penning

Because of the fact that in maximal flexion the sternum blocks further capital flexion, the head shifts parallel downward, and causes a translocation in the C0 – C2 complex.

Seen more in adolescents than adults.
The funicular part of the nuchal ligament

The funicular part of the nuchal ligament attaches to the protuberance of the occ. externa and variable to the post. tub. of C1

A false scheme of the nuchal lig.
FUNCTION of ALARE LIGAMENT

acc. to PENNING

MAINTAINS MIDDLE POSITION C2 BETWEEN CONDYLES C0 AND MYELUM

FUNCTION of ALARE LIGAMENT

acc. to: DVOŘAK & PANJABI 1987

• RESTRICTS ROTATION C0 – C1,2 COMPLEX
• ART. VERTEBRAE!!
FUNCTION of ALARE LIGAMENT

PENNING, DVOŘák & PANJABI

• Induces homo-lateral rotation C2 at homonymous lateral flexion C0

LIGAMENT VARIATION HIGH CERVICAL

HUGUENIN

ALARE LIGAMENT ANTERIOR and POSTERIOR
LIGAMENT VARIATION HIGH CERVICAL

DVOŘÁK & PANJABI

ALARE LIGAMENT OCCIPITAL
ALARE LIGAMENT ATLANTAL
ATLANTO DENTAL ANT. LIGAMENT

Some other varieties!
foramen transversarium = pr. transv. + rudimentaire rib
CONCLUSION:
- The normal C0-C1 joint in children 0 to 18 years is tightly held together by ligaments with a mean CCI (C0 – C1 interval) of 1.28 mm in the 89 subjects tested.
- There is great left-right joint symmetry in C0-C1 (left – right difference ≤ 1.09%)
- CCI and left-right symmetry do not appear to change in range of age 0 – 18 yrs.
Making sense of C1

• Movement C0 – C2 is controlled but not determined by C1?

• Without C1 traumatic luxation C0 C2 would more easily occur

• Meniscus

MENISCUS C1??
STABILITY C1

- TRANSVERSE LIGAMENT
- NUCHA LIGAMENT
- COMPRESSION FORCE C0 - C2

NOT ON C1 EN C2!? How the dura is attached to the vertebrae

 EWMM Nederland - cursus Kiss
The differences between higher and lower cerv. region
anatomic, morphological en bio-mechanical.

- Mobile capsules and ligaments
- Almost no muscular stability
- Horizontal orientation of fac. art. sup. C1
  Condyles C0 in infants is in height 50% < rt. adults
- No uncovertebral joints
- Wedge shaped corporae vertebrae *
- Physiological kyphosis
- The center of rotation in the sagittal plane (flexion-extension) is higher *
- Blunt sloping corner in frontal plane of the facies articular superior of the atlas (Sacher)
Child - Adult

- Cartilage – bone proportion is diff. to an adult – mainly cartilage with bone centres up to 14 – 18 years!
- The cartilage in the joints is thicker and more even.
- The dens is not ossified.
- The infants head is equal to 30% of total body weight – in adults is that 10%
- The connection of tissue is more even, and the periarticular tissue reaches further into the periphery. This explains why there is no sound (click - cavitation) during manipulation as expected in adults (discussion)
- Everything is softer, less accentuated.

Why?

The function has not yet determined the shape…

This makes it possible for the baby to survive the extreme physical conditions birth.