International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2016; 2(3): 33-37

www.orthopaper.com
Received: 09-05-2016
Accepted: 10-06-2016

Dr. Bipul Borthakur
Associate Professor, Assam Medical College and Hospital C/O Department of Orthopaedics, Assam Medical College and Hospital, Dibrugarh Assam, India.

Dr. Manabjyoti Talukdar
PG Student, Assam Medical College and Hospital C/O Department of Orthopaedics, Assam Medical College and Hospital, Dibrugarh Assam, India.

Correspondence
Dr. Bipul Borthakur
Associate Professor, Assam Medical College and Hospital C/O Department of Orthopaedics, Assam Medical College and Hospital, Dibrugarh Assam, India.

Cranio-cervical junction and management of C1-C2 dislocation

Dr. Bipul Borthakur and Dr. Manabjyoti Talukdar

Abstract
CCJ is a highly mobile complex junctional zone between skull and spinal column, which comprises the atlanto-occipital and the atlanto-axial joints and houses the spinal cord, multiple cranial nerves etc. Ligaments play a very important role in providing stability and deciding the limits of movements. The joints are responsible for the majority of the movement of the cervical spine and operate on different biomechanical principles.
The mechanical properties of atlantooccipital joint and atlantoaxial joint are determined by bony structures and ligamentous structures respectively. These 2 joints function togetherly to ensure optimal stability and mobility at the CCJ.
The transverse ligament is the major stabilizing ligament and permits rotation to occur while the alar ligaments prevent excessive rotation.
Injuries to CCJ is not uncommon particularly due to RTA and fall from height. Out of various conditions Rheumatoid arthritis is the most common arthropathy of the cervical spine causing inflammation of the joints in the CCJ leading to the instability of the atlantoaxial joint. Infections though rare but pyogenic and tuberculosis may do occur.
The patient presented with a H/O fall from bicycle 2 weeks back leading to weakness of B/L upper and lower limbs with associated abnormal sensation over back of head, neck & upper most part of chest. There was no other injuries and bladder and bowel was normally functioning. On clinical evaluation his power at C5-T1 and L2-S1 levels was 3/5 on the Right side and 4/5 on the Left side with bilateral impaired sensation over the C2, 3, 4 dermatomes and Clinicoradiologically he has been diagnosed as atlanto axial subluxation and Open reduction and internal fixation with Drummond wire was done.

Keywords: Craniocervical junction, Drummond wire

Introduction
CCJ is a highly mobile complex junctional zone between skull and spinal column, comprising of 2 joints—the atlanto-occipital and the atlanto-axial joints—and houses the spinal cord, multiple cranial nerves, and many important blood and lymphatic vessels that supply the head and neck area [1-3]

Bony components – Mainly consists of the bones (Fig 1) forming the atlanto-occipital and atlanto-axial joints [HYPERLINK \l "Dic" 4]

Ligaments – The ligaments play a deciding factor in limiting the movements between atlanto occipital and atlanto axial joints. The 2 most prominent ligaments of the CCJ are the transverse and alar ligaments [4-9].

(1) Transverse ligament
The transverse ligament of the atlas is the key component of the cruciform ligament and is one of the most important ligaments in the body (Figs. 2 and 3)
It is the largest, strongest, and thickest craniocervical ligament (mean height/thickness 6–7 mm) [11].
It maintains stability at the CCJ by locking the odontoid process anteriorly against the posterior aspect of the anterior arch of C-1, and it dividing into 2 compartments: the anterior compartment housing the odontoid process, and the posterior compartment containing primarily the spinal cord and spinal accessory nerves.

The transverse ligament runs posterior to the odontoid process of C-2 and attaches to the lateral tubercles of the atlas bilaterally [1, 11].

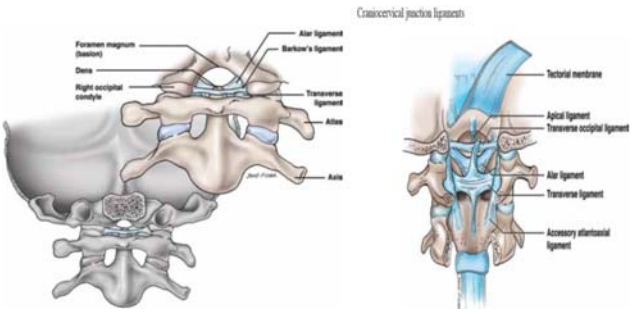

Fig 1 & 2: [HYPERLINK \l "Tub11" 4] Artist's drawing of the posterior CCJ illustrating its numerous specialized ligamentous structures. The tectorial membrane is reflected up and down in this drawing

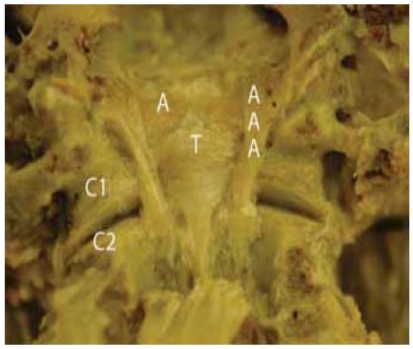

Fig 3: Cadaveric dissection illustrating the view of Fig. 2. Note the transverse ligament (T), alar ligament (A), accessory atlanto occipital membrane (AAA), and the atlas (C1) and axis (C2)

(2) Alar ligament

The alar ligament attaches the axis to the base of the skull.

Besides the major ligaments, there are certain accessory ligaments which also play a vital role in providing stability, however these small ligaments hardly gets mentioned in textbooks.

(3) Transverse Occipital Ligament

It is a small accessory ligament located posterosuperior to the alar ligaments and odontoid process (Figs. 1 and 3). It attaches to the inner aspect of the occipital condyles, posterosuperior to the alar ligament, superior to the transverse ligament, and extends horizontally across the foramen magnum [6, 14].

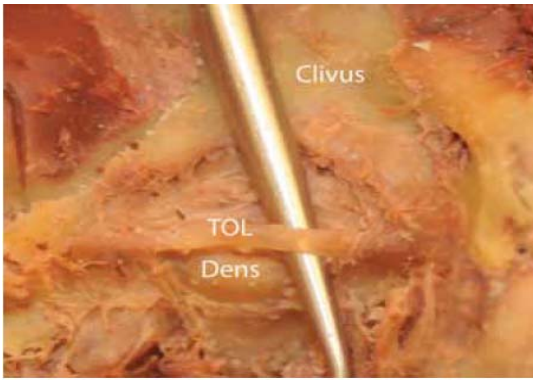

Fig 4: Cadaveric dissection noting the transverse occipital ligament (TOL)

(4) Accessory Atlantoaxial Ligament

The accessory atlantoaxial ligament is an important but often ignored ligament that inserts medially onto the dorsal surface of the axis and courses laterally and superiorly to insert posterior to the transverse ligament on the lateral mass of the atlas (Figs. 2 and 3) [8, 15-17].

(5) Lateral Atlanto occipital Ligament

The LAO ligament just lateral to the anterior atlantooccipital membrane, attaching to the anterolateral aspect of the transverse process of the atlas, and inserting onto the jugular process of the occipital bone [9, 18, 19].

(6) Barkow Ligament

The Barkow ligament is a horizontal band attaching onto the anteromedial aspect of the occipital condyles anterior to the attachment of the alar ligaments [4, 20] (Figs. 6 and 7).

(7) Apical Ligament

The apical ligament, also known as the middle odontoid ligament or suspensory ligament, attaches the tip of the odontoid process to the basion (Fig.). It runs in the triangular area between the left and right alar ligaments known as the supraodontoid space (apical cave) and travels just posterior to the alar ligaments and just anterior to the superior portion of the cruciform ligament [13, 17, 21, 22].

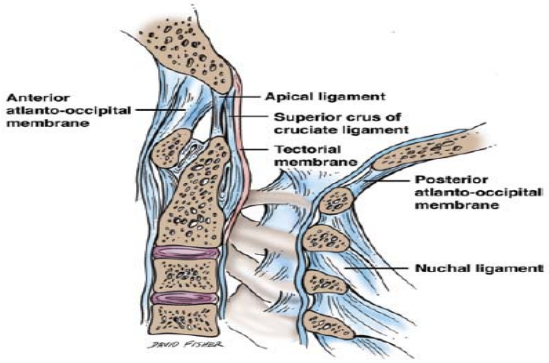

Fig 5: Diagram showing a sagittal view

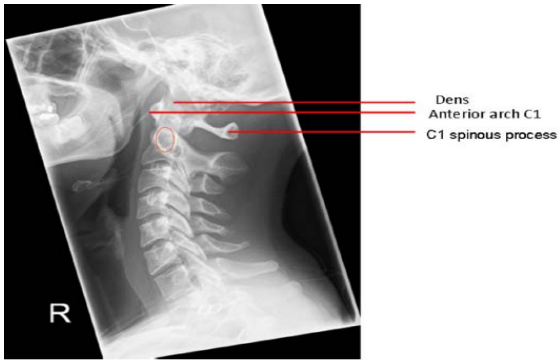

Fig 6: Lateral plain radiograph of the cervical spine demonstrating normal alignment. The red circle is referred to as the Harris' ring at the base of C2. A broken ring indicates a C2 fracture

(8) Tectorial Membrane

The tectorial membrane is a thin structure at the CCJ that serves as the posterior border to the supraodontoid space (Fig.) continues with the posterior longitudinal ligament [17, 23, 24].

The outermost layer is the widest and attaches as far laterally as the hypoglossal canals. The second layer is thicker and runs from the clivus to the body of the axis. A small bursa is often

present between the 2 layers over the odontoid process. The third layer is the deepest and is discontinuous as it attaches to the clivus above and then becomes frayed in the area over the odontoid apex.
Nerves and vessels often run between the different layers of the tectorial membrane.

(9) Posterior Atlantooccipital Membrane
It is a broad, thin ligament that attaches the posterior arch of the atlas inferiorly to the posterior rim of the foramen magnum superiorly (Fig.) [25-27].

(10) Anterior Atlantooccipital Membrane
This is a thin structure that attaching the anterior aspect of the atlas to the anterior rim of the foramen magnum. It is located just posterior to the prevertebral muscles of the neck and anterior to the ligament of Barkow [27-29].

(11) Nuchal Ligament
The nuchal ligament is the cephalic extension of the supraspinous ligament extending from the C-7 spinous process to the inion of the occipital bone. This ligament forms a midline septation dividing the posterior neck muscles on left and right sides [22].

Biomechanics of Cranio Cervical Junction
The atlantooccipital and the atlantoaxial joints are responsible for the majority of the movement of the cervical spine and operate on different biomechanical principles [1, 30].
The mechanical properties of the atlanto occipital and atlantoaxial joint are primarily determined by bony and ligamentous structures respectively. The prominent movements at the atlantooccipital joint are flexion and extension.
The primary movement at the atlantoaxial joint is axial rotation. Although these 2 joints function differently, they must act in unison to ensure optimal stability and mobility at the CCJ [31, 32].
The transverse ligament is the major stabilizing ligament at the atlantoaxial joint. The atlantoaxial joint is responsible for about 47° of rotation at the neck. The transverse ligament permits rotation to occur while the alar ligaments prevent excessive rotation [11, 33, 34].
The alar ligaments function as stabilizing structures of the atlantoaxial joint and act to limit axial rotation and lateral bending on the contralateral side. They are the only ligaments, except the transverse ligament, that are strong enough to stabilize the CCJ and prevent anterior displacement of the atlas. If the transverse ligament ruptures, the alar ligaments become responsible for preventing atlanto axial subluxation [13, 24].
Barkow ligament may function to support the CCJ, limiting extension of the atlantooccipital joint, and may assist the transverse ligament in containing the odontoid process [4].
AAO and PAO are soft-tissue structures critical to maintaining stability of the CCJ.

Common Medical Conditions That Affect the CCJ
There are several arthropathies, infections and traumatic conditions that tend to affect the ligaments of the CCJ.

1) Arthropathy
a) Rheumatoid arthritis is the most common inflammatory disease of the spine and is mostly present in the cranio-cervical region. It causes inflammation of the joints in the CCJ, as well as weakening/degradation of the transverse ligament, and therefore, instability of the atlantoaxial joint. It must be monitored and treated because it can lead to anterior subluxation of the atlas, which may require surgical fixation.
b) Down syndrome is another common pathology involving the ligaments of the CCJ.
c) Calcium pyrophosphate dehydrate deposition disease is another less common pathological entity associated with the transverse ligament presenting as cervical cord myelopathy.
d) The PAO membrane is thought to be involved with cervicogenic headaches due to its apparent interdigitation with the pain-sensitive spinal dural layer

2) Infections: CCJ infection is relatively rare. It may be blood born, secondary to direct spread, post traumatic or iatrogenic (following surgery or percutaneous interventions).
a) **Pyogenic osteomyelitis:** very rare at the CCJ, mostly are staphylococcus aureus infection involving C2 vertebra rarely septic arthritis of atlanto -axial joint are seen.
b) **Grisel Syndrome:** A condition where inflammatory disorders of the upper neck may result in secondary transverse atlantal ligament insufficiency, possibly due to hyperaemia and decalcification of the anterior arch of the atlas. It is seen in children who present with atlanto-axial instability following upper respiratory tract infection.
c) **Craniocervical TB:** Cervical TB accounts for 10 % of all cases of spinal TB, but is very rarely isolated to the CCJ (1% of cases). However it is a relatively common cause of CCJ instability and cervico-medullary compression in the developing world.

3) Tumours: May be benign or malignant and primary or secondary.

4) Trauma: Traumatic causes may be
a) Atlantooccipital dissociation
b) Ligamentous avulsion injuries.
c) Atlas fracture.
d) Atlantoaxial rotatory instability
e) Odontoid peg fractures.
f) Fractures of the axis including Hangman's fractures

Our case of Atlanto axial subluxation
The patient Mukheswar Gogoi 55 years male from Deogharia, Titabor, of Jorhat District presented with a H/O fall from bicycle 2 weeks back leading to weakness of B/L upper and lower limbs with associated abnormal sensation over back of head, neck & upper most part of chest. There was no other injuries and bladder and bowel was normally functioning.
On clinical evaluation his power at C5-T1 and L2-S1 levels was 3/5 on the Right side and 4/5 on the Left side with bilateral impaired sensation over the C2, 3, 4 dermatomes.
Patient was subjected for X ray study initially and later on CT scan of Cervical spine which shows C1 C2 subluxation.
The MRI picture shows significant narrowing of the spinal canal and compression of spinal cord by Dens.
Hence, Clinicoradiologically he has been diagnosed as atlanto axial subluxation and planned for surgery. Open reduction and internal fixation with Drummond wire was done and the various operative steps undertaken were as follows:

Fig 7: X-ray Cervical spine lateral view

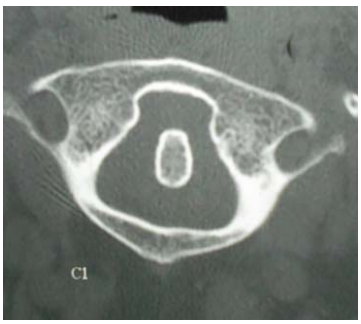

Fig 8: CT scan axial view

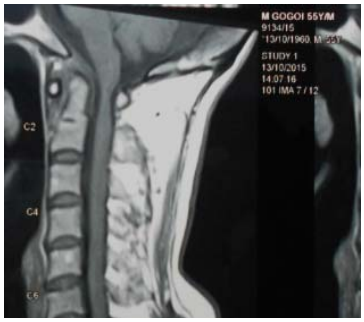

Fig 9: MRI SCAN shows: Atlanto-axial subluxation (ADI O.43 cm) resulting to constriction of upper cervical spinal canal in between odontoid process and posterior arch of atlas.

Fig 10: Position: Prone and Approach: posterior midline

Fig 11: Exposure of spinous processes

Fig 12: Passage of Reduction hook

The patient was positioned prone under GA; with cervical spine fixed in traction.
A posterior midline approach was taken.
2nd Cervical vertebra was identified and separation of soft tissues were done that was bridging between base of skull and 1st Cervical and 1st and 2nd cervical vertebrae.
Undermining of posterior arch of C1 was done and hook was placed anterior to posterior arch of C1.
Similarly another Hook was placed from the superior margin of posterior arch of C1.
Both the hooks were used to pull the C1 posteriorly and reduction was achieved.

Fig 13: Passage of Drummond wire

Fig 14: Final Reduction

Passing on Drummond wire with the help of hook was done and fixed with spinous process of 2nd cervical vertebra.
Following this the wires were tied over.
Fresh autogenous primary cancellous bone graft from the Iliac crest was done-placed between C1 and C2 arch.
(Brooks and Genkin's technique) Post operative Xrays show good reduction and stabilization of C1 - C2 with Drummond wire there was significant improvement of neurological status in post op period.

Conclusion: The ligaments of the CCJ play a vital role in maintaining structural stability in this region. A thorough working knowledge of this anatomy is, therefore, important for clinicians and surgeons who treat patients with conditions affecting this area.

References

1. Menezes AH, Traynelis VC. Anatomy and biomechanics of normal craniovertebral junction (a) and biomechanics of stabilization (b). Childs Nerv Syst. 2008; 24:1091-1100.
2. Menezes AH, Vogel TW. Specific entities affecting the craniocervical region: syndromes affecting the craniocervical junction. Childs Nerv Syst. 2008; 24:1155-1163.
3. Smoker WR, Khanna G. Imaging the craniocervical junction. Childs Nerv Syst. 2008; 24:1123-1145.
4. Tubbs RS, Dixon J, Loukas M, Shoja MM, Cohen-Gadol AA. Ligament of Barkow of the craniocervical junction: its anatomy and potential clinical and functional significance. J Neurosurg Spine. 2010; 12:619-622.
5. Tubbs RS, Grabb P, Spooner A, Wilson W, Oakes WJ. The apical ligament: anatomy and functional significance. J Neurosurg. 2000; 92(2 Suppl):197-200.
6. Tubbs RS, Griessenauer CJ, McDaniel JG, Burns AM, Kumbla A, Cohen-Gadol AA. The transverse occipital ligament: anatomy and potential functional significance. Neurosurgery 2010; 66(3 Suppl Operative):1-3.
7. Tubbs RS, Kelly DR, Humphrey ER, Chua GD, Shoja MM, Salter EG. The tectorial membrane: anatomical, biomechanical, and histological analysis. Clin Anat. 2007; 20:382-386.
8. Tubbs RS, Salter EG, Oakes WJ. The accessory atlantoaxial ligament. Neurosurgery. 2004; 55:400-404.
9. Tubbs RS, Stetler W, Shoja MM, Loukas M, Hansasuta A, Liechty P. The lateral atlantooccipital ligament. Surg Radiol Anat. 2007; 29:219-223.
10. Tubbs RS, Wellons JC III, Banks J, Blount JP, Oakes WJ. Quantitative anatomy of the transverse ligament tubercles. J Neurosurg. 2002; 97(3 Suppl):343-345.
11. Dickman CA, Mamourian A, Sonntag VK, Drayer BP. Magnetic resonance imaging of the transverse atlantal ligamentfor the evaluation of atlantoaxial instability. J Neurosurg. 1991; 75:221-227.
12. Krauss WE, Bledsoe JM, Clarke MJ, Nottmeier EW, Pichelmann MA. Rheumatoid arthritis of the craniovertebral junction. Neurosurgery. 2010; 66(3 Suppl):83-95.
13. Panjabi MM, Oxland TR, Parks EH. Quantitative anatomy of cervical spine ligaments. Part I. Upper cervical spine. J Spinal Disord. 1991; 4:270-276.
14. Lang J. Craniocervical region, osteology, and articulations. Neuro-Orthopedics 1986; 1:67-92.
15. Schaeffer JP. (ed): Morris' Human Anatomy A Complete Systematic Treatise, ed 11. New York: The Blakiston Company, 1953.
16. Yuksel M, Heiserman JE, Sonntag VK. Magnetic resonance imaging of the craniocervical junction at 3-T: observation of the accessory atlantoaxial ligaments. Neurosurgery. 2006; 59:888-893.
17. VanGilder JC, Menezes AH, Dolan KD. The Craniovertebral Junction and Its Abnormalities. Mount Kisco, NY: Futura Publishing Company, 1987.
18. Pick TP, Howden R. (eds): Gray's Anatomy, Descriptive and Surgical. Philadelphia: Lea Brothers, 1901.
19. Rhoton AL Jr: The posterior cranial fossa: microsurgical anatomy and surgical approaches. Neurosurgery. 2000; 47(Suppl):S5-S298.
20. Tuli S, Tator CH, Fehlings MG, Mackay M. Occipital condyle fractures. Neurosurgery. 1997; 41:368-377.
21. Haffajee MR, Thompson C, Govender S. The supraodontoid space or apical cave at the craniocervical junction: a microdissection study. Clin Anat. 2008; 21:405-415.
22. Hecker P. Appareil ligamenteux occipito-atloïdo-axoïdien: étude d'anatomie comparée. Arch Anat Histol Embryol. 1922; 1:417-433.
23. Farley FA, Gebarśki SS, Garton HL. Tectorial membrane injuries in children. J Spinal Disord Tech. 2005; 18:136-138.
24. Krakenes J, Kaale BR, Rorvik J, Gilhus NE. MRI assessment of normal ligamentous structures in the craniovertebral junction. Neuroradiology. 2001; 43:1089-1097.
25. Zumpano MP, Hartwell S, Jagos CS. Soft tissue connection between rectus capitus posterior minor and the posterior atlanto-occipital membrane: a cadaveric study. Clin Anat. 2006; 19:522-527.
26. Tubbs RS, Wellons JC III, Blount JP, Oakes WJ. Posterior atlantooccipital membrane for duraplasty. Technical note. J Neurosurg. 2002; 97(2 Suppl):266-268.
27. Hack GD, Koritzer RT, Robinson WL, Hallgren RC, Greenman PE. Anatomic relation between the rectus capitis posterior minor muscle and the dura mater. Spine. 1995; 20:2484-2486.
28. Thompson VP. Anatomical research lives! Nat Med. 1995; 1:297-298.
29. Williams PL. (ed): Gray's Anatomy: The Anatomical Basis of Medicine and Surgery, ed 38. London: Churchill Livingstone, 1996
30. Panjabi M, Dvorak J, Crisco J III, Oda T, Hilibrand A, Grob D. Flexion, extension, and lateral bending of the upper cervical spine in response to alar ligament transections. J Spinal Disord. 1991; 4:157-167.
31. Martin MD, Bruner HJ, Maiman DJ. Anatomic and biomechanical considerations of the craniovertebral junction. Neurosurgery. 2010; 66(3 Suppl):2-6.
32. Nassos JT, Ghanayem AJ, Sasso RC, Tzermiadianos MN, Voronov LI, Havey RM *et al*. Biomechanical evaluation of segmental occipitoatlantoaxial stabilization techniques. Spine. 2009; 34:2740-2744.
33. Cattrysse E, Barbero M, Kool P, Gagey O, Clarys JP, Van Roy P. 3D morphometry of the transverse and alar ligaments in the occipito-atlanto-axial complex: an in vitro analysis. Clin Anat. 2007; 20:892-898.
34. Driscoll DR. Anatomical and biomechanical characteristics of upper cervical ligamentous structures: a review. J Manipulative Physiol Ther. 1987; 10:107-110.