CRANIOVERTEBRAL JUNCTION ANOMALIES- DIAGNOSIS AND MANAGEMENT

PRESENTER- DR ANAND V K

MODERATOR- DR P S CHANDRA

DEPARTMENT OF NEUROSURGERY
AIIMS, NEW DELHI

9/2/2011

RADIOLOGY OF CVJ

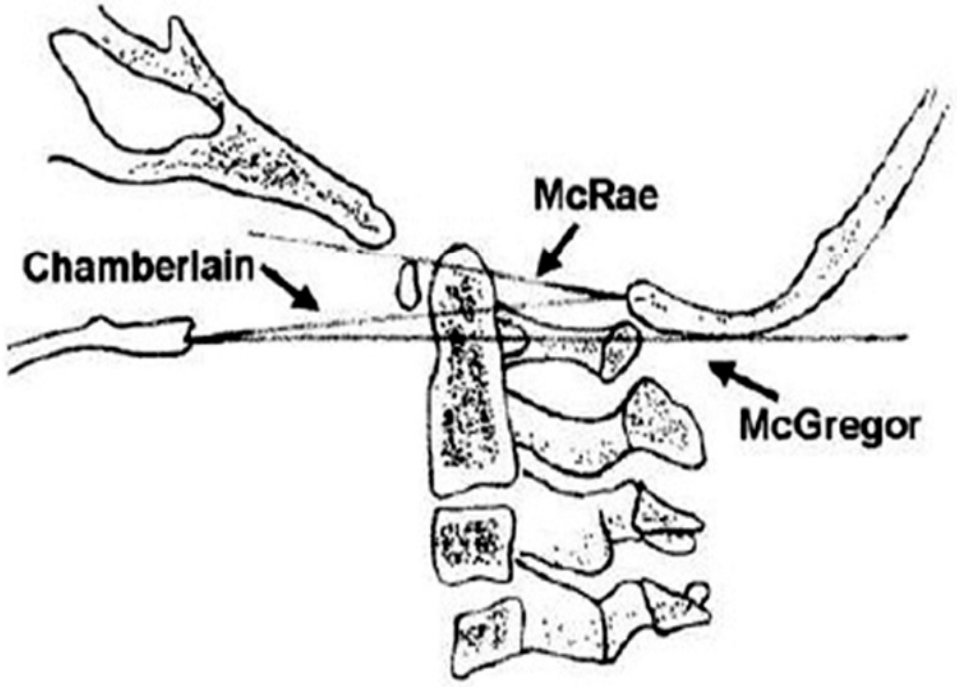
CRANIOMETRY:

- Uses a series of lines, planes & angles to define the normal anatomic relationships of the CVJ.
- Plain Xrays,3DCT or on MRI.
- No single measurement is helpful.
- Disadvantages ;; anatomic structures and planes vary within a normal range.

RADIOLOGY OF CVJ

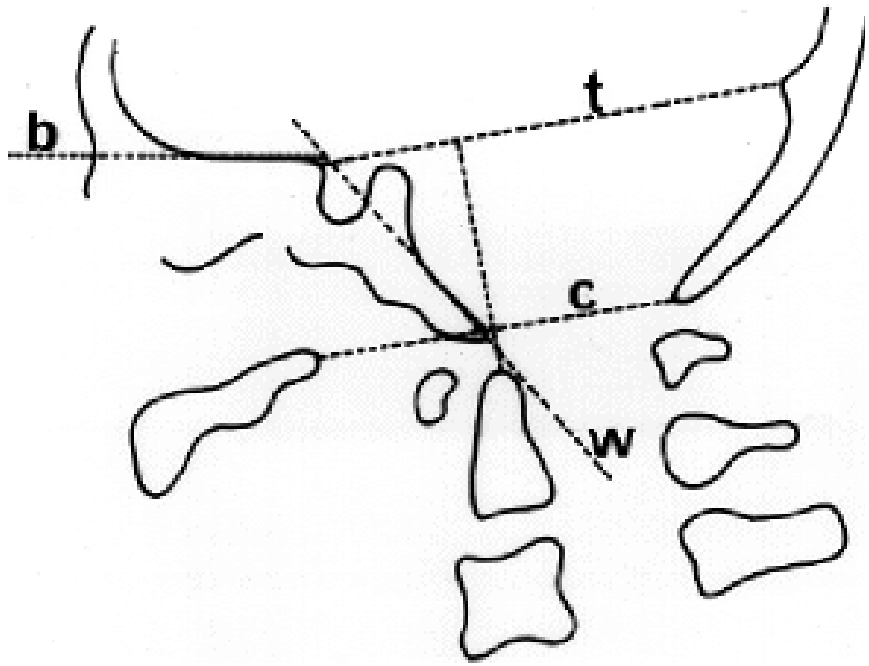
LATERAL PROJECTION OF SKULL X-RAY:

- Palato–occipital (Chamberlain's line) (>5 mm)
- Palato–suboccipitalline (McGregor line) (> 7mm)
- Foramen magnum line (McRae line) (Tip of dens below this line)



RADIOLOGY OF CVJ

- Height of the posterior cranial fossa (Klaus Index) (<30 mm - BI)
- Wackenhein's clival canal line (Tip of dens lies below)
- Bull's angle (Atlanto - palatal angle) (< 10^0 – normal , >13 BI)

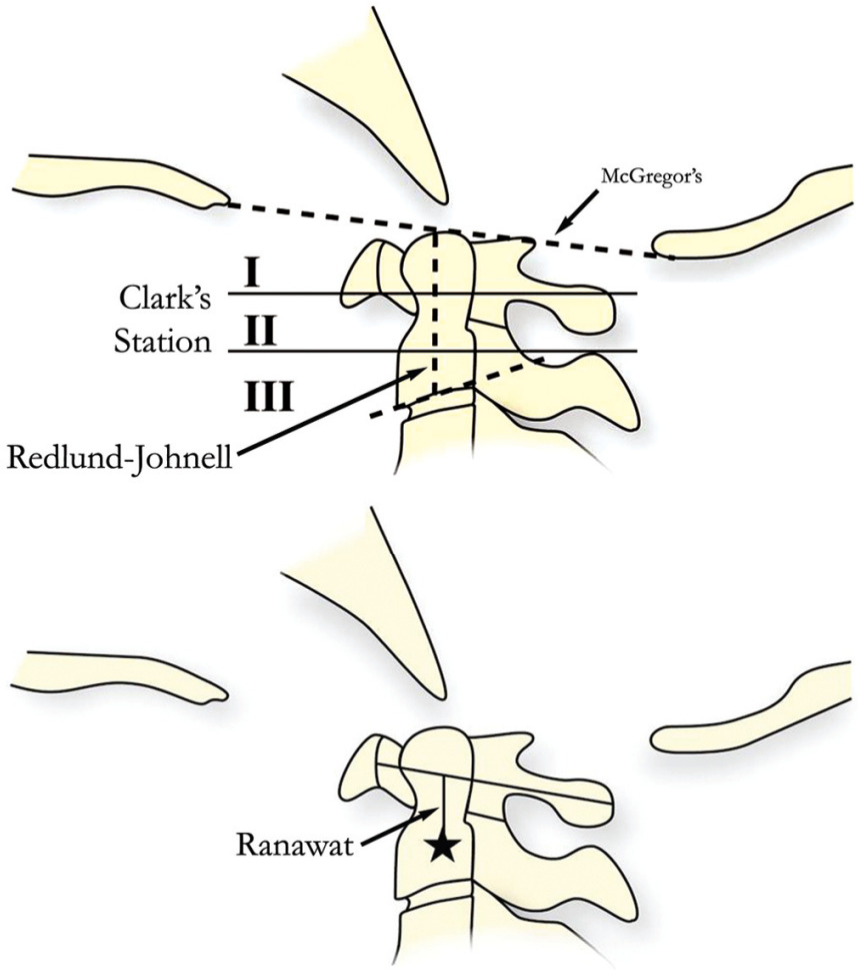


RADIOLOGY OF CVJ

Clark's station (BI - if ant ring of C1 is in zone II or III)

Redlund - Johnell (normal > 34 mm)

Ranawat (if < 15 mm – BI)



RADIOLOGY OF CVJ

FRONTAL PROJECTION OF SKULL X-RAY:

- Bimastoid line (Fischgold & Metzer)
- Bidigastric line (Fischgold & Metzer)
- Condylar angle (Schmidt & Fischer)

FOR DIAGNOSIS OF PLATYBASIA:

- Basal angle (Welcher)
- Boogard's angle

OCCIPUT ANOMALIES

THE OCCIPUT :

- The basi occiput forms the lower portion of the clivus.
- The upper portion of the clivus is formed by the basisphenoid, separated from the basi occiput by the sphenooccipital synchondrosis.
- The age at which this synchondrosis fuses ranges from “after the 12 yr” – 14 yrs for girls and 16 yrs for boys.
- Most occipital anomalies are associated with decreased skull base height and basilar invagination.

CondylusTertius:

- Proatlas persists or when it fails to integrate, an ossifled remnant may be present at the distal end of the clivus, called the condylus tertius or 3rd occipital condyle.

CondylusTertius:

- This third condyle may form a joint or pseudojoint with the odontoid process or with the anterior arch of the atlas and may lead to limitation in the range of motion of the CVJ.

- There is an increased prevalence of os odontoideum associated with this abnormality.

Condylar Hypoplasia:

- In condylar hypoplasia, the occipital condyles are underdeveloped and have a flattened appearance, leading to BI (violation of the Chamberlain line) and widening of the atlanto occipital joint axis angle.

- The lateral masses of the atlas may be fused to the hypoplastic condyles, further accentuating the BI.

- Condylar hypoplasia limits, or may even abolish, movements at the A-O joint.

Atlanto-occipital Assimilation / Occipitalization of Atlas:

- The failure of segmentation between the skull and first cervical vertebra results in assimilation of the atlas.
- Incidence – 0.08 to 3 %.
- India – 40 to 50 % are associated among CVJ anomalies.
- The assimilation may be complete or partial.
- It invariably results in basilar invagination.
- Wackenheim clivus baseline may be normal, but the clivus-canal angle may be decreased.

TOPOGRAPHIC FORMS (WACKENHEIM):

- ***Type I: Occipitalization (generally subtotal) associated with BI.***
- ***Type II: Occipitalization (generally subtotal) associated with BI & fusion of axis & 3rdcervical vertebrae.***
- ***Type III: Total or subtotal occipitalization with BI & maldevelopment of the transverse ligament.***
- Type III may be associated with various malformations like C2-C3 fusion, hemivertebra, dens aplasia, tertiary condyle, etc.

Contd…

- The neurological symptoms are not caused by occipitalization proper but rather by the fact that in the absence of a free atlas, TL fails to develop which causes posterior displacement of axis & compression of the spinal cord.

- Instability b/w atlas & axis is reducible in patients <15 yr's but after that irreducible state occurs.

- Its combination with segmentation failure of 2nd& 3rdcervical vertebrae results in gradual loosening of the atlanto-dental joint with progressive atlanto-axial luxation in children in about 50% of cases.

ATLAS :

- With the exception of the various atlanto occipital assimilations, most atlas anomalies, when isolated, produce no abnormal CVJ relationships and are not associated with basilar invagination.

- The vast majority of anomalies consist of various arch clefts, aplasias, and hypoplasias.

- Arch anomalies are frequently mistaken for fractures in the evaluation of plain radiographs of patients with a history of cervical spine trauma.

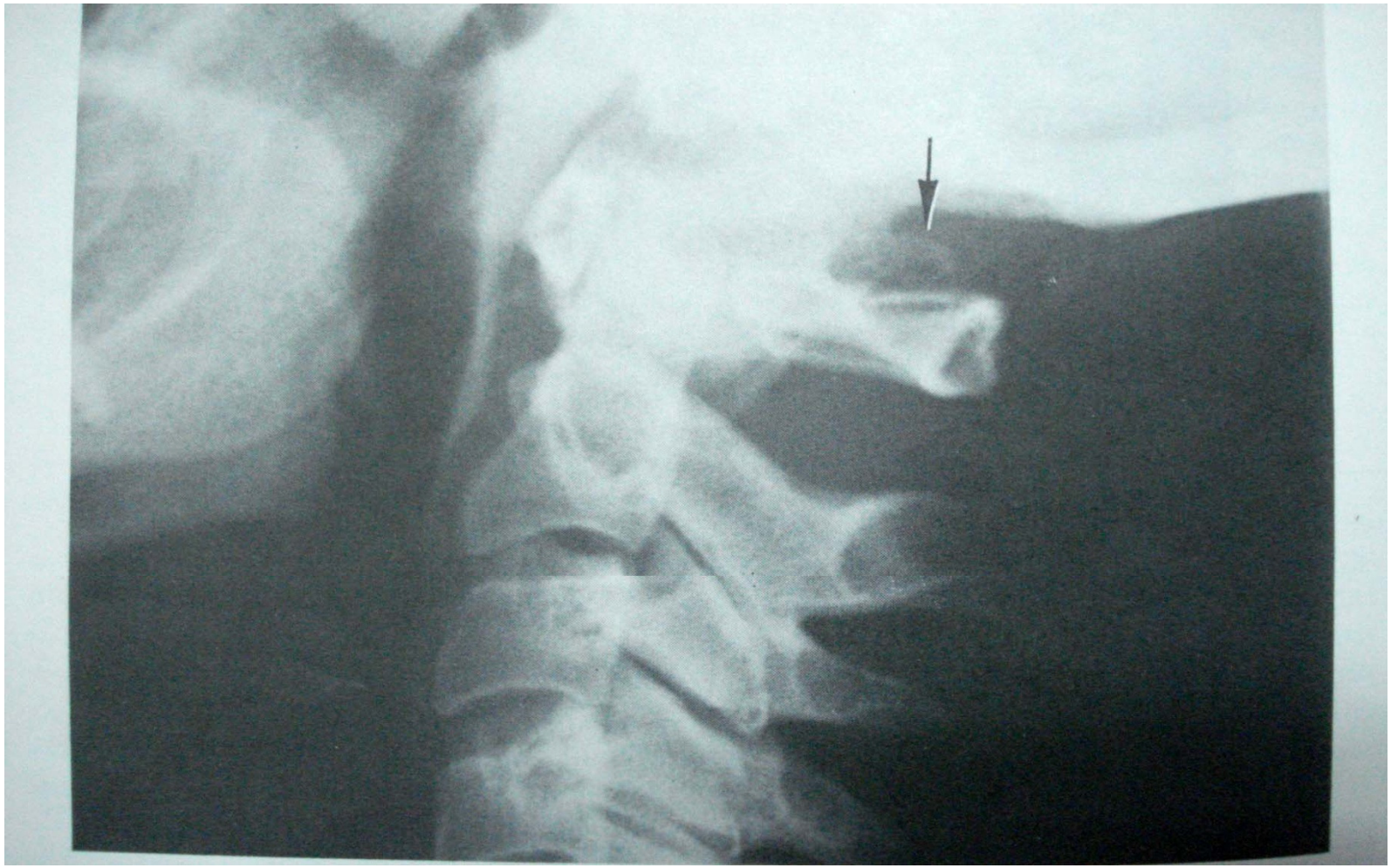
PONTICULUS POSTICUS / KIMMERLE'S DEFORMITY :

- It is a bony ridge projecting posteriorly from the articular edge of the atlas superior articular facet.

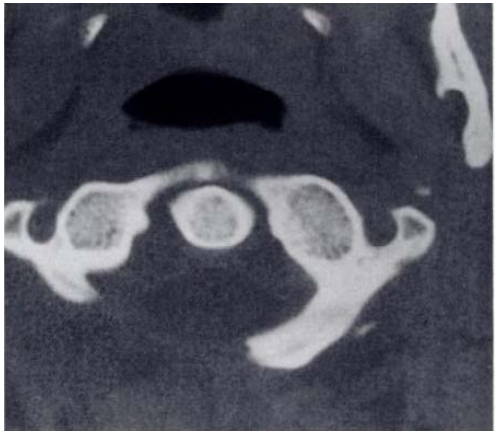
- The bony projection may be only a few mm long or may elongate to unite with the adjacent neural arch of the atlas to produce an "*ARCUATE CANAL" through which the vertebral artery passes.*

- This is due to ossification of a portion of the oblique A-O ligament.

Ponticulus posticus



Posterior Arch Anomalies (MC atlas anomaly) :



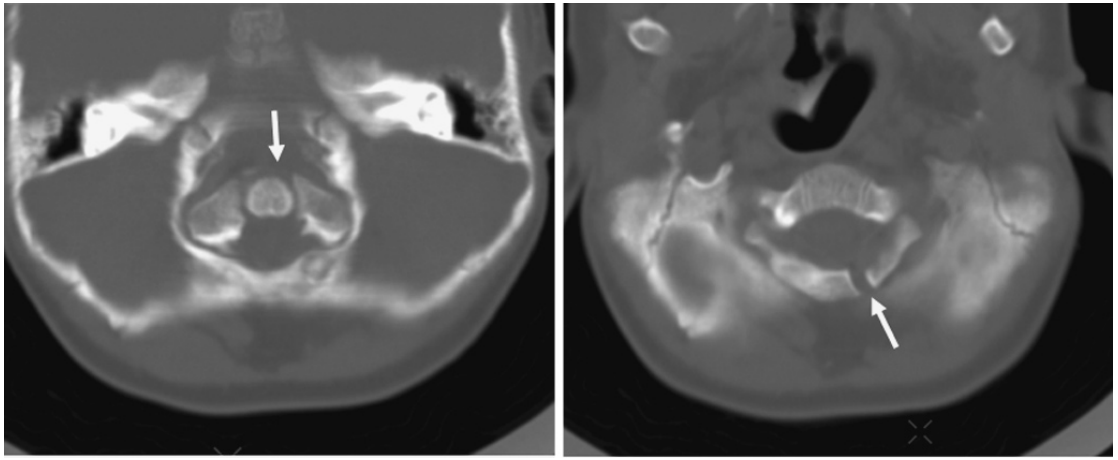
- Total or partial aplasia of the posterior atlas arch is rare.
- Although absence of the posterior arch, when isolated, is usually asymptomatic, but may be associated with anterior atlantoaxial subluxation.

- Bilateral atlantoaxial subluxation may be associated with both total and partial aplasias, simulating the Jefferson fracture.

Contd…

- Clefts of the atlas arches are much more common.
- Posterior rachischis is, most common, is observed in *4% of adults.*
- The majority of posterior atlas clefts (97%) are midline, whereas lateral clefts, through the sulcus of the vertebral artery, account for the remaining 3%.
- Posterior arch rachischis may be superimposed on the odontoid process or the axis body on the open-mouth odontoid view, simulating a fracture.

SPLIT ATLAS:



- In contrast to posterior arch rachischis, anterior arch rachischis quite rare (0. 1 %).
- Typically encountered in association with posterior rachischis -“*split atlas”.*

- Normally, on a lateral radiograph, the anterior arch of the atlas appears crescentic or half-moon-shaped, with dens cortical bone surrounding the medullary cavity and a well-defined predental space.

- In anterior arch rachischis , the anterior arch appears fat or plump and rounded in configuration, appearing to ‘‘overlap’‘ the odontoid process (making identification of the predental space impossible); the arch may have un sharp, duplicated anterior margins

CONGENITAL ODONTOID ANOMALIES OR DYSPLASIAS

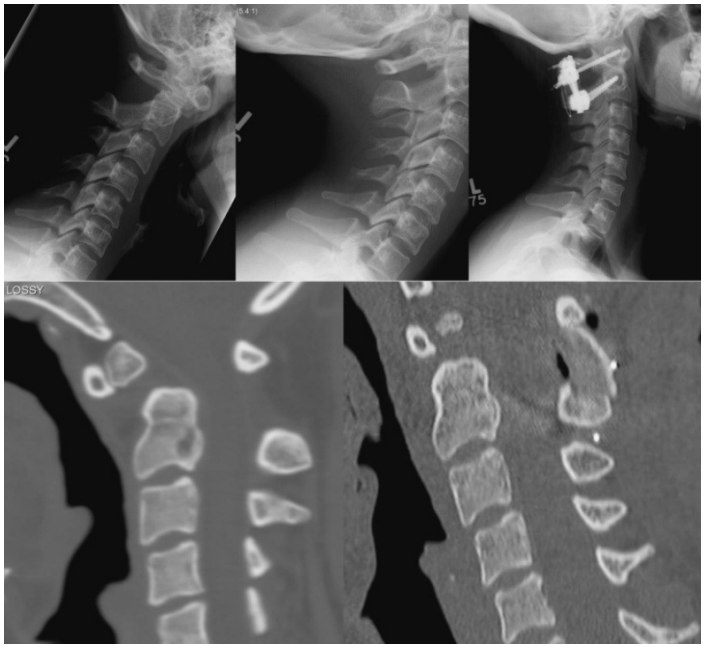
- Type I : Os odontoideum
- Type II : Ossiculum terminale
- Type III : Agenesis of odontoid base
- Type IV : Agenesis of apical segment
- Type V : Agenesis of odontoid

OS ODONTOIDEUM

- *Giacomini (1886) ,*
- *independent osseous structure lying cephalad to the axis body in the location of the odontoid process.*
- The anterior arch of C1 rounded, posterior arch - hypoplastic.
- Congenital / Traumatic (current Hypothesis) / vascular.
- Orthotopic / Dystopic (unstable)
- Associated with connective tissue disorders.

Os Odontoideum : Etiology and surgical Management ; ARVIN ET AL ; Neurosurgery / vol 66/ no 3/ march 2010 suppl

Contd…



- Reducible – on flexion, dorsal compression of the cord occurs but on extension ventral compression occurs secondary to increased angulation anteriorly.
- Irreducible – due to displacement of TL ventral to the ossicle.

- C/F – Asymptomatic
  - Neck pain --- C2 – may be only symptom
  - myelopathy.
  - VBI
- D/D – Ossiculum terminale Persistence

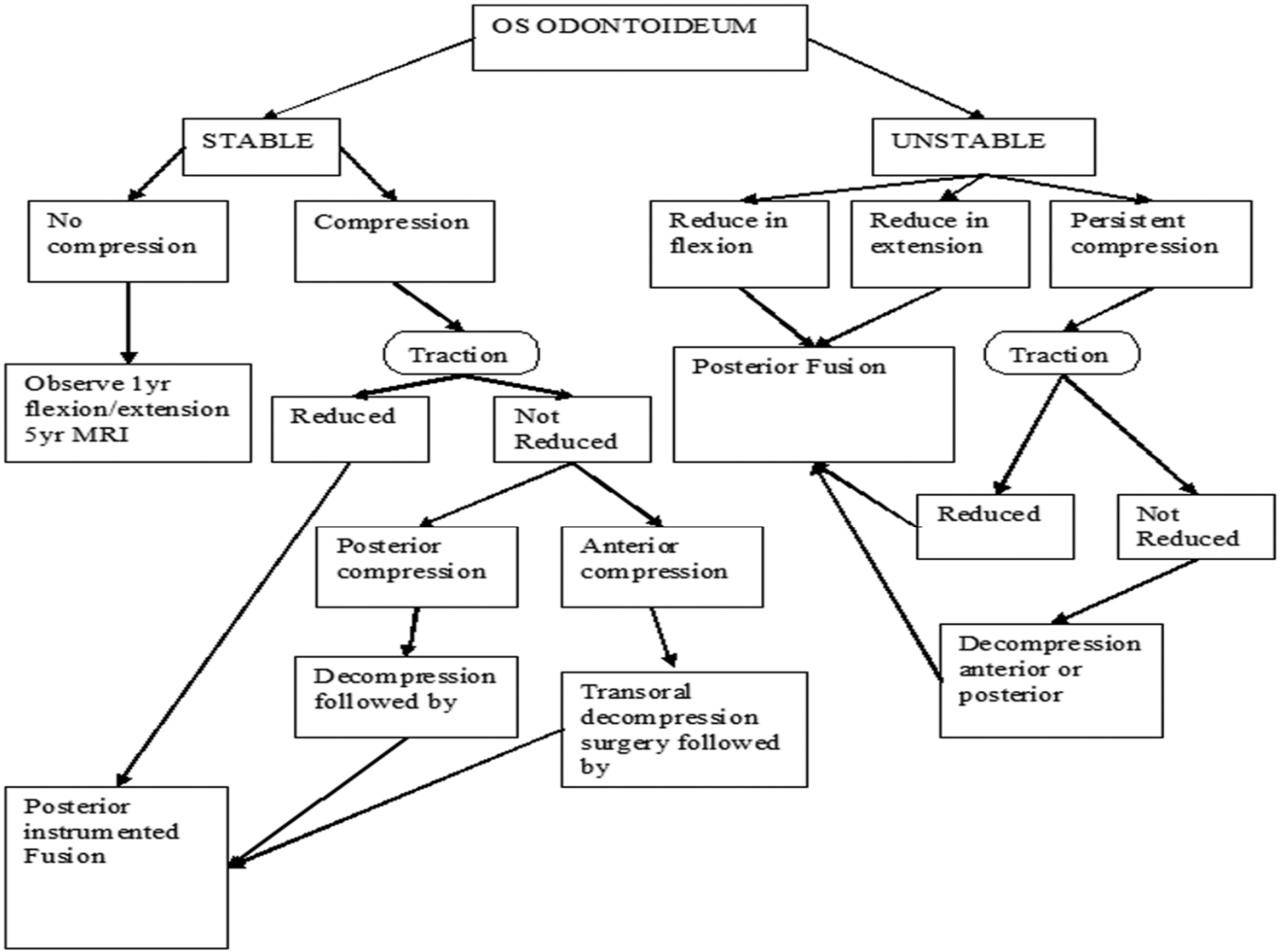
OS ODONTOIDEUM

Treatment:

- Use of traction --- Controversial.

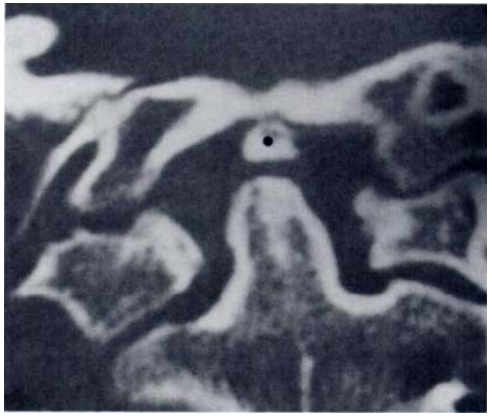
Surgical Techniques:

- Goal --- Remove compression at FM
  --- Stabilize spine in relation to subaxial spine.



Suggested algorithm for the management of a patient with os odontoideum. MRI, magnetic resonance imaging.

Persistent OssiculumTerminale



- Also called Bergman ossicle, results from failure of fusion of the terminal ossicle to the remainder of the odontoid process.
- The fusion typically is accomplished by 12 years of age.
- Bergman ossicle may be confused with a type 1 odontoid fracture (avulsion of the terminal ossicle), and absolute differentiation between the two diagnoses may be difficult.
- Whether traumatic or congenital in origin, this anomaly is stable when isolated and of relatively little clinical significance.
- The odontoid process is usually normal in height.

Odontoid Aplasia:

- Total aplasia of the odontoid process is extremely rare.
- A true aplasia is associated with an excavation defect into the body of axis.
- may simulate os odontoideum, as the os fragment may be perfectly projected over the atlas arch on the open mouth odontoid view.

KLIPPEL FEIL SYNDROME

- Described first by Klippel and Feil in 1912.
- Etiology is unknown.
- Segmentation failure of cervical somites during the third and eighth weeks of gestation.
- Classic triad (50%) --- Low posterior hair line, short neck and limited neck movements.

TYPES:

- Type 1: Cervical spine fusion in which elements of many vertebrae are incorporated into a single block.
- Type 2: Cervical spine fusion in which there is failure of complete segmentation at only one or two cervical levels and may include an occipito – atlantal fusion.
- Type 3: Type 1 or type 2 fusion with co-existing segmentation errors in the lower dorsal or lumbar spine.

KLIPPEL FEIL SYNDROME

ASSOCIATED CONDITIONS:

- Scoliosis- Up to 60% have >15 degrees curve.
- Genito- urinary- up to 65%.Most common is absence of kidney.
- Sprengel's deformity- approx. 35%
- Cardio - pulmonary- 5-15%, most commonly V.S.D.
- Deafness-30%, all types, MC mixed.
- Sykinesis - Mirror motions have been described in up to 20% of patients under the age of 5.
- Cranio- cervical abnormalities (25%) -Includes C1-C2 hypermobility and instability, BI, Chiari I malformation, diastematomyelia, & syringomyelia.

KLIPPEL FEIL SYNDROME

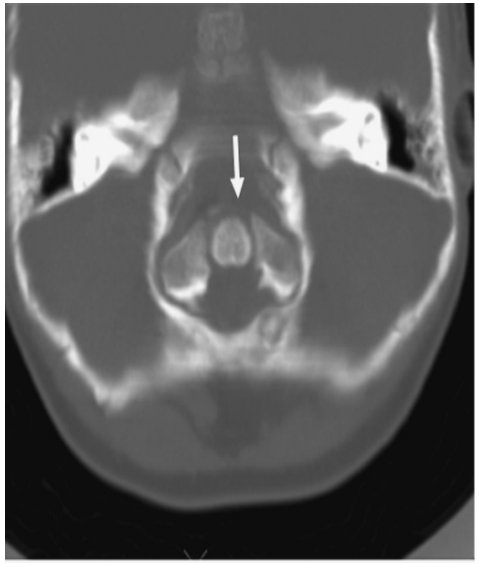
SYMPTOMS:

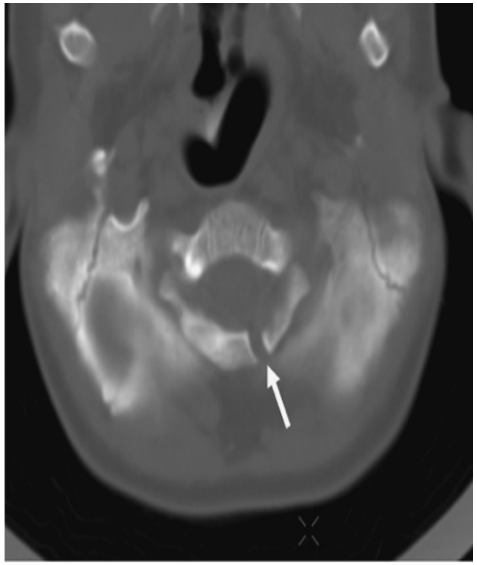
- Due to the hypermobility occurring at the open segments, can lead to either frank instability or osteoarthritis.
- Mechanical symptoms due to joint irritation.
- Neurologic symptoms due to root irritation or spinal cord compression.

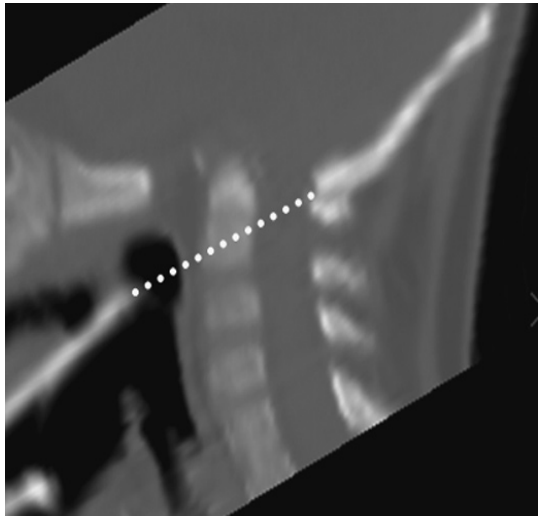
MANAGEMENT :

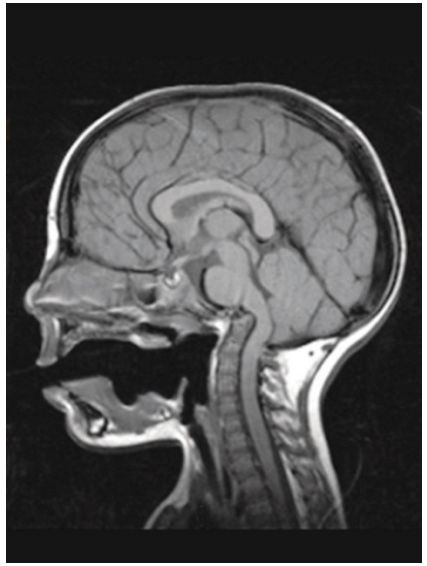
- Usually conservative, rarely surgery required.

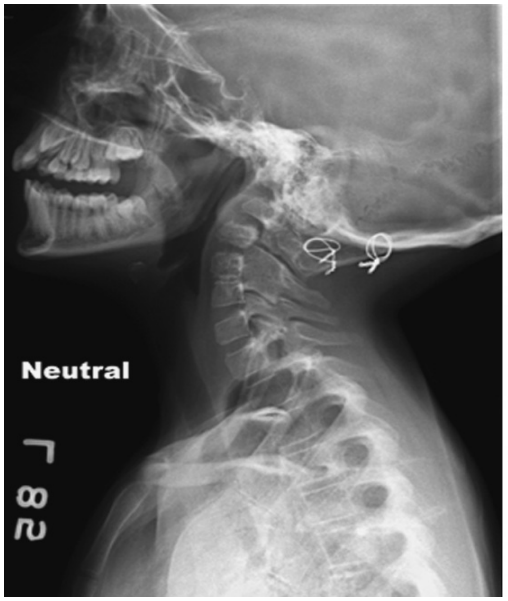
The CVJ and its Abnormalities by John C. VanGilder / Arnold H. Menezes / Kenneth D.Dolan ; University of Iowa School of Medicine.











Posteroanterior ***and lateral cervical radiographs***
*Demonstrate basilar invagination, partial atlanto-occipital assimilation, and fusion of the posterior elements of C4 to 5 (Klippel-Feil anomaly)****CT imaging*** *shows unfused ring of C1 (arrow). The Chamberlain line is demarcated*
by the dotted white line, and the tip of the odontoid lies 14 mm above this line.

MR imaging shows
Severe BI
follow up x -ray cervical spine

Smith and Menezes ; Basilar Invagination : Neurosurgery vol 66 / no 3/ march 2010 suppl

BASILAR INVAGINATION

- The floor of the skull is indented by the upper cervical spine, & hence the tip of odontoid is more cephalad protruding into the FM.

- Primary invagination – developmental, MC
- Secondary invagination -- Acquired.

- Primary BI--- associated with occipitoatlantal fusion, hypoplasia of the atlas, a bifid posterior arch of the atlas, odontoid anomalies.
- 25 – 35% -- ACM , Syringomyelia , Hydrocephalous
- VA anomalies common

BASILAR INVAGINATION

Topographic types of BI :

- Anterior BI : hypoplasia of the basilar process of the occipital bone.
- Posterior BI: posterior margin of the FM is invaginated.
- BI in the lateral condylar area.
- Unilateral BI.
- BI of the occipital condyles (Paramedian BI) – Condylar hypoplasia
- Generalized BI

BASILAR INVAGINATION

- *<u>SIGNS / SYMPTOMS:</u> usually occur in 2nd or 3rd decade.*
- Short neck(78%), torticollis (68%) , low hair line (48%), Webbed neck (47%) are local findings
- s/s of associated ACM (cerebellar & vestibular disturbances) & syringomyelia (25 to 35%).
- Motor & sensory disturbances (85%).
- Lower cranial nerves involvement
- Headache & pain in the nape of neck (greater occipital N)
- s/s of raised ICP (HCP) due to posterior encroachment which causes blockage of aqueduct of sylvius.
- Compression of cerebellum & vestibular apparatus leading to vertical or lateral nystagmus (65%) (not due to direct pressure from post rim of FM but rather due to a thickened band of dura).
- Vertebral artery insufficiency s/s.

IMAGING

Imaging Parameters:

- Should be suspected if C1C2 facet complex can not be visualized in open mouth AP view of CVJ X-ray.

Lateral Xray:

- Chamberlain line – 5 mm.
- Mc Gregor line – 7 mm.
- Mc Rae line – Tip should be below .

  --- FM < 19 mm.
- MRI --- Soft tissue , ligaments ,cord signal changes, severity of BI

BASILAR INVAGINATION

Surgical treatment : Indications

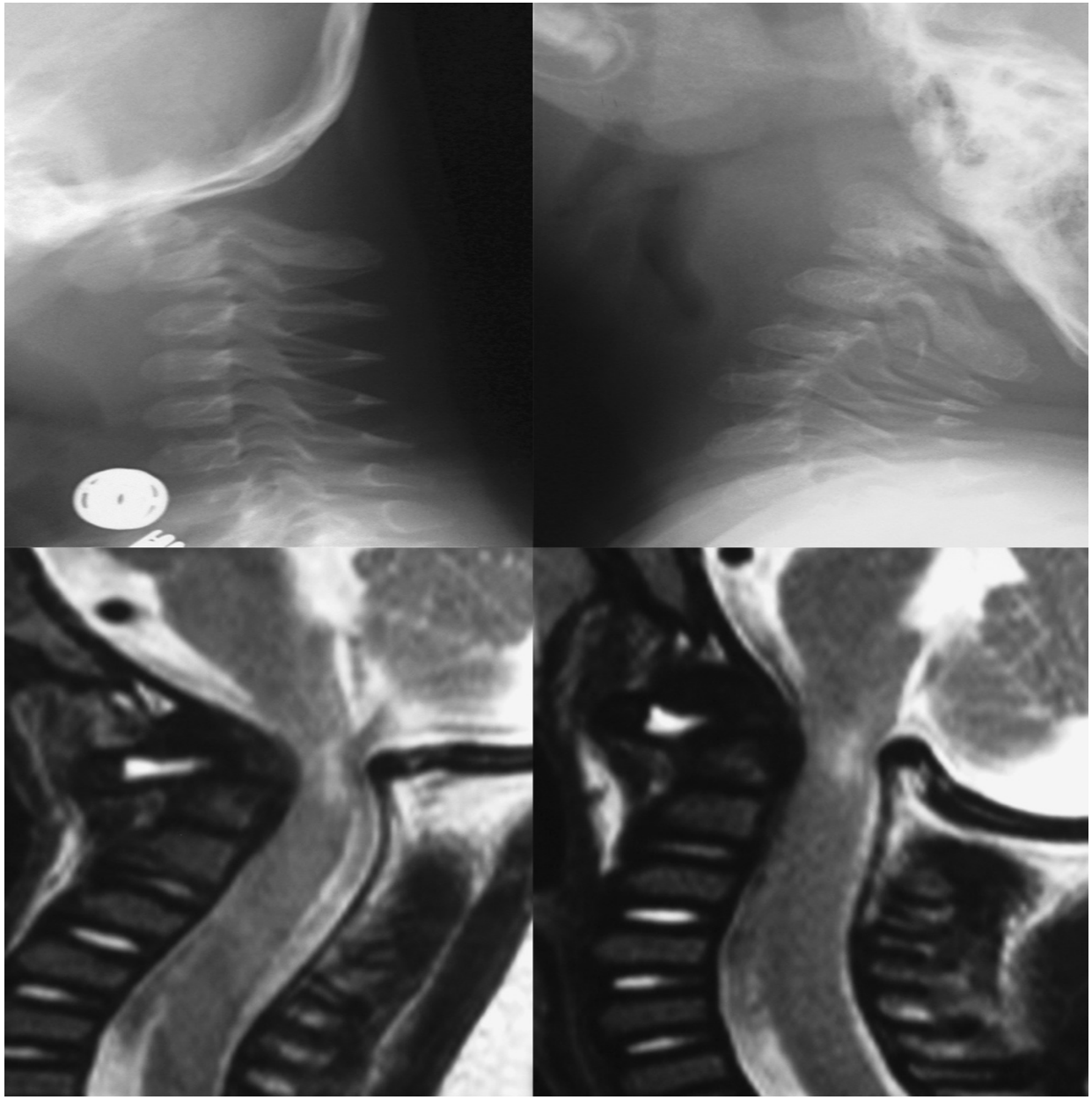
- All symptomatic patients.
- Subset of neurologically intact patients with mild BI and lack of significant compression may be followed up.

- If Reducible --- posterior decompression with fusion.
- Irreducible --- Anterior decompression + Posterior fusion.

CVJ ANOMALIES IN DOWN SYNDROME

- First described in 1965 by Tishler & Martel.
- Characterized by increased ligamentous laxity and abnormal joint and bony anatomy (abnormal curved shape of Occipital condyle and C1 articular facet).
- Incidence of radiologic AA instability -- 7-40%,

  < 1% of patients are symptomatic.
- Bony anomalies involving the occipital condyle , C1 ring, and Os odontoideum (6%) also increased in Down syndrome.
- Dense not secured against ant arch of C1 during flexion / Extension. May also have rotatory instability.



Pre op flexion / extension X-ray and Dynamic MRI (T2WI , Sag) images in Down syndrome

CVJ ANOMALIES IN DOWN SYNDROME

Radiological Screening & Recommendations

(AAP -2007)

- Os odontoideum --- Sx.
- Canal width < 14 mm
  with or without ADI > 5 mm

↓

MRI

-- Signal changes

-- Significant Compression

--- No SCI

↓

-- Follow up – 1 yr

-- Restriction of high risk activities

- Symptomatic compressions – surgery.

CVJ ANOMALIES IN DOWN SYNDROME

SURGICAL TREATMENT :

- In most cases – Posterior instrumentation + Fusion.

  Transoral decompression – if irreducible Ventral compression.
- Fusion rate 58 – 95% (Screw based fixation)

  Wire based fixation 40% (? Resorbed bone graft)

Hakinson and Anderson et al : CVJ abnormalies in Down syndrome : Neurosurgery/vol 66/ no 3/ march 2010 suppl

ATLANTO-AXIAL DISLOCATION OR INSTABILITY

GREENBERG'S CLASSIFICATION;

- Incompetence of the odontoid process-
- Incompetence of the Transverse ligament

WADIA CLASSIFICATION :

- *Group I: AAD with occipitalization of atlas & fusion of C2 & C3.*
- *Group II: odontoid in competence due to its maldevelopment with no occipitalization of atlas.*
- *Group III: odontoid dislocation but no maldevelopment of dens or occipitalization of atlas.*
- 57% of all CVJ anomalies.
- 8.3% of all causes of cervical compression

ATLANTO-AXIAL DISLOCATION OR INSTABILITY

- On the open mouth odontoid view, the combined spread of the lateral masses of C1 on C2 should not exceed 6.9 mm.
- > 6.9 mm -- rupture of the transverse ligament.
- An atlantoaxial distance greater than 4-5 mm, as demonstrated by lateral radiographs, is indicative of AAI.

ATLANTO-AXIAL DISLOCATION OR INSTABILITY

- Posterior atlantodental interval (PADI) measured from the posterior border of the dens to the anterior border of the posterior tubercle.
- This index may be more important because it more directly assesses the spinal canal width.
- Normal range 19 –32 mm in male & 19 –30mm in females.
- Below 19mm, neurological manifestations occur.

ATLANTO-AXIAL DISLOCATION OR INSTABILITY

- Type I injuries (stable subluxations) – Hard Collar.
- Type II injuries may be potentially unstable.
- Type III and IV rotatory displacements that are unstable are treated surgically with a reduction and C1-2 fusion.

- The techniques of fusion vary from sublaminar wiring techniques like Brooks or Gallie, Halifax clamp, or transarticular screw of Magerl.

SURGICAL APPROACHES FOR VENTRAL DECOMPRESSION

- Anterior :
  - Standard transoral approach.
  - Extended transoral approaches.

    --- Transoral mandibulotomy

    --- Transoral mandibulotomy + Palatotomy

    --- Transoral mandibulotomy + glossotomy

    --- Transoral + Lefort I Maxillotomy.

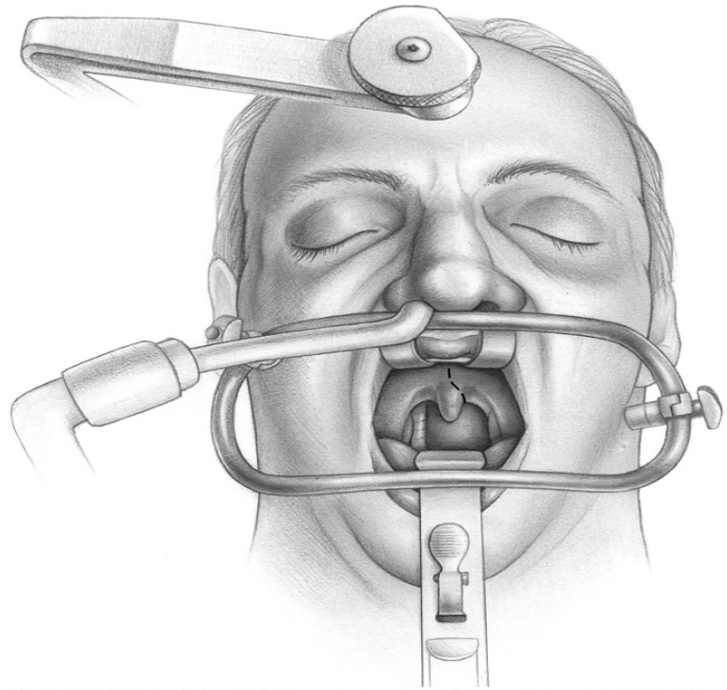
  - Endoscopic transoral approach
- Lateral extrapharyngeal approach

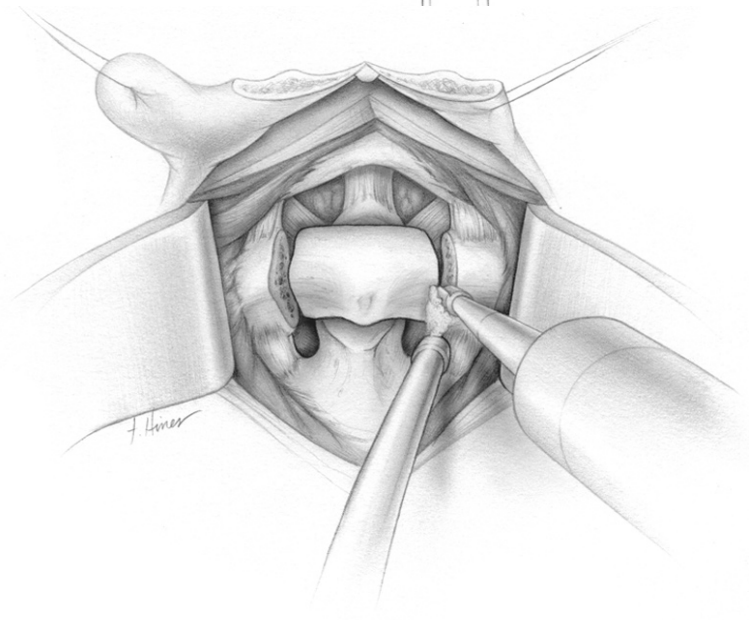
TRANS ORAL APPROACHES

- 1st by – kanavel (1919)
- Fang and Ong (1962)
- Arnold Menezes (1977)
- Interdental opening -- > 25mm

- Why ?
  - --- Performed in midline avascular plane
  - --- most direct route to osseous and soft tissue abnormalities ventral to brainstem & CVJ.
  - --- ICA; Masticatory muscles, TM Joint VII N, Vestibulocochlear apparatus are avoided

- Important to identify C1 tubercle.
- 15 mm wide trough is created in the arch of C1.
- Along with odontoid, Alar, apical, transverse ligaments should be severed.
- Remove all the granulation tissue till pulsatile dura clearly visible.
- Inadvertant dural puncture – Sealed immediately.





- Standard approach :

  1) Lower clivus to C2C3 interface.

  2) No uniform consensus regarding extent of exposure.

  3) palatotomy increases exposure to mid clivus.

- Mandibulotomy ;

  --- shortens the operative distance.

  --- Provides wide angle.

  --- mid clivus to C2C3 interface

- Mandibulo glossotomy ;

  --- Further reduces the distance

  --- Upper 1/3 clivus to C3-C4 interface.

- Mandibulo glossotomy + Palatotomy ;

  --- extends rostral exposure to spenoid sinus.

  --- At the cost of velopharyneleal insufficiency (30%) dysphagia, nasal regurgitation hypernasal voice.

COMPLICATIONS

- Early

-- bleeding
-- soft tissue swelling
-- infection
-- CSF leak
-- wound breakdown
-- dislocated mandible
-- nausea, vomiting, aspiration
-- blocked eustachian tube

Late

-- velopharyngeal insufficiency
-- nasal regurgitation
-- nasal speech
-- poor mouth opening
-- dental malocclusion

Intermediate

-- delayed arterial bleeding
-- wound break down
-- wound / chest infection
-- CSF leak
-- velopharyngeal insufficiency
-- nasal voice
-- nasal regurgitation

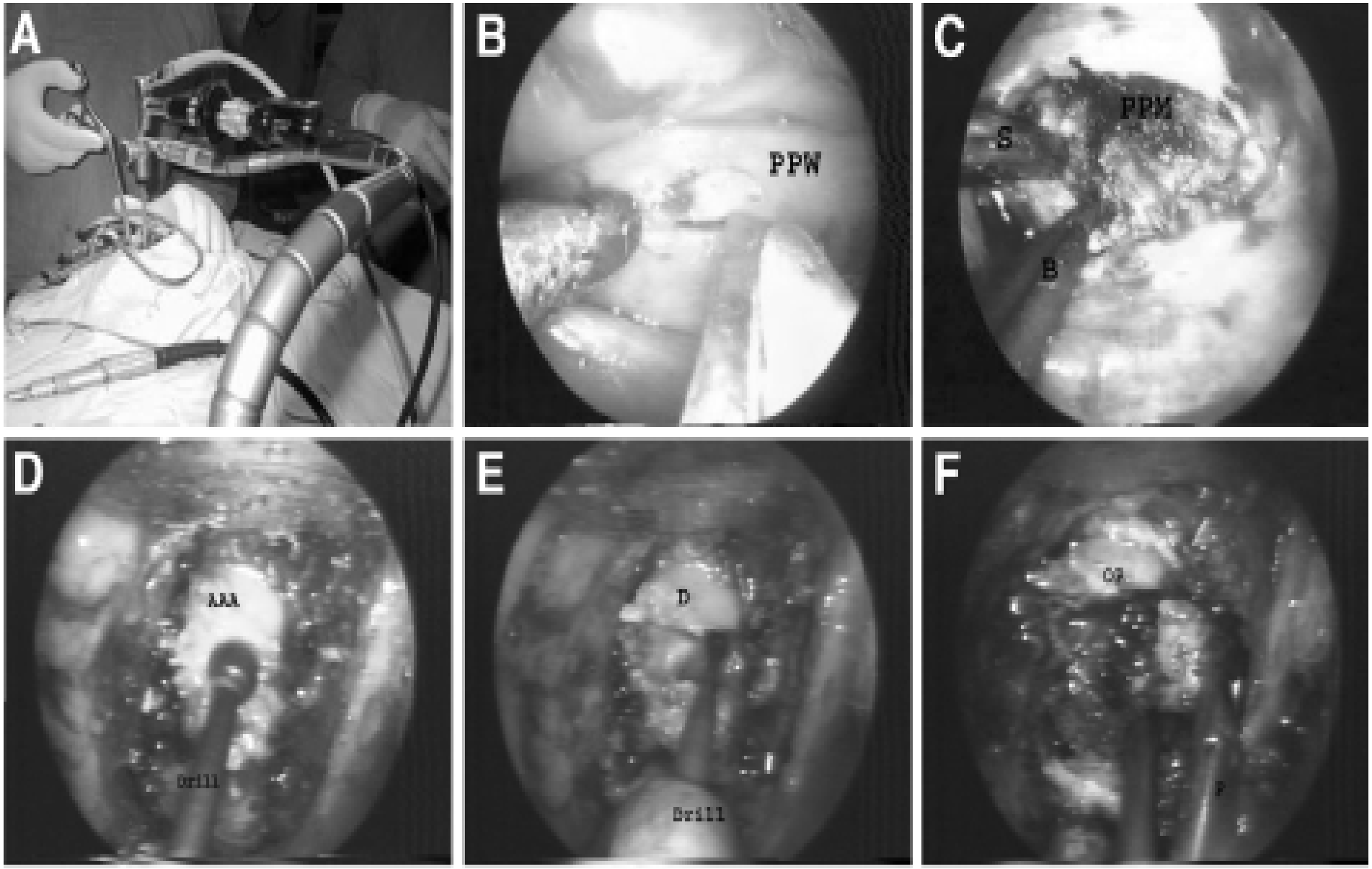
ENDOSCOPIC APPROACH

- 0^{o} right angled endoscope for illumination.
- Endoscope brought into the left side of oral cavity and fixed with table mounted holding device.
- Incision made for clivus to C2.
- Lateral limit of exposure kept at 15 mm – on each side.
- Under endoscopic view ant arch of C1 drilled to expose dens.
- Dens drilling conducted from base.

BENEFITS OF ENDOSCOPE

- Viewing angle endoscopes obviate the need for soft palate split.
- Difficulty in viewing through the microscope at retrouvular region.
- Can effectively preserve Velopharyngeal function.

Endoscopic transoral surgery for CVJ anomalies; M. Husain et al ; J Neurosurgery : Spine/ vol 5/ oct 2006


A
B
PPW
C
PPW
S
B
D
AAA
Drill
E
D
Drill
F
CP
P
S

C1 - C2 FIXATION

- First described by Hadra in 1891
- Modified by Cone in 1937
- Three basic cable wire fixation
  - Gallie
  - Brooks
  - Sonntag modification of gallies technique.
- Indicated in AAD with intact C1C2 laminae
- Contraindication
  - Absent posterior element
  - Severe osteoporosis
  - Narrow canal diameter
- Fusion rates increase when external orthosis is used
- Quadriparesis can occur upto 5 to 7 % of cases
- Breakage of wire might occur

GALLIE

- 20 gauge wire under C1 arch
- Inferior part notched over spinous process of C2
- H shaped graft placed in between decorticated C1 and C2 arch
- Notch inferiorly in the midline
- Offer little rotational or extension stability
- High rate of non union

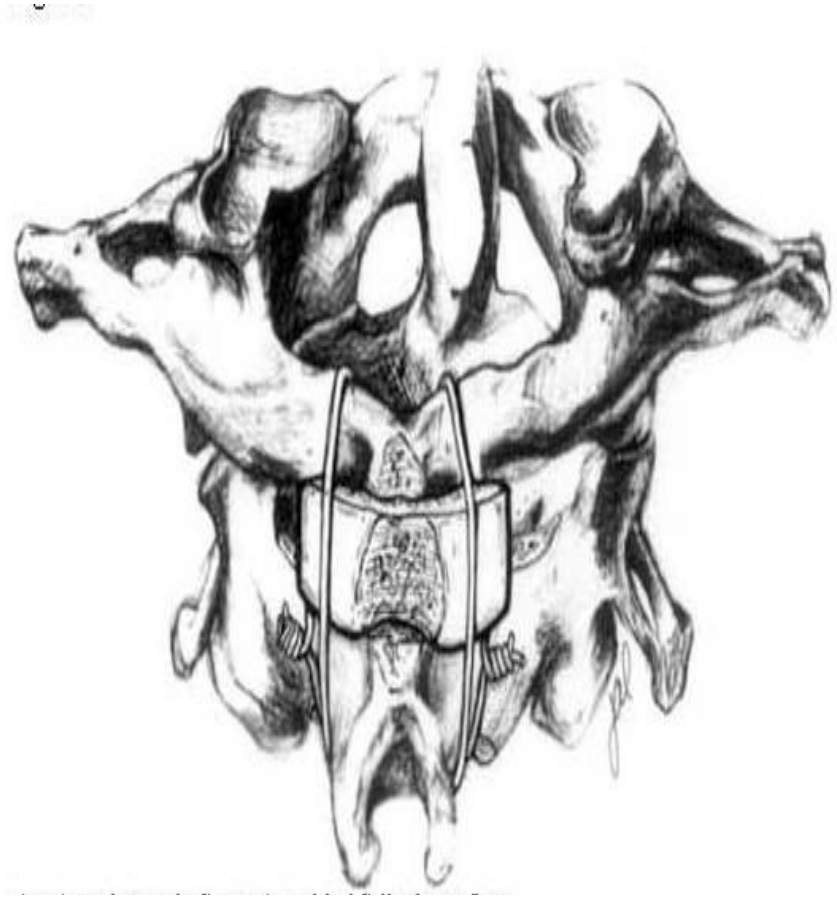
BROOKS

- Superior to gallie in biomechanical studies

  esp. rotation
- Caries risk of passing additional wire beneath two lamina
- Two rectangular bone graft fashioned to wedge between C1 and C2

SONNTAG DICKMAN

- One bicortical graft wedged between C1 and C2
- Single sublaminar wire passed under C1
- Wire looped below C2 spinous process trapping the graft between C1 C2
- Avoids passing second sublaminar wire



LAMINAR CLAMPS

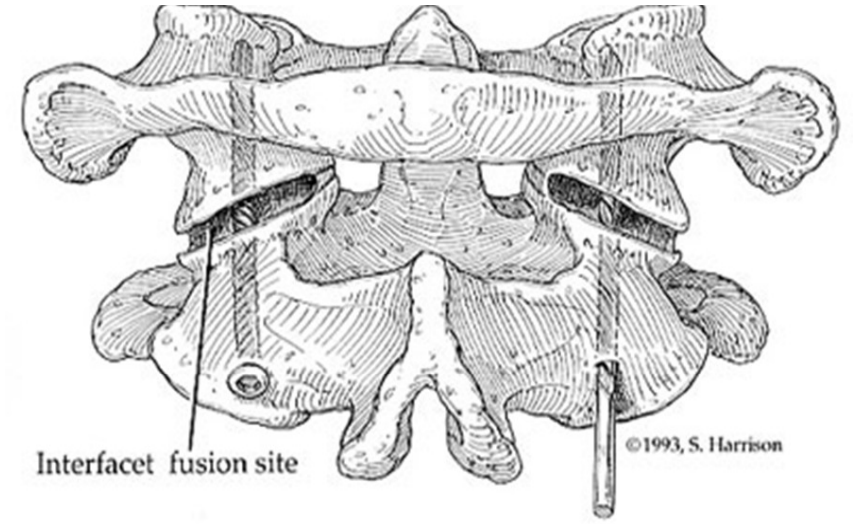
- Offers posterior laminar fixation without passing sublaminar wire
- Upper clamp placed above lamina of C1
- Inferior clamp placed below C2
- Sequential tightening of clamps to ensure engagement of laminae
- Interlaminar graft may be used
- Associated with implant slippage
- High pseudoarthrosis rate
- C1 ring fracture

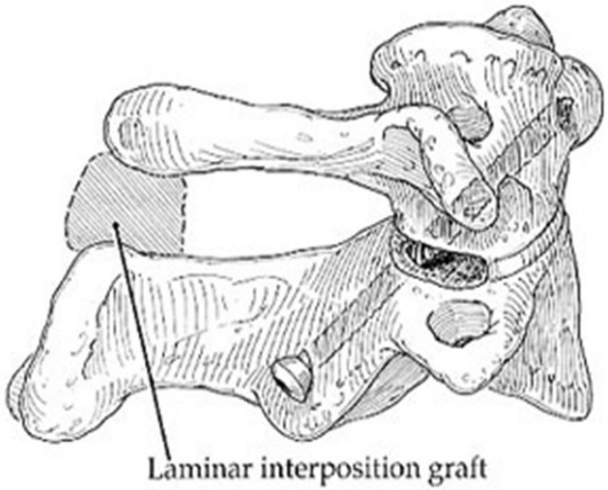
TRANSARTICULAR SCREW FIXATION

- Used when posterior arches incompetent
- Superior to wiring methods in fusion rates
- Severe osteopenic patients may require fixation through articular facets
- Imperative to delineate vertebral arteries course
- not feasible if vertebral arteries are too medial
- Provides absolutely no movement in the region
- Procedure is technically difficult
- Spinal cord injury, hypoglossal injury, vertebral artery injury 4 - 8%.
- Magerl technique provides stiffest stabilization with least amount of rotation and lateral bending
- Provides three point fixation
- Follows most closely biomechanical rules on internal fixation
- Fusion rates between 85% to 98% and well tolerated in elderly

POSTERIOR TRANSARTICULAR SCREW

- Point of entry 2mm up ,2mm in from the medial ½ of inferior facet of C2.
- Transarticular screw placed through pars interarticularis of C2 penetrating C1 C2 facet into lateral masses of C1
- Screw directed 25º towards midline and 25º cranial
- Three point fixation can be obtained





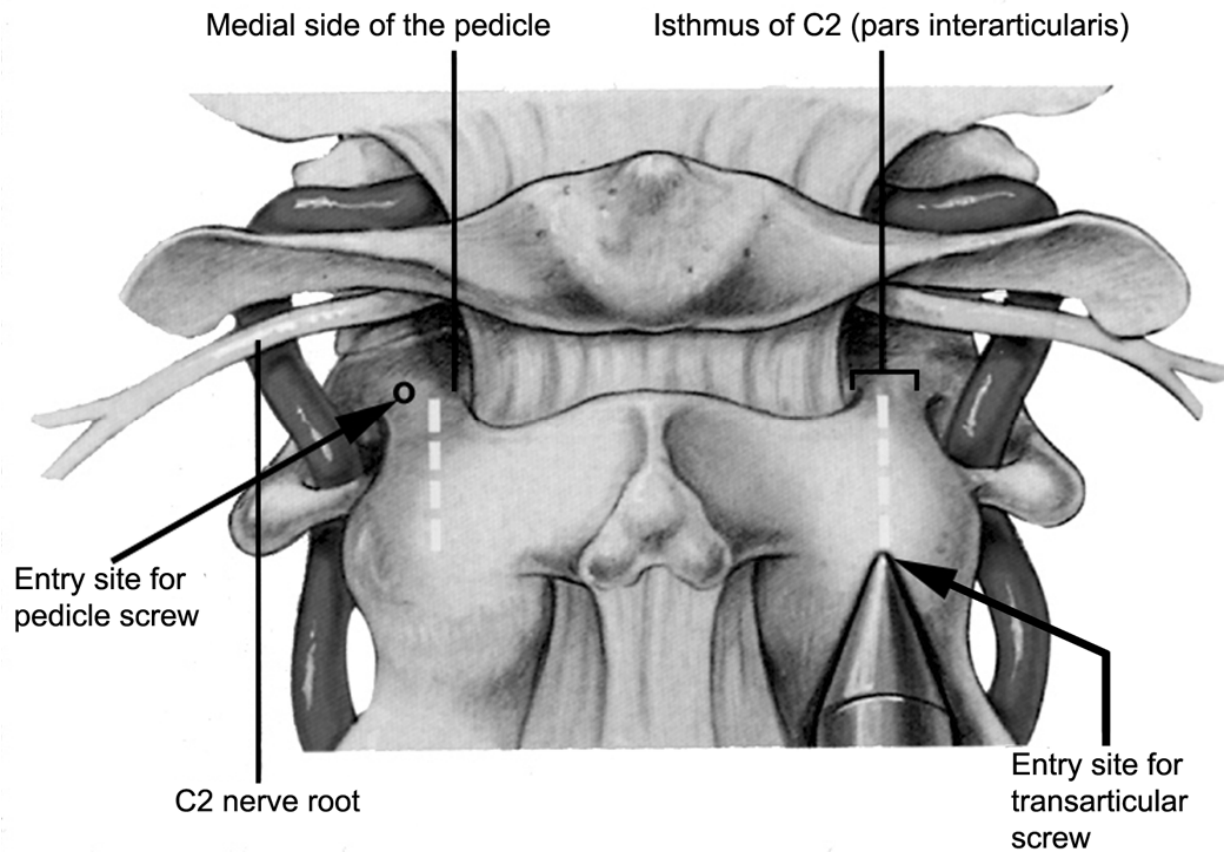
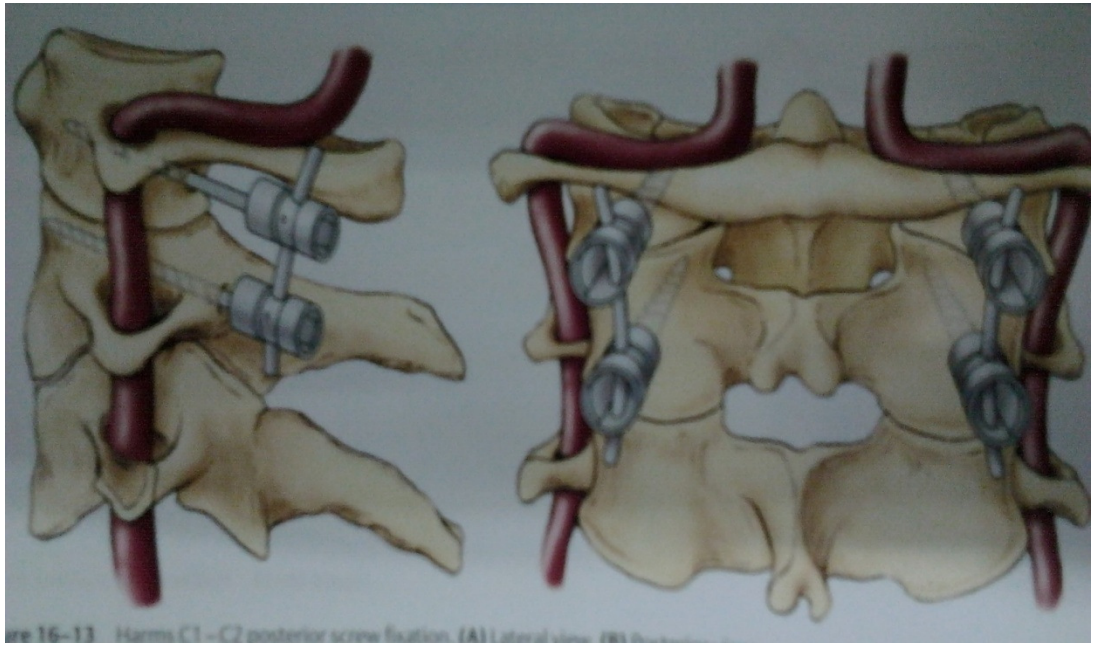

Medial side of the pedicle
Isthmus of C2 (pars interarticularis)
Entry site for pedicle screw
C2 nerve root
Entry site for transarticular screw

図 2

LATERAL MASS SCREW FIXATION

- Jurgen Harms technique of C1 C2 fixation
- C1 lateral mass screw and C2 pedicle screw with rod reconstruction
- Reduction of C1 C2 can be achieved using rod as a lever arm
- Can be used in patients with compromised posterior element
- Easier than placement of transarticular screws



C1 LATERAL MASS WITH C2 PEDICLE SCREW WITH PLATE FIXATION

- Provides immediate stability
- Achieved 100% fusion rate
- Anatomic alignment not necessary
- Technically demanding
- Distraction of C1 C2 joint space necessary.
- C2 nerve root mobilized
- 3.5 mm poly axial screws (26 – 34 mm) are used.

Goel A, Laheri Y. Place and screw fixation for atlanto – axial subluation, Acta Neurochir (Wien). 1994; 129 (1-2):47-53

OCCIPITO CERVICAL STABILIZATION

- Indicated in pt with AAD occipitalised hypoplastic or bifid atlas
- Posterior decompression of foramen magnum and C1 arch required especially Arnold chiari
- Wire and bone graft fusion by artificial arch of atlas
- Bony ridge of occipital bone and occipitalized atlas created
- Artificial arch and C2 decorticated and one midline and two lateral notch formed
- Wire passed through the notch
- Graft of iliac crest wedged between C2 and artificial arch and wire is tightened
- Rarely used now.

OCCIPITO CERVICAL FUSION

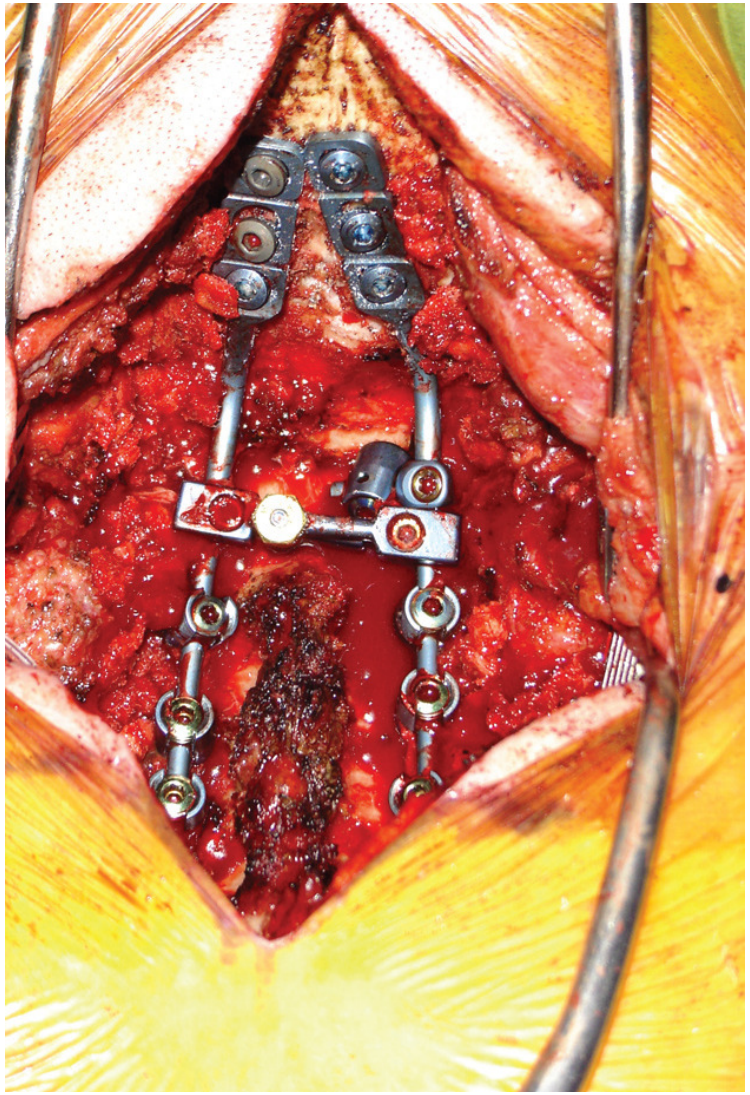
- Contoured rods
- C1 arch removed
- Rod is placed over occipital bone and c2 and c3
- Rod fixed over occipital bone by three burr holes and wires passed through it
- Absolute bony contract is required to prevent vertical movements

OCCIPITO CERVICAL FUSION

- Currently MC used suboccipital fixation method is bicortical screw fixation into midline suboccipital keel and paramedian cranium.
- 4.5/6 mm for lateral screws, 4.5/8 –12 mm for midline screws.

1-piece “inverted U” or “inverted Y”–shaped rod/plate with occipital and cervical wiring and/or screws
Modular (more than 1 piece) occipital plate-cervical rod constructs with occipital and cervical screws
Occipital buttons connected to cervical rods
Condylar polyaxial screws connected to cervical rods

- Cervical fixation
  - Lateral mass screws
  - Laminar screws
  - Transarticular screws
  - or any of combinations.
- Provides immediate stabilization
- Screw and plate – rod fixation instrumentation allows surgeon to determine the optimal screw fixation point and to perform deformity correction
- Highest osseous fusion rate (94-97%).



Nuances of Occipital fixation – P. V Mummaneni et al Neurosurgery/ vol 66/ no 3/ march 2010 suppl.


THANK YOU