Dissertation on

"IMAGING EVALUATION OF SUSPECTED CRANIO-VERTEBRAL JUNCTION ANOMALIES USING CT, MRI, CT VERTEBRAL ANGIOGRAPHY "

Submitted in partial fulfilment of the regulations

required for the award of

M.D. DEGREE

IN

RADIODIAGNOSIS

BRANCH VII

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THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

CHENNAI – 600032

COIMBATORE MEDICAL COLLEGE

COIMBATORE

MAY 2020

DECLARATION

I **DR.M.KARTHICK,** declare that I carried out this work on **"IMAGING EVALUATION OF SUSPECTED CRANIO-VERTEBRAL JUNCTION ANOMALIES USING CT, MRI, CT VERTEBRAL ANGIOGRAPHY"** at the department of Radiodiagnosis, COIMBATORE MEDICAL COLLEGE HOSPITAL. I also declare that this bonafide work or a part of this work was not submitted by me or any other for any award, degree, or diploma to any other university, board either in India or abroad.

This is submitted to The Tamilnadu Dr. M.G.R. Medical University, Chennai in partial fulfillment of the rules and regulation for the M. D. Degree examination in Radiodiagnosis.

DR. M.KARTHICK.

Place:

Date:

CERTIFICATE BY THE INSTITUTION

This is to certify that **DR.M.KARTHICK,** Post - Graduate Student (May 2017 to May 2020) in the Department of Radiodiagnosis, COIMBATORE MEDICAL COLLEGE HOSPITAL,COIMBATORE, has done this dissertation on **"IMAGING EVALUATION OF SUSPECTED CRANIO-VERTEBRAL JUNCTION ANOMALIES USING CT, MRI, CT VERTEBRAL ANGIOGRAPHY"** under my guidance and supervision in partial fulfillment of the regulations laid down by the Tamilnadu Dr. M. G. R. Medical University, Chennai, for M.D. (Radiodiagnosis) Degree Examination to be held in May 2020.

Date:

Guide and Professor,
Department of Radiodiagnosis,
Coimbatore medical college &Hospital,

Date:

DR.N.Murali M.D.R.D,
Professor and HOD
Department of Radiodiagnosis,
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Date:

Dean,
Coimbatore medical college &Hospital,

CERTIFICATE BY THE GUIDE

This is to certify that **DR.M. KARTHICK,** Post - Graduate Student (May 2017 To May 2020) in the Department of Radiodiagnosis, Coimbatore medical college &Hospital, has done this dissertation on **"IMAGING EVALUATION OF SUSPECTED CRANIO-VERTEBRAL JUNCTION ANOMALIES USING CT, MRI, CT VERTEBRAL ANGIOGRAPHY"** under my guidance and supervision in partial fulfillment of the regulations laid down by the Tamilnadu Dr. M.G.R. Medical University, Chennai, for M.D. (Radiodiagnosis), Degree Examination to be held in May 2020 .

DR.N.Murali M.D.R.D,
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ACKNOWLEDGEMENT

I heartfully thank the Almighty, for showering his endless grace and blessings on me and making me able to complete this venture successfully .

I express my profound thanks to my esteemed Professor and HOD

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I sincerely thank all the patients who participated in this study for their cooperation

URKUND

Urkund Analysis Result

Analysed Document: cvj.docx (D57221619)
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Sources included in the report:

Dr.Srajan Dashore MD Radioldiagnosis thesis.docx (D30618799)
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Instances where selected sources appear:

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ABSTRACT

OBJECTIVES :

To evaluate the incidence of congenital Craniovertebral Junction Anomalies in different age groups, their sex prevalence, their clinical findings, radiological abnormalities that aids in the management and final outcome.

MATERIALS AND METHODS :

About 30 patients with CVJ Anomalies were taken for this descriptive study. All the Congenital CVJ Anomalies in all the age & sex groups were taken for the study. All the personal, clinical, radiological findings were entered and results were obtained.

RESULTS :

The CVJ Anomalies were equally distributed in all age groups.The CVJ anomalies were predominantly seen in the male population. The bony anomalies are more commonly (97%) seen than the soft tissue anomalies . Basilar invagination (80%) was the most common congenital bony anomaly and Arnold Chiari malformation was the most common soft tissue anomaly noticed in our study. The abnormal course of the vertebral artery were seen in 30 % cases.

CONCLUSION:

Among congenital anomalies, the bony anomalies(basilar invagination) were observed commoner than the soft tissue anomalies with male predominance and abnormal course of vertebral artery were seen in 30 % cases which, stress the importance of pre-operative angiographic study of vertebral artery.

TABLE OF CONTENTS

INTRODUCTION

The most complex and dynamic region of the cervical spine is Cranio Vertebral Junction, which is being the transit zone between cranium and spine. CVJ consist of complex bony anatomy and major neurovascular structures. It includes occiput,atlas,axis and supporting ligaments .

Numerous classical reviews have been made to clarify its complex pathology by doing multiple evaluation. The incidence rate of different types of CVJ anomalies are varied according to different demographic environment & genetic factors. CVJ anomalies are more frequently encountered in indian subcontinent than the rest of the world. In India, CVJ anomalies are more prevalently seen in Bihar, Uttar Pradesh, Rajasthan & Gujarat. These anomalies can be either due to bony or soft tissue anomalies. They are commonly distributed in all age groups and equally in both sex groups.These anomalies can be classified either congenital or acquired on the basis of etiology .

Anatomy and pathology of craniovertebral junction can be clearly made out by doing investigations like Computed Tomography(CT),Magnetic Resonance Imaging(MRI).Most of the CVJ

anomalies are associated with abnormal course of the vertebral artery which is evaluated by doing CT angiography.

METHODS:

The present study was designed as descriptive study and it was carried out in the department of radiology in collaboration with the department of neuro-medicine and neuro-surgery in government Coimbatore medical college hospital. A written informed consent was obtained from all patients undergoing CT/MRI. Iohexol contrast was administered through intravenous route after getting informed consent and after giving test dose.

AIMS AND OBJECTIVES

The aims & objectives of this study are as follows:

1. To diagnose the incidence of various congenital anomalies of CVJ.
2. To evaluate the various components of CVJ anomaly namely osseous omponent,cervicomedullary compression,CSF flow disturbances and anomalies of vertebral artery.
3. To assess the importance of CT/MRI in planning of surgical management.

REVIEW OF LITERATURE

Literature is reviewed as follows :

1. Outline the normal anatomy of Craniovertebral Junction .
2. Etiological based classification of different CVJ anomalies.
3. Different clinical presentations of CVJ anomalies.
4. Different radiological study to diagnose the CVJ anomalies.
5. Brief view of literature about CVJ anomalies.

1. OUTLINE THE NORMAL ANATOMY OF CRANIOVERTEBRAL JUNCTION

CranioVertebral Junction is nothing but collective terminology which includes occiput,foramen magnum,clivus,atlas, axis and supporting ligaments. CVJ also includes cervico medullary junction which encloses medulla, cervical spinal cord and lower cranial nerves.

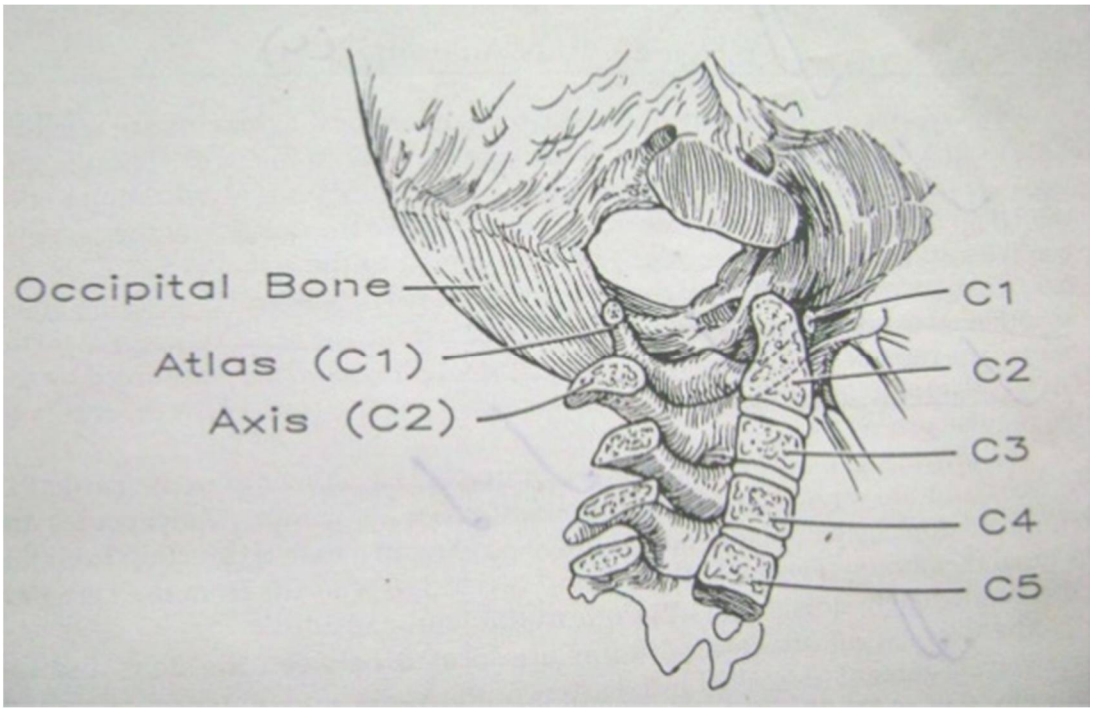


Figure 1. normal bony anatomy of craniovertebral junction.

The atlantoaxial complex is unique because it is horizontally oriented. The facet joints appear as flat . This provides pivoting motion at the atlantodental articulation, which is aided by the special ligamentous support.

Principle stabilizing ligaments of C1 are,

1) Transverse atlantal ligament

2) Alar ligament

Secondary stabilizing ligaments :

1) Apical ligament of dens

2) Anterior & posterior atlanto occipital membrane

3) Tectorial membrane

4) Ligamentum flavum

5) Anterior & posterior longitudinal ligament

6) Capsular ligaments

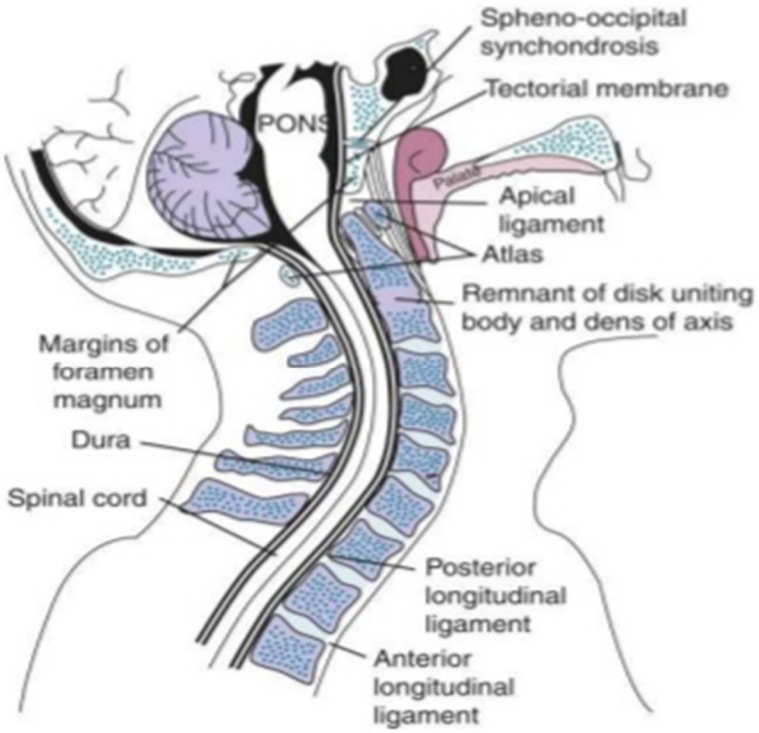


Figure 2 : Ligaments of CVJ

Ligaments that connect the atlas to the Occiput :-

A. Anterior atlanto occipital membrane:- It extends from the anterior margin of Foramen Magnum to the anterior arch of C1. It is the cephalad extension of the Anterior Longitudinal Ligament.

B. Posterior atlanto occipital membrane :- It connects the posterior margin of Foramen Magnum to the posterior arch of C1.

C. Ascending band of Cruciate ligament.

2. Ligaments that connect the axis to the occiput :-

A) Tectorial Membrane:-

Superficial part: It is the cephalad continuation of Posterior longitudinal ligament.A strong band connecting to the dorsal surface of Foramen Magnum above and the dorsal surface of C2 & C3 bodies below.

Deep portion : It is located laterally which connects Axis to the occipital condyles.

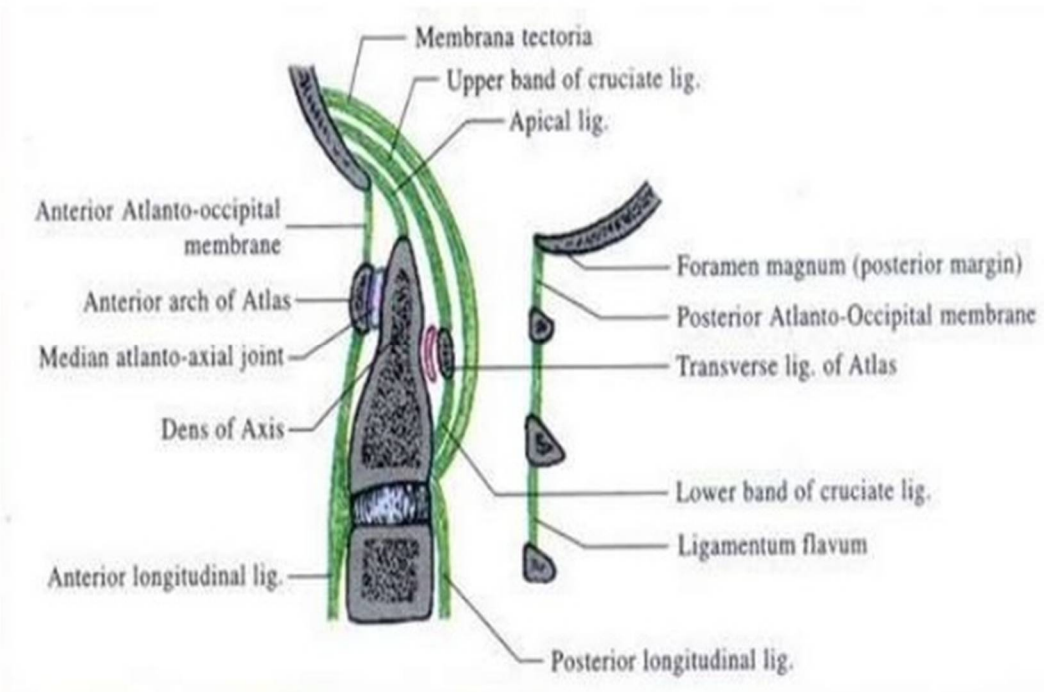


Figure 2 : Ligaments of CVJ

3. Ligaments that connect axis to atlas ;

A)Transverse Ligament : It is the horizontal component of Cruciate ligament and It provides the majority of strength.

B)Atlanto-alar portion of Alar ligament

C)Descending band of Cruciate ligament.

ORIGIN & COURSE OF VERTEBRAL ARTERY

Vertebral artery is originating from 1st part of subclavian artery. It has 4 segments. Among these V3 segment is the one , observed to have an abnormal course in case of CVJ anomalies. It is most commonly associated with occipitalisation of atlas.

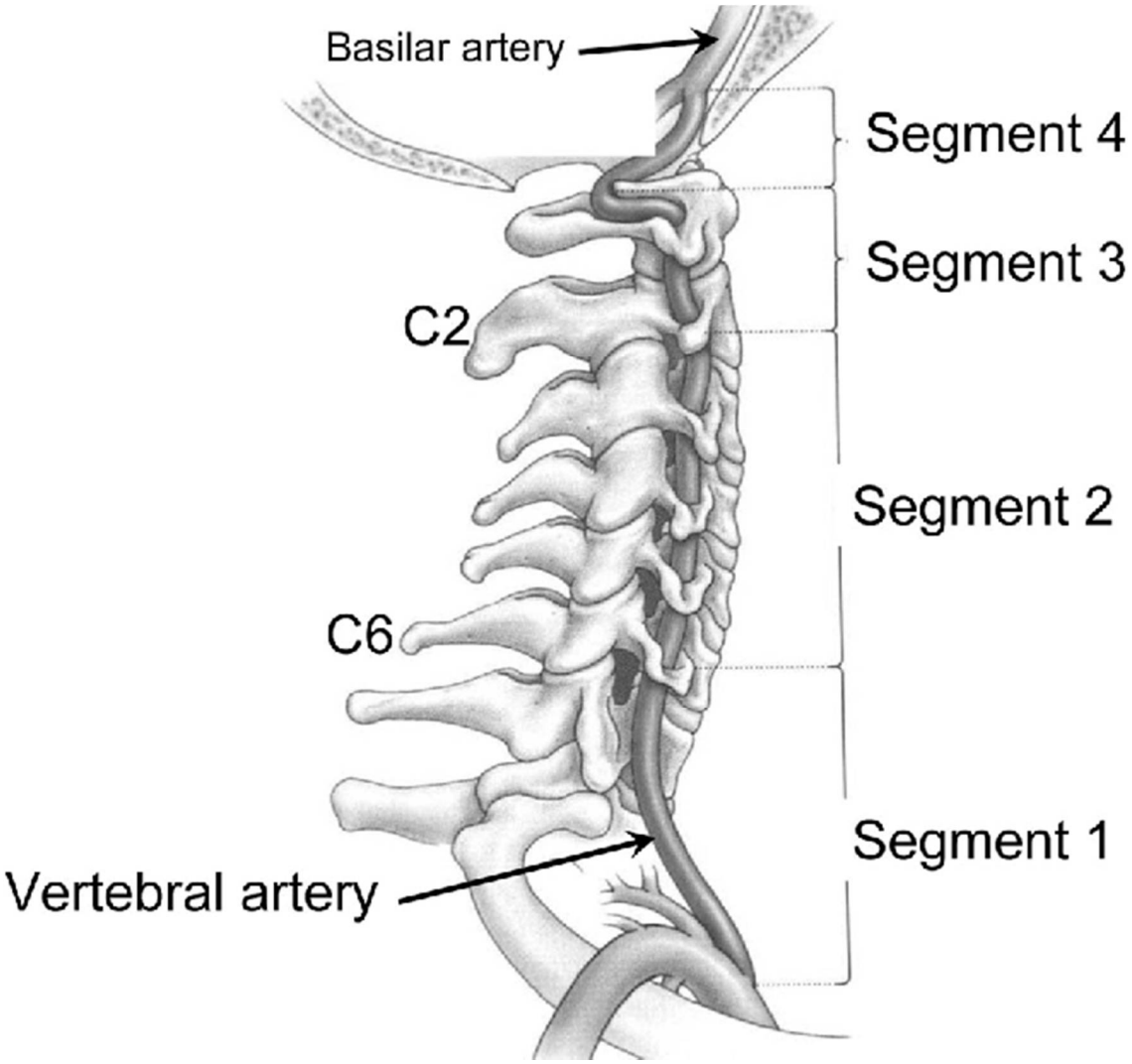


Figure 4 : various segments of vertebral artery

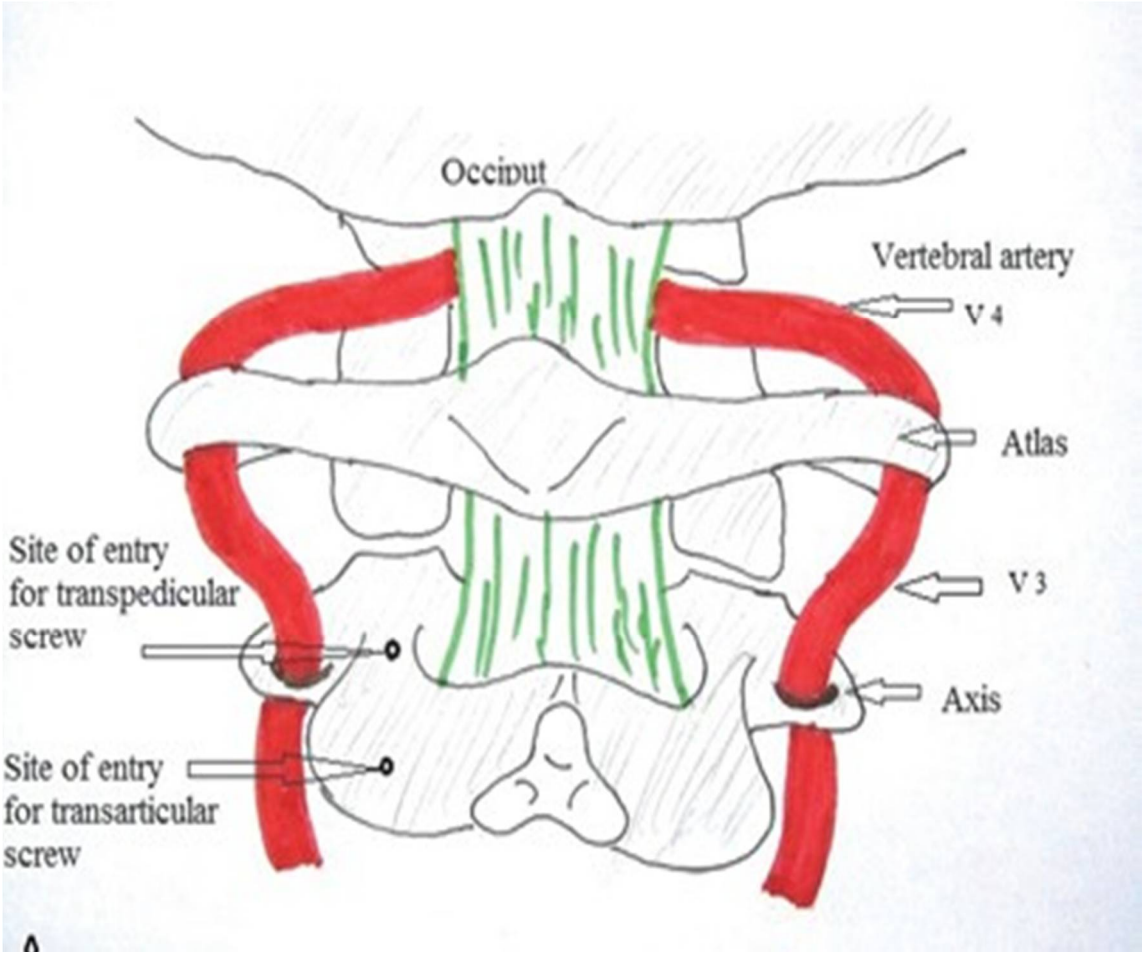


Figure 5 : shows course of vertebral artery

ABNORMAL COURSE OF VERTEBRAL ARTERY:

4 types of abnormal course of vertebral artery noted.

Type1-enters spinal canal below the C1 posterior arch & course is seen below the occipitalized C1 lateral mass.

Type2- enters spinal canal below the C1 posterior arch & course is seen posterior the occipitalized C1 lateral mass.

Type3-passing through C0-C1fusion complex

Type4- absent vertebral artery.

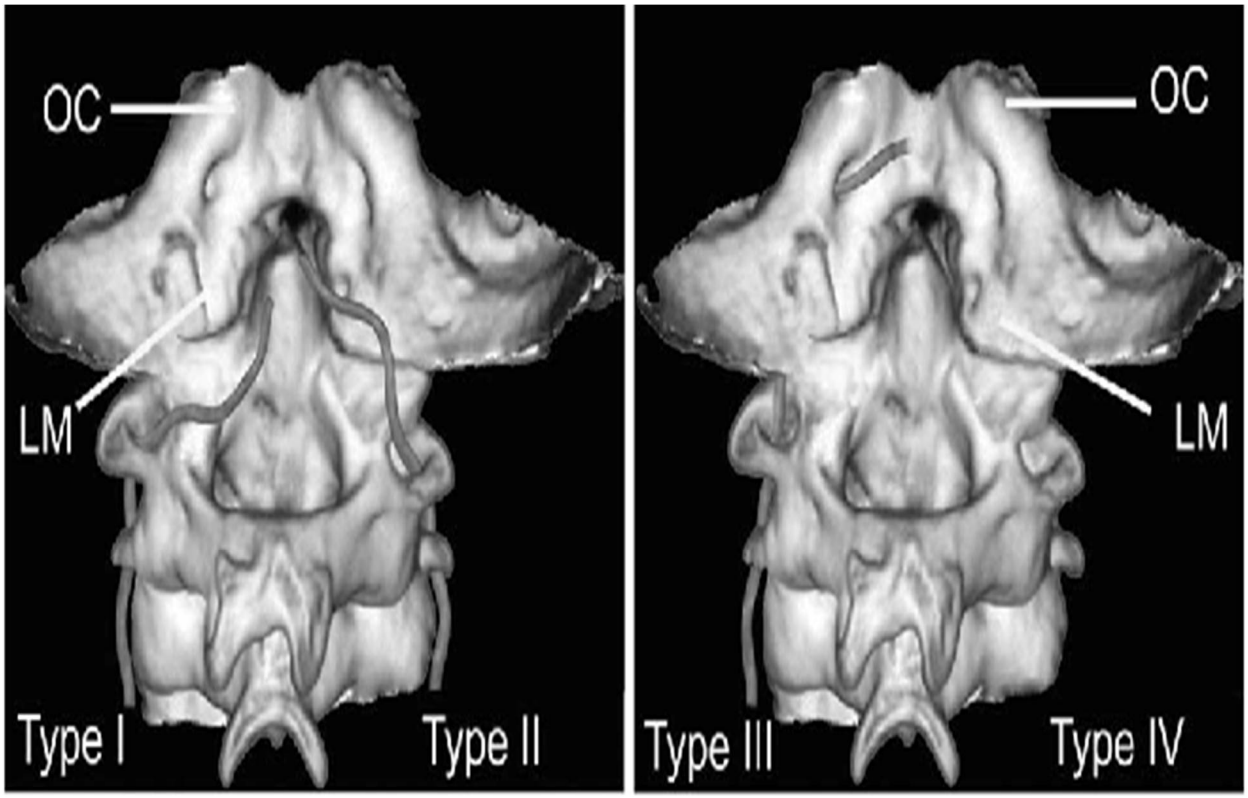


Figure 6 : Shows Various Types of Abnormal Course Of Vertebral Artery

II. CLASSIFICATION OF CVJ ANOMALIES ;

I. Congenital Anomalies :

A. Malformations of Occipital Bone :

1). Clivus segmentations

2). Occipital bone abnormalities

3). Remnants around the Foramen magnum

4). Atlas variants

5). Dens segmentation anomalies.

6). Basilar invagination

7).Condylar hypoplasia

B. Malformations of Atlas :

1). Assimilation of Atlas

2). Atlantoaxial fusion

3). Aplasia of Atlas arches.

C. Malformations of the Axis :

1). Irregular AtlantoAxial segmentation

2). Dens Dysplasias

3). Ossiculum terminale persistens

4). OsOdontoideum

5). Hypoplasia – aplasia

D. Segmentation failure of C2/C3

II. Acquired & developmental abnormalities craniocervical Junction

A. Abnormalities of Foramen Magnum

1. Secondary Basilar Invagination (Basilar Impression) -Paget's disease, Rheumatoid Arthritis, Osteomalacia, Rickets.

2. Foraminal stenosis (e.g., Achondroplasia)

B. Atlantoaxial instability

1. Errors in metabolism (e.g., Morquio's syndrome)
2. Down syndrome
3. Infections (e.g., Grisel's syndrome)
4. Inflammatory (e.g., Rheumatoid arthritis)

5. Traumatic Occipitoatlantal and atlantoaxial dislocation, Osodointoideum
6. Tumors (e.g., Neurofibromatosis)
7. Miscellaneous (e.g., fetal warfarin syndrome, Conradi's syndrome, syringomyelia)

8 THE ARNOLD CHIARI MALFORMATION

CHIARI TYPE FEATURES

Type1- Tonsillar Herniation >5mm inferior to

The foramen magnum . No associated brainstem herniation noted.

Type2- Herniation of cerebellar vermis, brainstem and fourth ventricle through the foramen magnum. It is seen Associated with myelomeningocele and multiple brain anomalies. Hydrocephalus &syringomyelia are very common.

Type-3 High cervical or occipital encephalocele

Type-4 Hypoplasia or aplasia of the cerebellum and the tentorium cerebelli.

II. CLINCAL FEATURES : there is multiplicity of signs and symptoms as a result of compromise of lower brainstem, cervical spinal cord, cranial nerves, cervical roots & vascular supply

1) Cervical manifestation:

-pain,

- stiffness,

-torticollis,

- neck movements restriction

2) transient vascular symptoms:

- vertigo,

- transient altered sensorium,

-transient paralysis,

- transient visual field loss,

-confusion.

3) features of myelopathy:

-varying degrees of paralysis,

-posterior column signs

4) brain stem dysfunction:

-dysphagia,

-internuclear ophthalmoplegia,

-sleep apnea,

-respiratory movements

5) cerebellar signs

6) cranial nerve involvement

RADIOLOGICAL INVESTIGATIONS :

1) Dynamic X-rays Cervical spine: The X-rays of cervical spine, lateral views on both Flexion and Extension views to assess the reducibility of the CVJ Anomaly. Atlanto Dental Interval (ADI) – is the distance between the anterior surface of the Dens to the posterior edge of the anterior arch of Atlas. Normal values : Adults – 3mm.Children – 4mm.

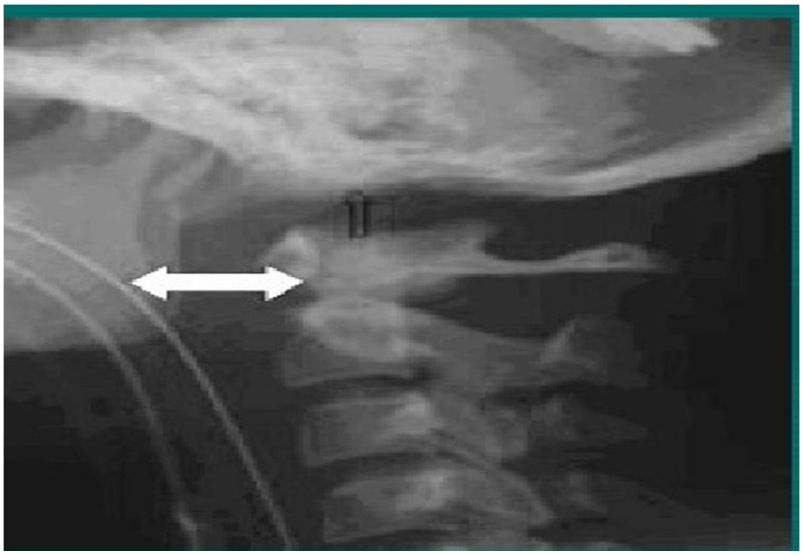


Figure 7 : Shows Atlanto Axial Dislocation

2) CT Cranio vertebral Junction:

- To evaluate the bony anomalies like basilar Invagination, atlantooccipital assimilation, atlas arch defects , atlanto axial subluxation, os odontoideum, platybasia etc. are identified.
- CT helps to assess associated skeletal deformities like kyphosis, scoliosis and Congenital Block vertebrae as in klippel-feil syndrome .
- CT is also used to study about the rotatory atlantoaxial subluxation, focal hematomas.
- Inflammatory conditions like Tuberculosis, Rheumatoid arthritis are evaluated by CT which is used to assess bony erosion and displacement.

3) MRI Cervical Spine: To analyse the descent of the cerebellar tonsil, Brainstem herniation, Spinal cord compression with intrinsic changes and presence of syrinx.

CRANIOMETRIC ASSESSMENT:

Various anatomical lines are studied by using X rays, CT scan & MRI Cervical spine. Not a single line is used.

Mc Rae's line – It is the Foramen Magnum line connecting the Basion to Opisthion. The normal foramen magnum diameter is 40 mm. The effective canal diameter less than 20 mm implies foraminal stenosis with severe cervico medullary compression.

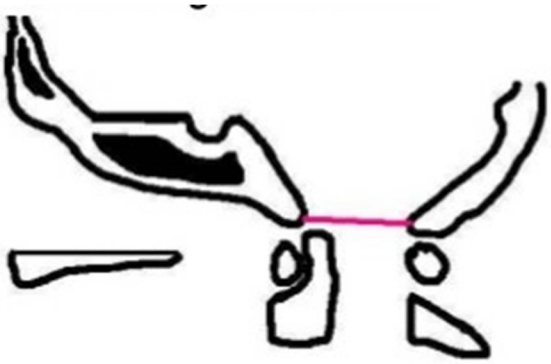


Figure 8 : Mc Rae's line

Mc Gregor's line (Palato suboccipital line) – the line connecting the posterior most surface of hard palate to the internal surface of the Occiput. The tip of the Odontoid process should lie below this line.

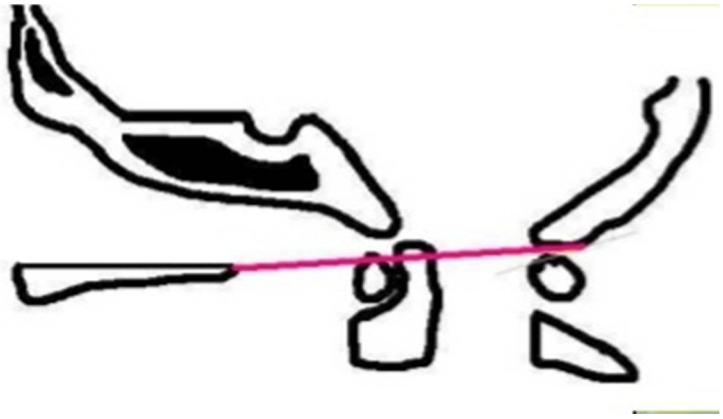


Figure 9 : Mc Gregor's line Palato suboccipital line

Chamberlain's line (Palato occipital line) – It is the line connecting the posterior surface of hard palate to the inferiormost surface of the opisthion. Normally the tip of odontoid should lie below this line.

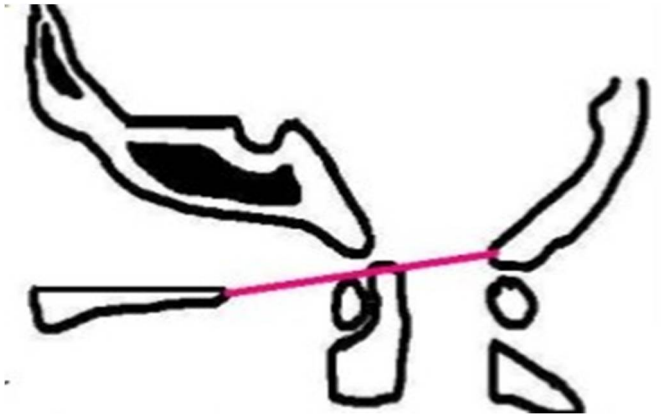


Figure 10 : Chamberlain's line

WACKENHEIM'S CLIVUS CANAL LINE :

It is the tangential line along the clivus & by extrapolating it inferiorly downwards. Normally the odontoid process lies below or does not cross more than 2.5mm above this line.

WELCHER'S BASAL ANGLE :

It is the angle formed between the nasion tuberculum line and the tuberculum basion line. Normally it is around 130 degrees. More than 143 degrees implies flat skull base.

Figure 11 : Chamberlain's line

REVIEW OF LITERATURE

Deepali onkar et al had done a study of congenital anomalies of cranio vertebral junction by computed tomography and its embryological basis in about 26 patients.Basilar invagination and atlanto-occipital assimilation were being encounterd as the common abnormality.This study emphasized that CT is the primary modality to evaluate the congenital bony abnormalities.

Atul Goel et al had done a retrospective study in 3300 patients with CVJ anomalies from 1971 to 2009 and divided them into two groups as basilar invagination with presence (Group A) or absence (Group B) of clinical & Radiological evidence of instability. Basilar Invagination in group A patients appeared to be related to mechanical instability where as Group B related to be secondary to embryological dysgenesis. The management of these patients were different which where based on stability.

Gyo-chang song et al had studies retrospectively in 82 patients from 2005 to 2011 about the clinical outcome & effectiveness of surgical treatment in Occipitocervical fusion as the surgical treatment of CVJ Instability. About 9 patients remained the same after surgery. Among 73 patients with cervical myelopathy, clinical Improvement noted in 58

cases, 3 patients died about 2 months after surgery, Fusion achieved in about 47 patients.

Sanjay Behari et al had conducted retrospective study on 54 patients from 2000 to 2006 who underwent procedure of occipito cervical contoured rod stabilization. About 50 patients had atlantoaxial dislocation, 3 of them had Tuberculosis of CVJ and one had Rheumatoid Arthritis. About 24 patients had improved symptoms after the procedure, 18 patients got stabilized and 6 deteriorated at a mean follow up. About 6 patients had lost follow up.

S.S. Kale & Parkanj et al had studied retrospectively about 189 patients of CVJ anomalies from 2001 to 2010. About 162 patients had reported as congenital anomalies, 18 patients had traumatic causes and remaining 9 patients had inflammatory cause due to tuberculosis .They were treated based on etiology.

Giussani . C et al had studied a series of clinically symptomatic children with CVJ Anomalies and analysed long term effectiveness of aggressive management of CVJ Anomalies based on clinical improvement, spinal stability & child growth. Among CVJ patients, 3 were with Down Syndrome , 1 was with Morquio syndrome was seen in our study.

Wang C had studied the Intra operative reduction, Instrumentation & Fusion of CVJ Anomalies in about 33 patients. OsOdointoideum was seen in about 8 patients, Occipitalisation of Atlas in 19 patients, malunion of Odontoid in 5 patients.

Menezes et al had studied prospectively in 100 patients with primary CVJ Anomalies and hindbrain herniation syndrome. Hindbrain herniation was seen with 4 the occipital sclerotome abnormalities. They became symptomatic with canal diameter 3mm. In children, ADI > 5mm was taken as positive for Atlanto Axial Subluxation.

Sivaraju L ,et al had studied about three dimensional computed tomography angiographic study of the vertebral artery in patients with congenital craniovertebral junction anomalies.Totally 169 patients were studied, out of which 86 were presented with bony abnormalities.It stated that most of the abnormal course of the vertebral artery was being associated with occipitalisation of atlas.

Wang et al has done a observational study about three dimensional computed tomography angiographic study of the vertebral artery in patients with congenital craniovertebral junction anomalies. Totally 36 patients who presented with occipitalisation of atlas,were examined .He had noticed four different types of abnormal course of vertebral artey

seen in those patients. This study found to be useful in surgical management of these patients to avoid iatrogenic injuries.

CRANIOMETRIC ASSESSMENT IN CT/MRI :

Various anatomical lines were studied from , CT of CVJ and MRI of CVJ.

1. **MC RAE'S LINE :**

It is the foramen magnum line which connects the Basion and Opisthion. Tip of the dens should be less than this line.if exceeds this line, it suggests basilar invagination.

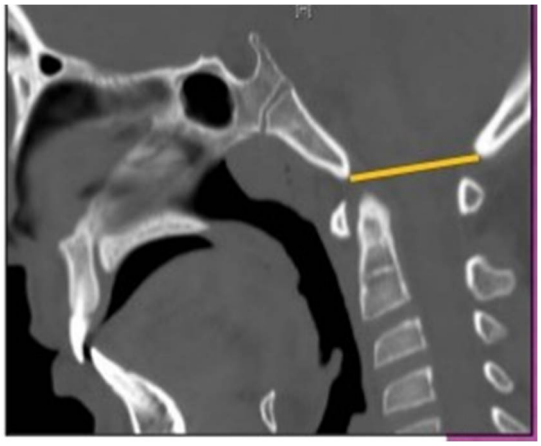


Figure 12 : Mc Rae's Line

2. **MC GREGOR'S LINE :**

It is the line which is connecting the posterior surface of palate to the Occiput. Tip of dens should be less than 5mm to this line.If exceeds >5mm suggests basilar invagination.

3. CHAMBERLAIN'S LINE :

It is the line which is connecting the posterior surface of palate to the inferior surface of the Occiput. .It should be less than 3mm.if exceeds 3mm , it suggests basilar invagination.

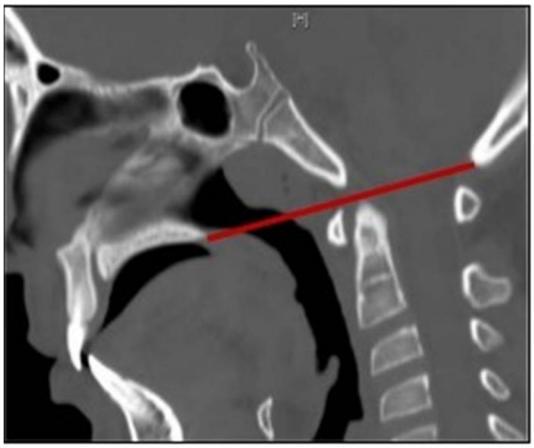


Figure 13 : Chamberlain's Line

4. WACKENHEIM'S CLIVUS CANAL LINE :

It is the tangential line, drawn along the clivus and by extrapolating it downwards. Normally the tip of the dens should lie below or should not exceed 2.5mm above this line. Tip of dens above and if transects this line suggests basilar invagination

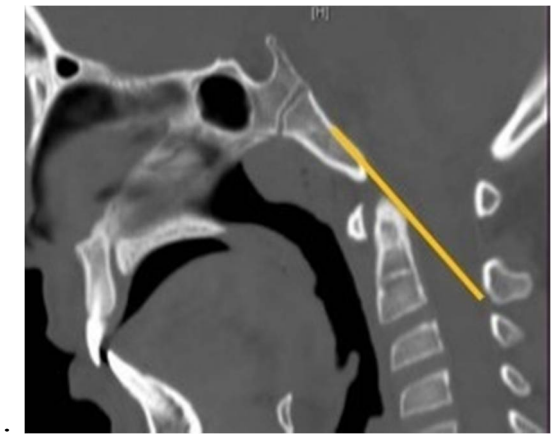


Figure 14 : Wackenheim's Clivus Canal Line

5. BIMASTOID LINE:

It is the line which connecting tips of mastoid process on both sides.If the tip of dens lies 10mm above this line, it suggests basilar invagination.

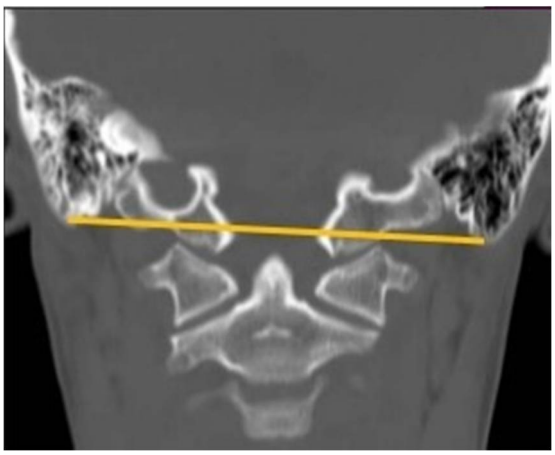


Figure 15 : Bimastoid Line

6. DIGASTRIC LINE:

It is the line joining the fossae of digastrics muscles on both sides undersurface of skull just medial to mastoid process.tip of dens should not extend above this line. If extended above this line it suggests basilar invagination.

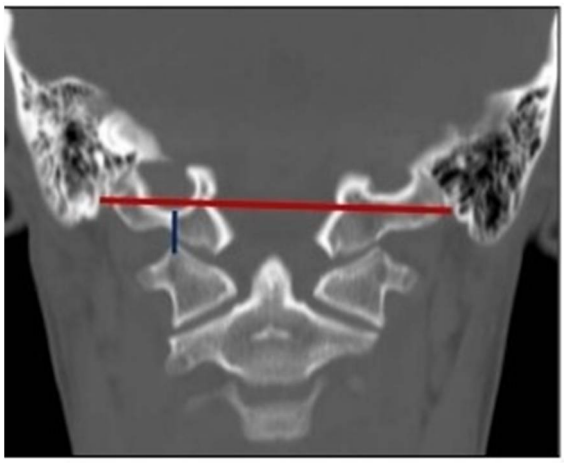


Figure 16 : Digastric Line

7. CLIVUS CANAL ANGLE:

It is the angle between clivus and posterior axial line.It ranges normally from 150-180 degree.If it is <150 degree indicates platybasia.

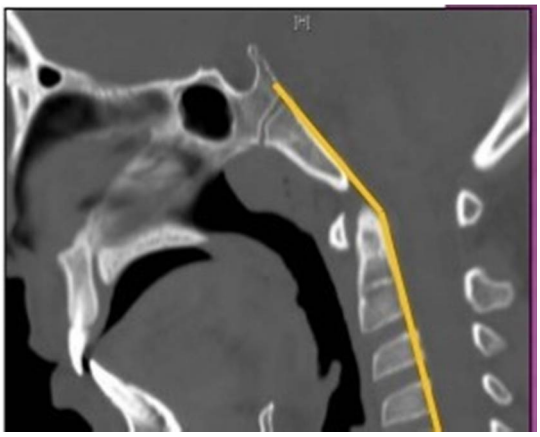


Figure 17 : Clivus Canal Angle

8. WELCHER'S BASAL ANGLE :

It is the Angle between tuberculum basion line and the nasion tuberculum line . The angle above 143 degree was taken as positive for Platybasia.

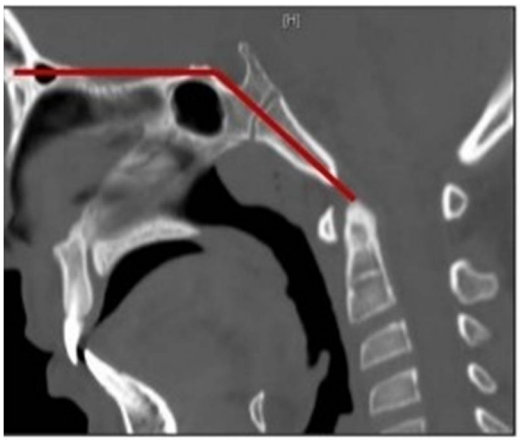


Figure 18 : Welcher's Basal Angle

CT of CV Junction: Various bony anomalies like basilar Invagination, occipitalisation of atals, atlanto axial dislocation, platybasia were studied.

MRI of CV Junction : Apart from Craniometric assessment, tonsillar and cerebellar herniation, Atlanto axial subluxation were studied. MRI was used to rule out syringomyelia, any intrinsic cord changes, prevertebral abcesses.

CRITERIA FOR ETIOLOGICAL DIAGNOSIS :

Based on the history & thorough clinical examination, the congenital CVJ Anomalies were broadly categorized into bony and soft tissue anomalies. Among the congenital Bony CVJ Anomalies, , basilar invagination, occipitalisation of atlas,platybasia and congenital Atlanto Axial dislocation were studied. Among the Congenital Soft tissue CVJ Anomalies, Arnold Chiari malformations were studied.

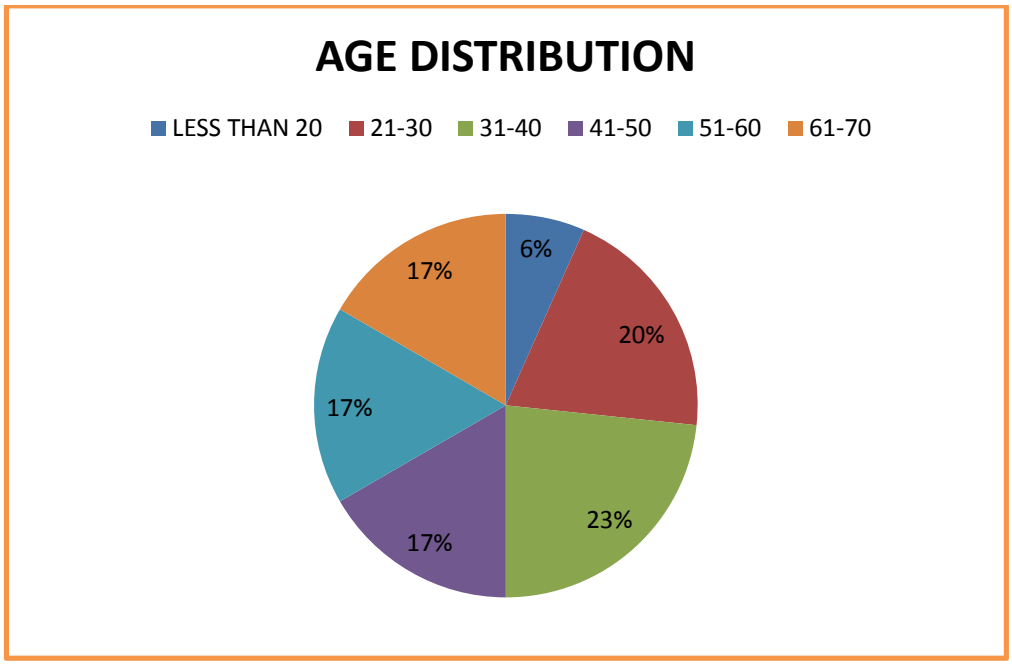
OBSERVATION AND RESULTS

About 30 cases of Craniovertebral junction Anomalies were evaluated during the study period of January 2018 to june2019. The summary of the 30 cases were given in the Master Chart.

AGE DISTRIBUTION

AGE IN YEARS	NO OF PATIENTS	PERCENTAGE
LESS THAN 20	2	6%
21-30	6	20%
31-40	7	23%
41-50	5	17%
51-60	5	17%
61-70	5	17%

Out of 30 patients, about 2 patients were 20 years, 6 patients were seen from 21 to 30 years, 7 patients from 31 to 40 years, 5 patients from 41 to 50 years and 5 patients from 51 to 60 years and 5 patients from 60-70 years.

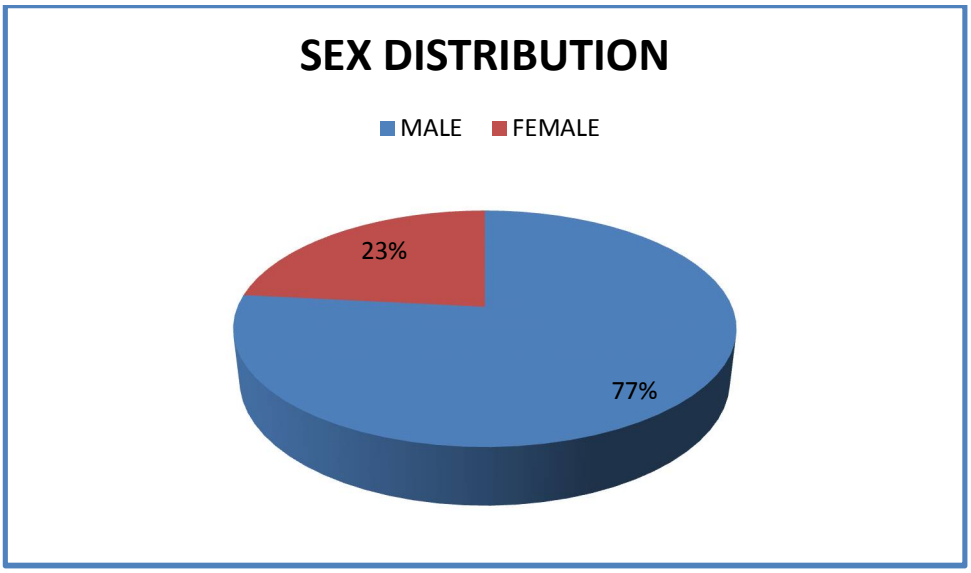


Out of 30 cases, age groups between 31-40 years and 21-30 years were found to be the most commonly affected ,accounting to about 23% and 20% respectively.

SEX DISTRIBUTION

Out of 30 cases, about 23 cases were male and 7 cases were female. Males were found to be most commonly affected with gender wise distribution about 77%.

SEX	NO OF PATIENTS	PERCENTAGE
MALE	23	77%
FEMALE	7	23%



In our study, CVJ anomalies were more prevalently seen in male population about 77%.

P value – 0.01 Male population commonly have CVJ anomalies in our study

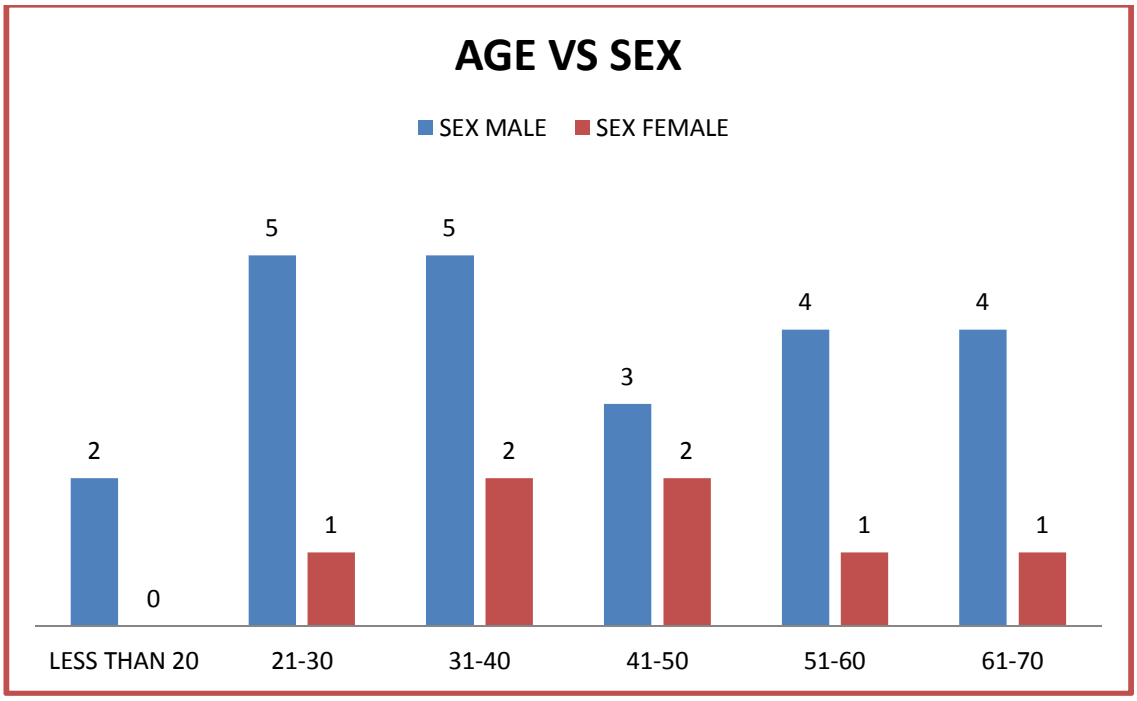
DISTRIBUTION OF AGE ACCORDING TO GENDER

AGE VS SEX

AGE IN YEARS	SEX	
	MALE	FEMALE
LESS THAN 20	2	0
21-30	5	1
31-40	5	2
41-50	3	2
51-60	4	1
61-70	4	1

In less than 20 years of age, there were 2 males and no females. In age group 21-30 years of age,5were males and 1 was female. In 31-40 years of age, 5were males and 2 were females.

In 41-50 years of age, 3 were males and 2 were females.In 51-60 years of age,4 were males and 1 was female. In 61-70 years of age, 4 were male and 1 was female.

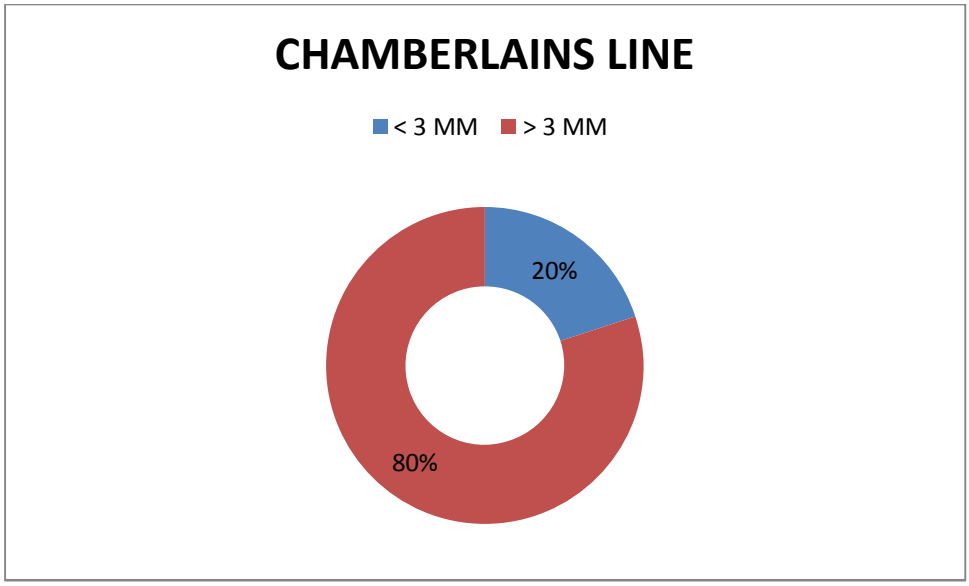


significant P value 0.595 and showed no much difference in age distribution in relation with sex.

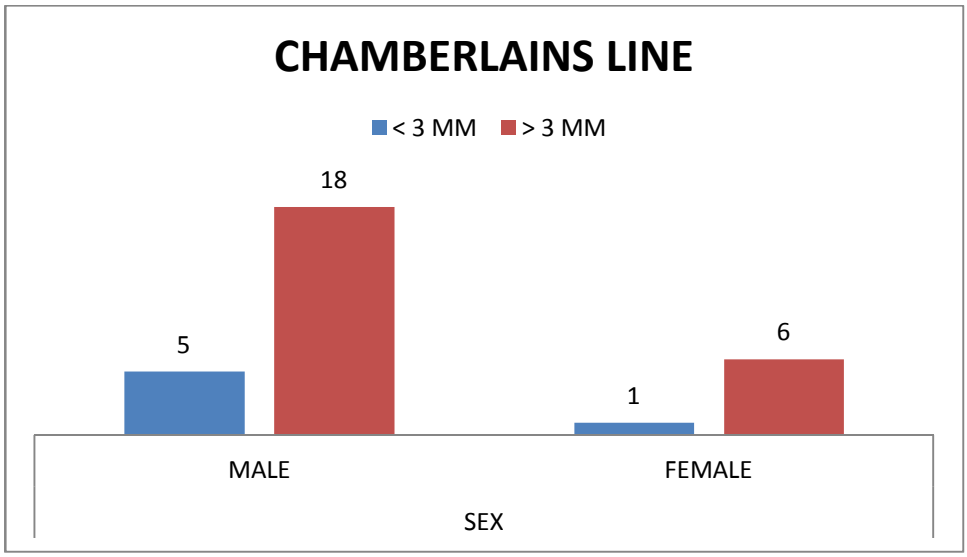
CHAMBERLAINS LINE

CHAMBERLAINS LINE	NO OF PATIENTS	PERCENTAGE
< 3 MM	6	20%
> 3 MM	24	80%

Abnormal Chamberlain‘s line was noted in 24 patients out of 30 patients, that accounted for 80% .



CHAMBERLAINS LINE	SEX	
	MALE	FEMALE
< 3 MM	5	1
> 3 MM	18	6



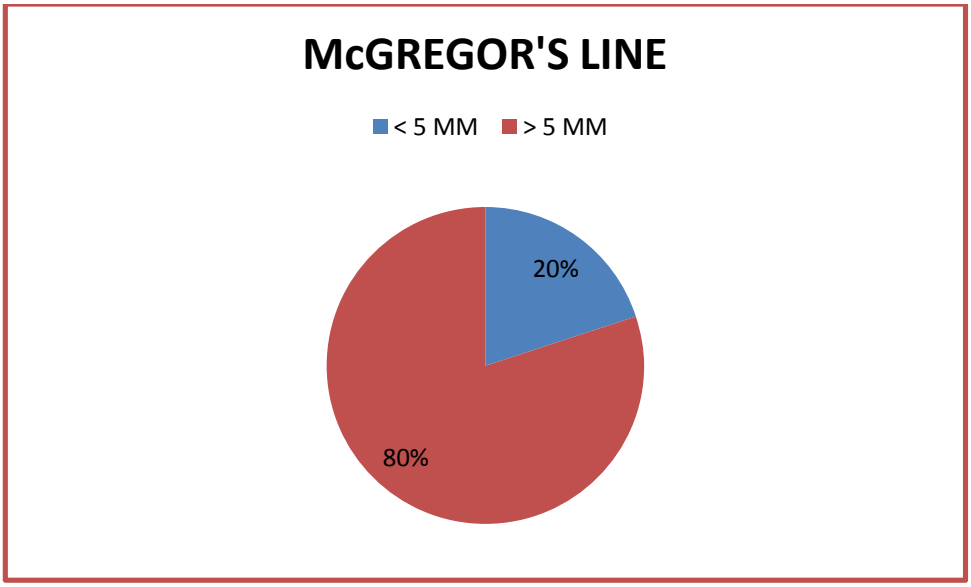
Abnormal chamberlain's line of more than 3mm noted predominantly in male population.

P value -0.02 chamberlain's line more than 3 mm was commonly seen significantly in male.

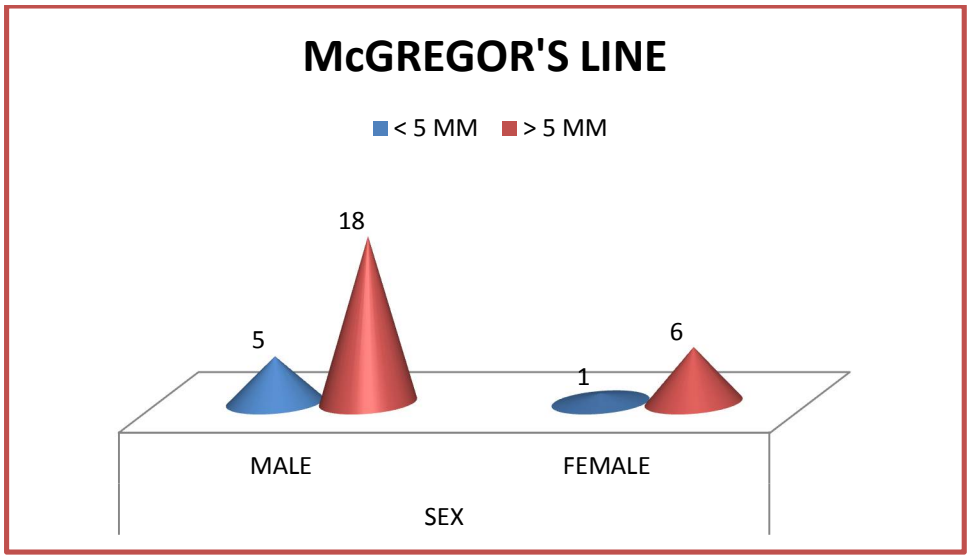
McGREGOR'S LINE

McGREGOR'S LINE	NO OF PATIENTS	PERCENTAGE
< 5 MM	6	20%
> 5 MM	24	80%

Abnormal McGregor's line was noted in 24 patients out of 30 patients and it accounted for about 80%.



McGREGORS LINE	SEX	
	MALE	FEMALE
< 5 MM	5	1
> 5 MM	18	6

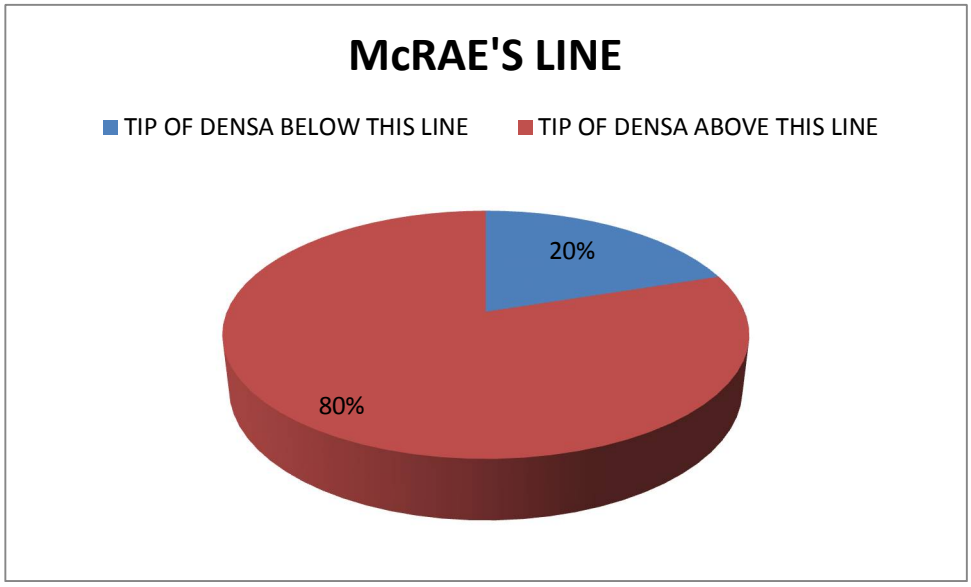


Abnormal McGregor's line of more than 5mm was noted predominantly in male population.

P value -0.02 McGregor's line more than 5 mm was commonly seen significantly in male.

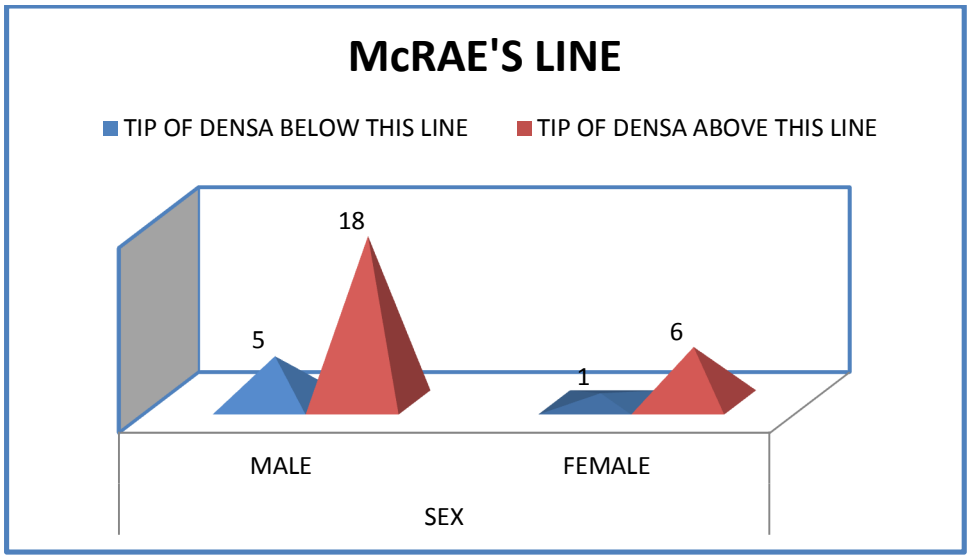
McRAE'S LINE

McRAE'S LINE	NO OF PATIENTS	PERCENTAGE
TIP OF DENS BELOW THIS LINE	6	20%
TIP OF DENS ABOVE THIS LINE	24	80%



Abnormal McRae's line was noted in 24 patients out of 30 patients and it accounted for about 80%

McRAE'S LINE	SEX	
	MALE	FEMALE
TIP OF DENS BELOW THIS LINE	5	1
TIP OF DENS ABOVE THIS LINE	18	6

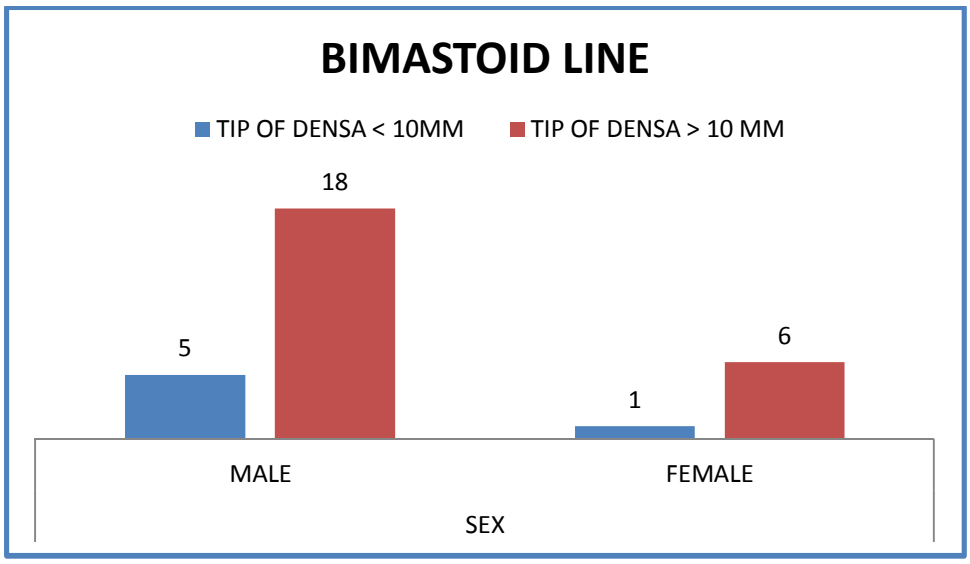


Abnormal McRae's line (tip of dens above this line) noted predominantly in male population.

P value -0.02 abnormal McRae's line was commonly seen significantly in male.

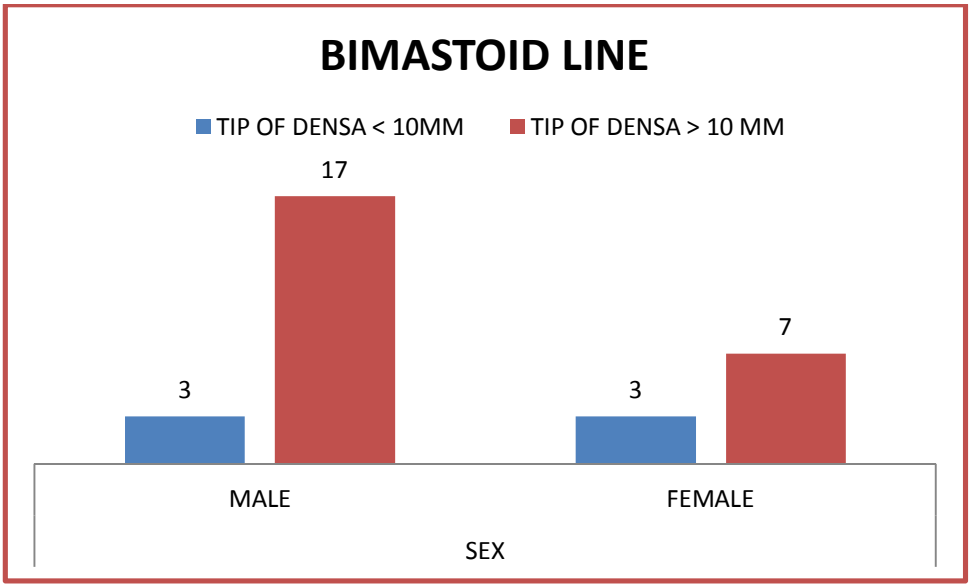
BIMASTOID LINE

BIMASTOID LINE	NO OF PATIENTS	PERCENTAGE
TIP OF DENS < 10MM	6	20%
TIP OF DENS > 10 MM	24	80%



BIMASTOID LINE	SEX	
	MALE	FEMALE
TIP OF DENS < 10MM	5	1
TIP OF DENS > 10 MM	18	6

Abnormal bimastoid line was noted in 24 patients out of 30 patients and it accounted for about 80% of abnormal bimastoid line

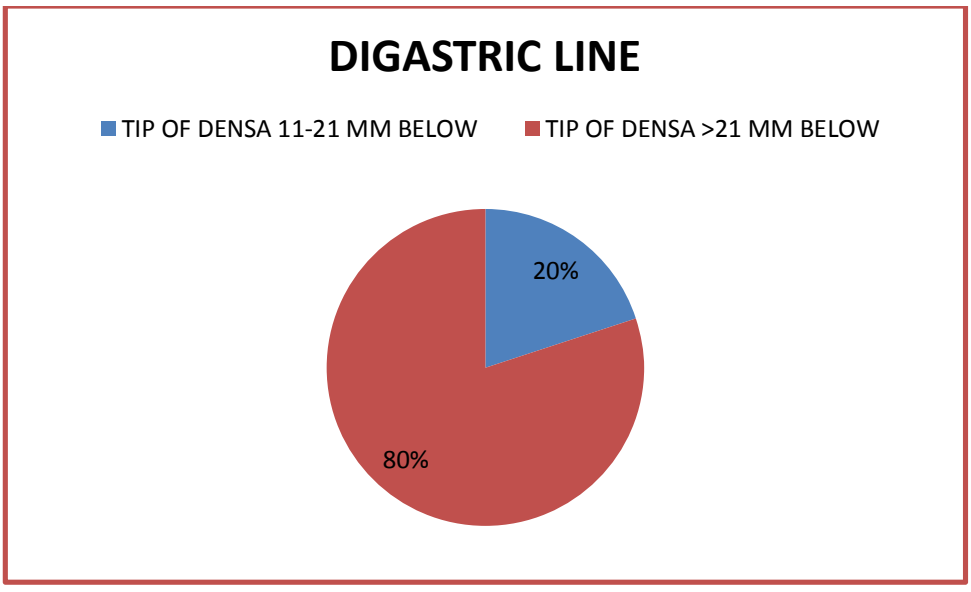


abnormal bimastoid line (more than 10 mm) was noted predominantly in male population.

P value -0.02 bimastoid line more than 10 mm was commonly seen significantly in male.

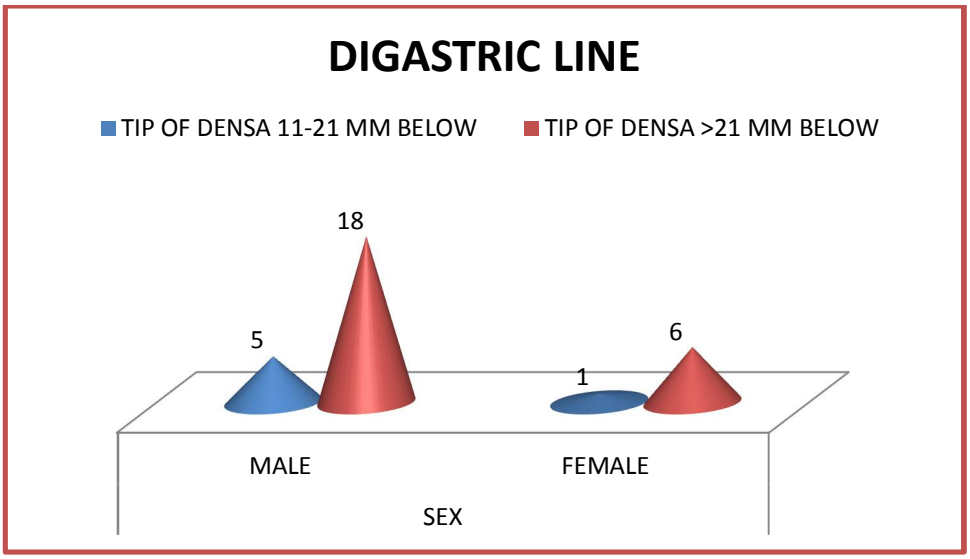
DIGASTRIC LINE

DIGASTRIC LINE	NO OF PATIENTS	PERCENTAGE
TIP OF DENSA 11-21 MM BELOW	6	20%
TIP OF DENSA >21 MM BELOW	24	80%



Abnormal digastric line was noted in 24 patients out of 30 patients and it accounted for about 80%.

DIGASTRIC LINE	SEX	
	MALE	FEMALE
TIP OF DENS 11-21 MM BELOW	5	1
TIP OF DENS >21 MM BELOW	18	6

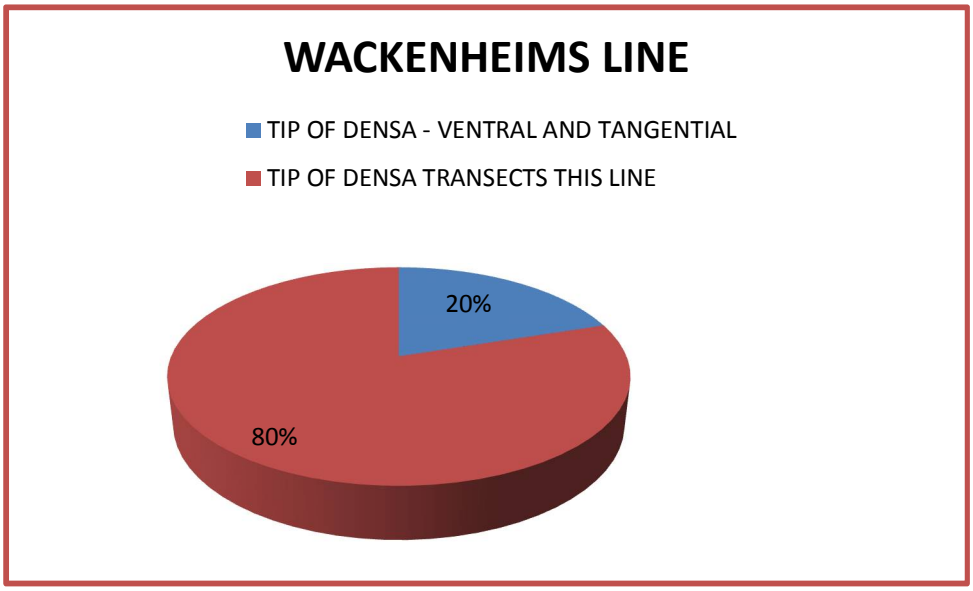


Abnormal digastric line (more than 21 mm) was noted predominantly in male population.

P value -0.02 digastric line more than 21 mm wass commonly seen significantly in male.

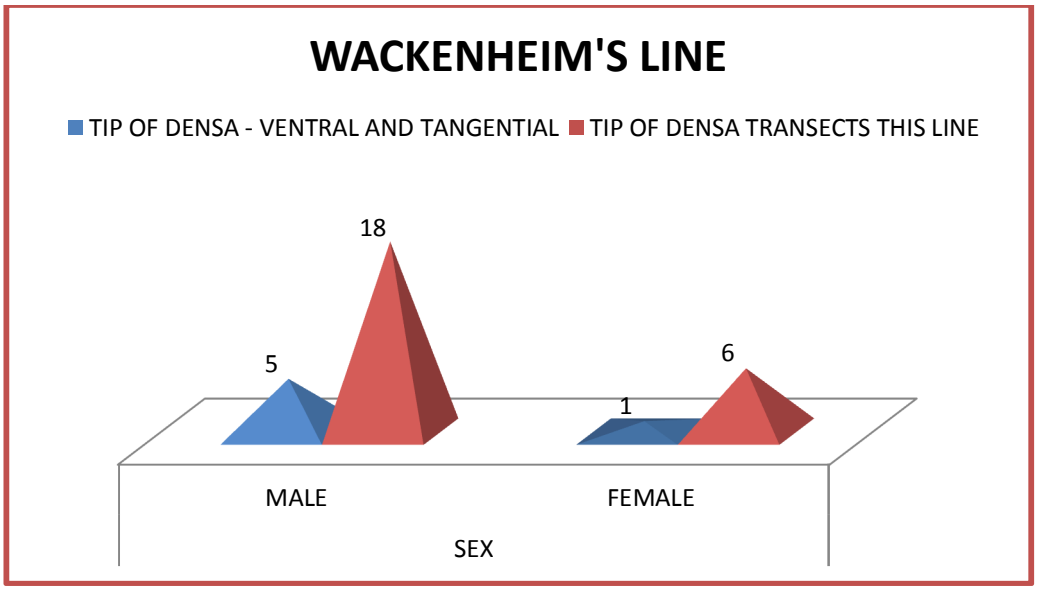
WACKENHEIM'S LINE

WACKENHEIMS LINE	NO OF PATIENTS	PERCENTAGE
TIP OF DENS - VENTRAL AND TANGENTIAL	6	20%
TIP OF DENS TRANSECTS THIS LINE	24	80%



Abnormal Wackenheim's line was noted in 24 patients out of 30 patients and it accounted for about 80% of abnormal Wackenheim's line.

WACKENHEIMS LINE	SEX	
	MALE	FEMALE
TIP OF DENS - VENTRAL AND TANGENTIAL	5	1
TIP OF DENS TRANSECTS THIS LINE	18	6

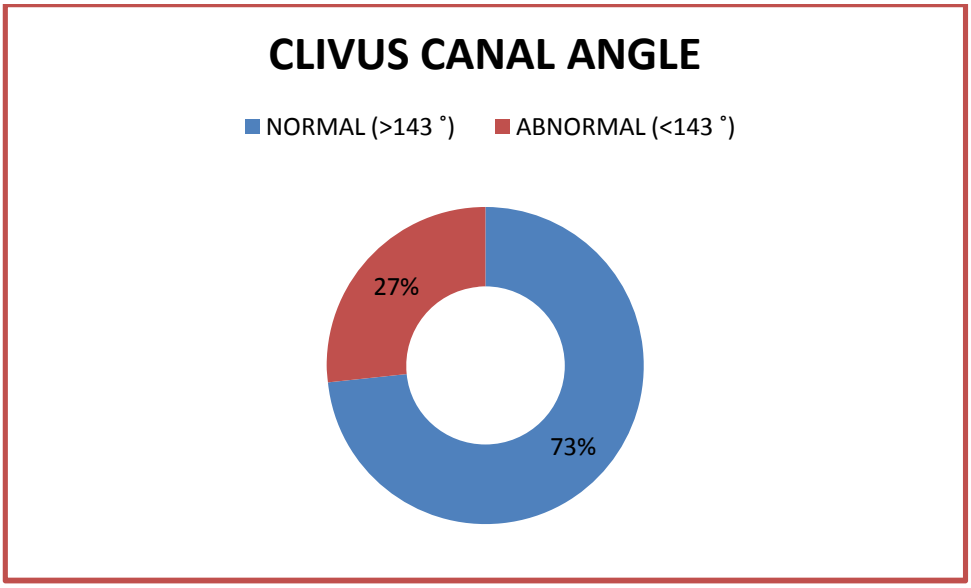


Abnormal wackenheim's line (tip of dens transecting this line) was noted predominantly in male population.

P value -0.02 abnormal wackenheim's line was commonly seen significantly in male.

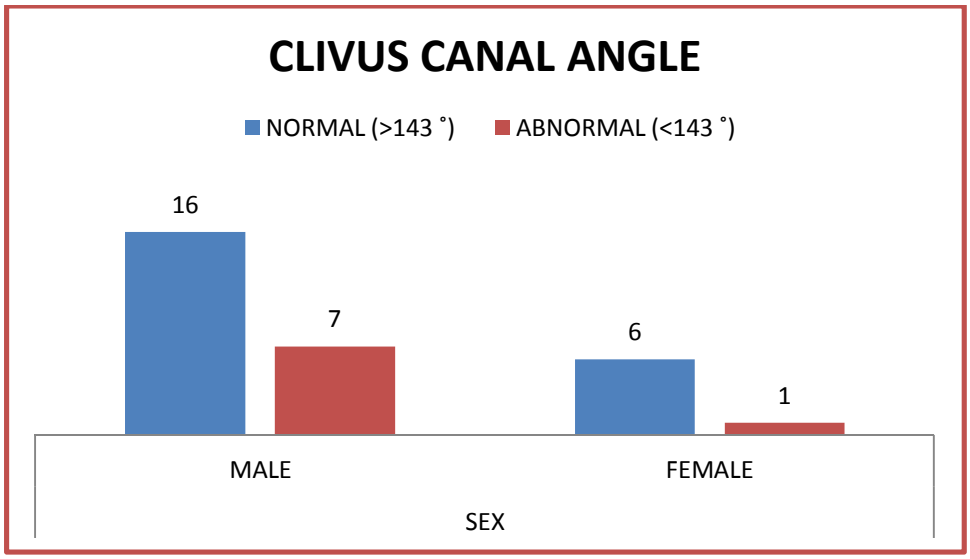
CLIVUS CANAL ANGLE

CLIVUS CANAL ANGLE	NO OF PATIENTS	PERCENTAGE
NORMAL (>143 ˚)	22	20%
ABNORMAL (<143 ˚)	8	80%



Abnormal clivus canal angle(<143degree) was noted in 8 patients out of 30 patients and it accounted for about 27% of abnormal clivus canal angle.

CLIVUS CANAL ANGLE	SEX	
	MALE	FEMALE
NORMAL (>143 ˚)	16	6
ABNORMAL (<143 ˚)	7	1

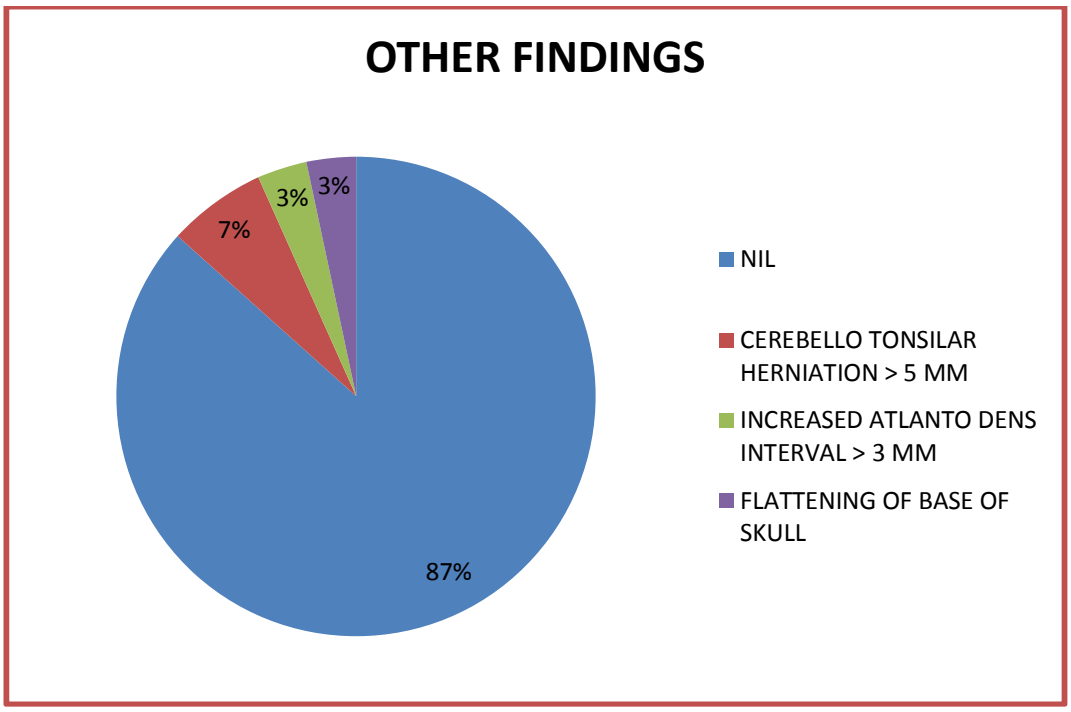


Abnormal clivus canal angle (<143degree) was noted predominantly in male population. It indicated platybasia.

P value -0.01 abnormal clivus angle seen significantly in male.

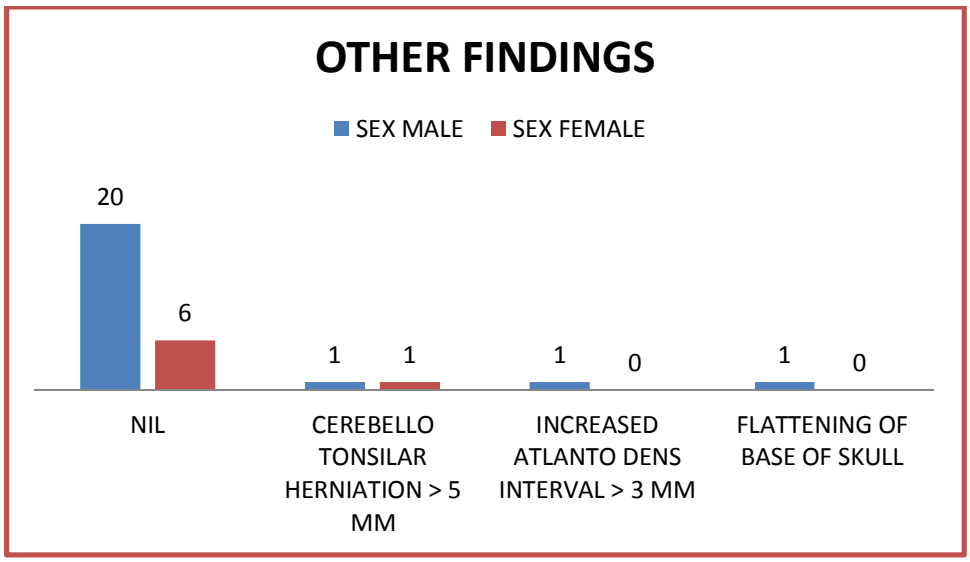
OTHER FINDINGS

OTHER FINDINGS	NO OF PATIENTS	PEECENTAGE
NIL	26	87%
CEREBELLO TONSILAR HERNIATION > 5 MM	2	7%
INCREASED ATLANTO DENS INTERVAL > 3 MM	1	3%
FLATTNING OF BASE OF SKULL (WELCHER'S BASAL ANGLE >143degree)	1	3%



In our study, apart from the major craniometric measurements that favoured the diagnosis of basilar invagination, few other parameters were included like herniation of cerebellar tonsil, increased atlanto dens interval and flattening of base of skull that aided the diagnosis like Arnold-Chiari malformation, atlantoaxial dislocation and platybasia respectively.Among these findings, cerebellar tonsil herniation was seen in 6%population favoured the diagnosis of Arnold-Chiari malformation

OTHER FINDINGS	SEX	
	MALE	FEMALE
NIL	20	6
CEREBELLO TONSILAR HERNIATION > 5 MM	1	1
INCREASED ATLANTO DENS INTERVAL > 3 MM	1	0
FLATTENING OF BASE OF SKULL	1	0



Out of 30 patients, cerebello tonsilar herniation was seen in 2 paatients each one in both male and female. Increased Atlanto dens interval was seen in only one male and flattening of base of skull seen in one male only.

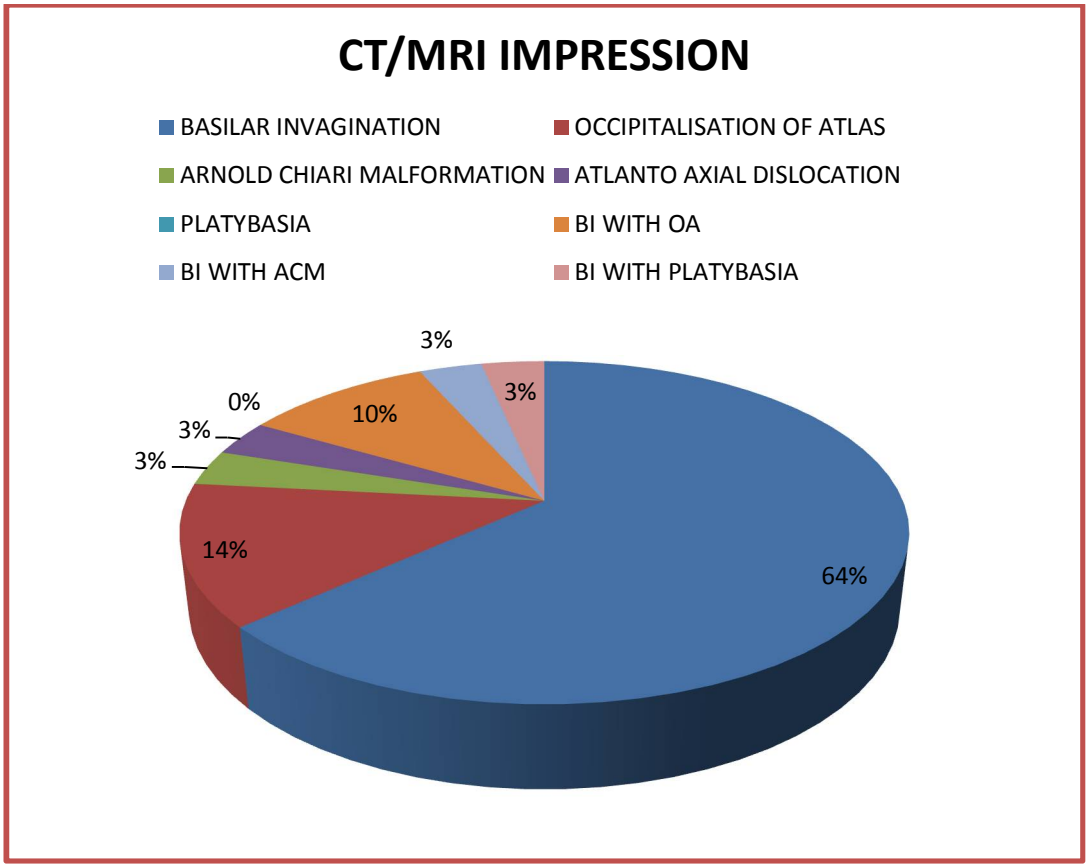
P value – 0.736 no significant difference in other findings

CT/MRI IMPRESSION

Among total 30 congenital anomalies of CVJ, 24 cases were being associated with isolated bony anomalies and 4 of them had multiple bony anomalies.One had isolated soft tissue anomaly and one had combination of both anomalies.

CT/MRI IMPRESSION	NO OF PATIENTS	PERCENTAGE
BASILAR INVAGINATION	19	64%
OCCIPITALISATION OF ATLAS	4	14%
ARNOLD CHIARI MALFORMATION	1	3%
ATLANTO AXIAL DISLOCATION	1	3%
PLATYBASIA	0	0%
BI WITH OA	3	10%
BI WITH ACM	1	3%
BI WITH PLATYBASIA	1	3%

Basilar invagination was the most common bony anomaly(90%) seen in our study.It was s seen in about 64% in isolated cases and also seen about 16% in combined anomalies. Arnold Chiari malformation is the most common soft tissue anomaly(6%) seen in our study. It accounted for about 3% in isolated anomalies and 3% in combination with basilar invagiantion.



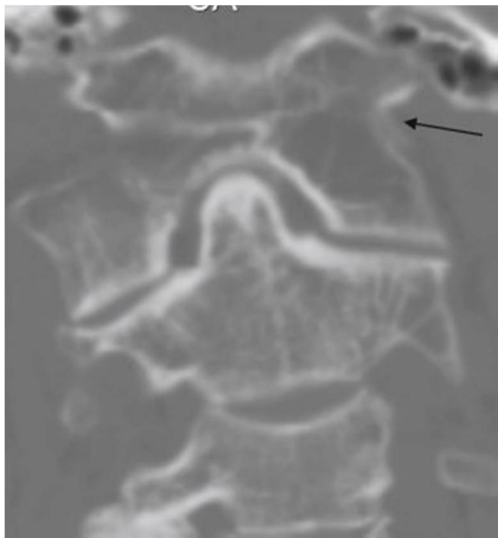
CT/MRI IMPRESSION	SEX	
	MALE	FEMALE
BASILAR INVAGINATION	16	3
OCCIPITALISATION OF ATLAS	2	2
ARNOLD CHIARI MALFORMATION	1	0
ATLANTO AXIAL DISLOCATION	1	0
PLATYBASIA	0	0
BI WITH OA	2	1
BI WITH ACM	0	1
BI WITH PLATYBASIA	1	0

Basilar invagination was the most common anomaly seen in both male and female about 24 cases but predominantly seen involving males about 19 cases.

Case no. 11: CT sagittal view shows basilar invagination

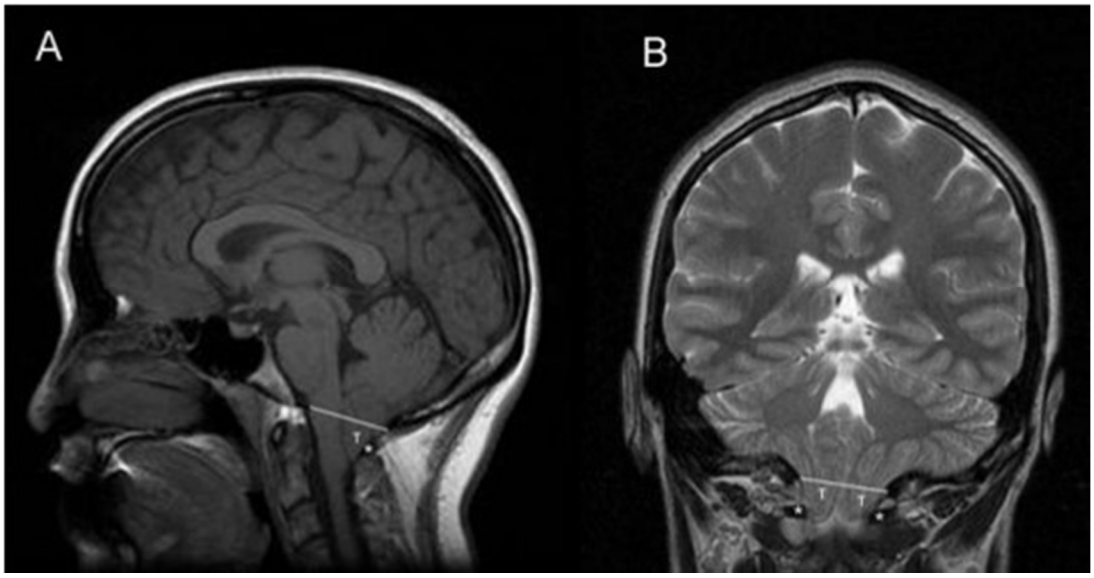
Case No.15: MRI T2sagital view shows basilar invagination

Isolated Occipitalisation of atlas was seen in 2 cases,one each in males and females . Occipitalisation of atlas was associated with basilar invagination seen in 2 males and 1 female,



Case no 4 : CT Shows Occipitalisation of atlas

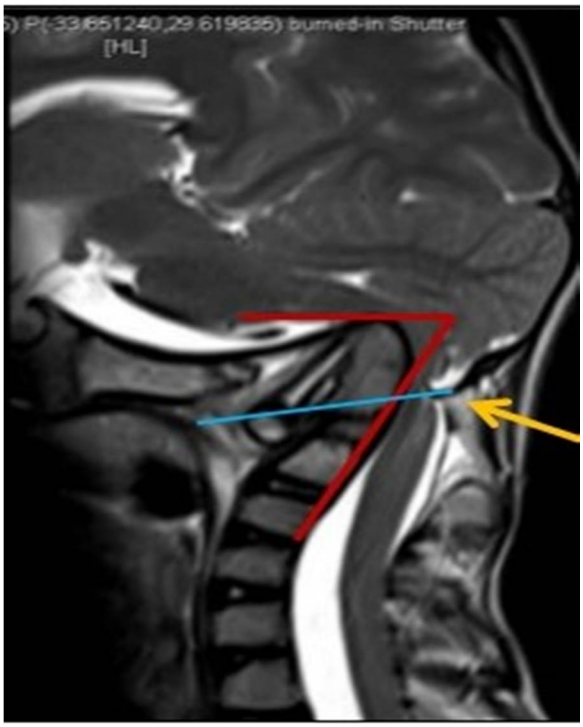
Isolated Arnold-Chiari malformation was seen in 1 male case and another Arnold-Chiari malformation was seen associated with basilar invagination.



Case no 2: T1 sagittal & T2 coronal MRI shows tonsillar herniation.

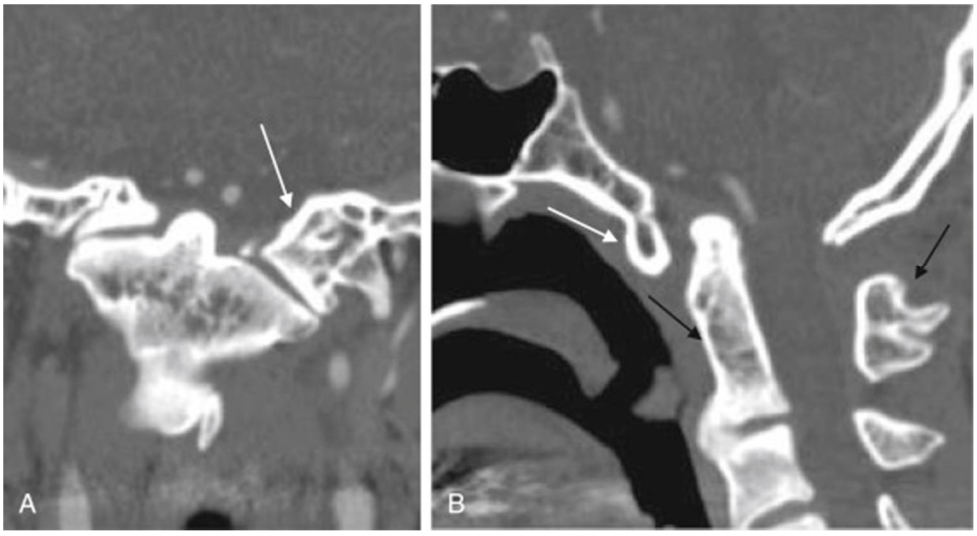
Solitary case of atlanto axial dislocation was seen in one male patient.

Platybasia is noted in single case .It is seen associated with basilar invagination.



case no 17 : T2 sagittal MRI shows Platybasia (decreased clivus canal angle) and basilar invagiantion

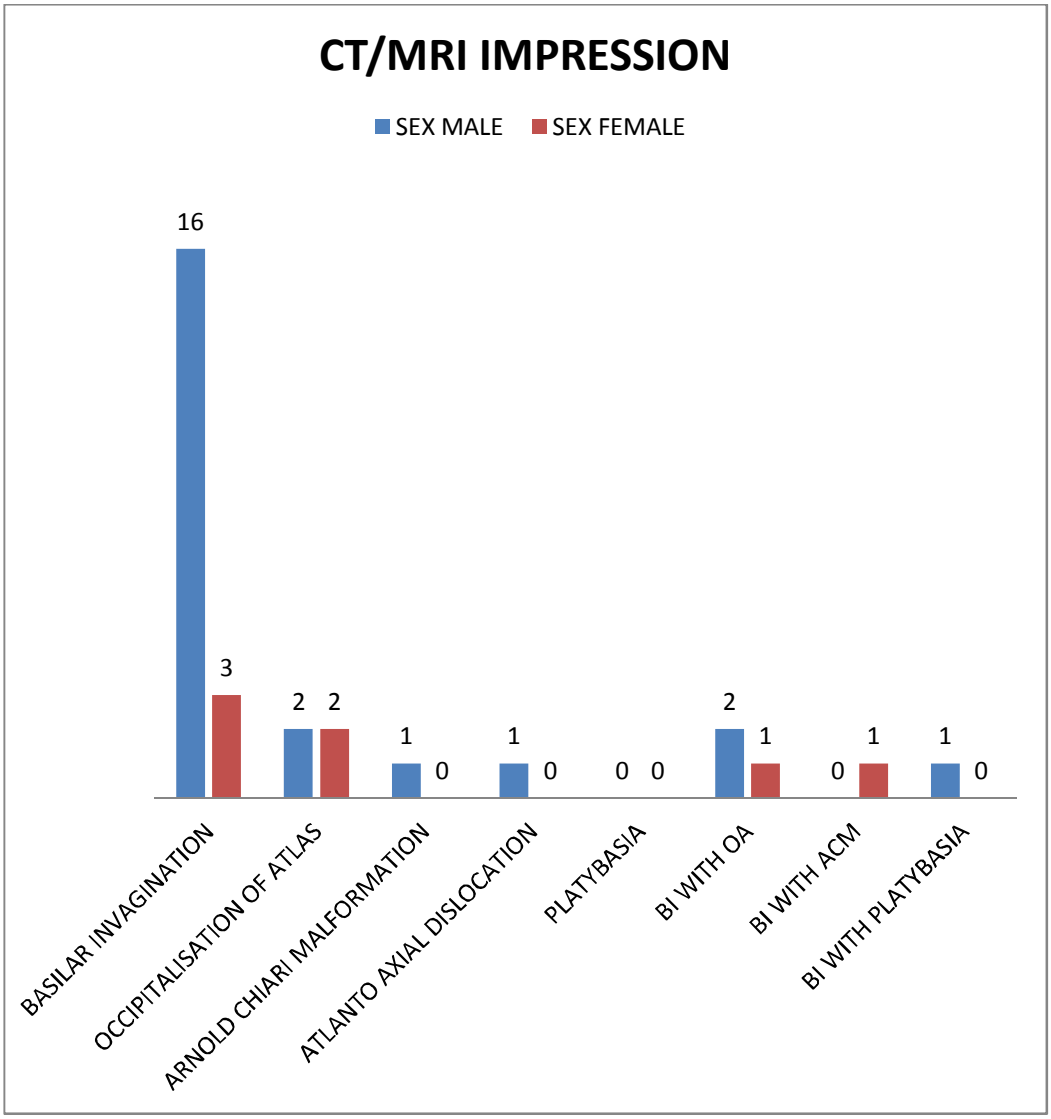
Occipitalisation of atlas is most commonly seen in male population. It is seen associated with basilar invagination.



Case no 25: Figure A shows occipitalisation of atlas(white arrow),

Figure B shows basilar invagination (black arrow) in CT

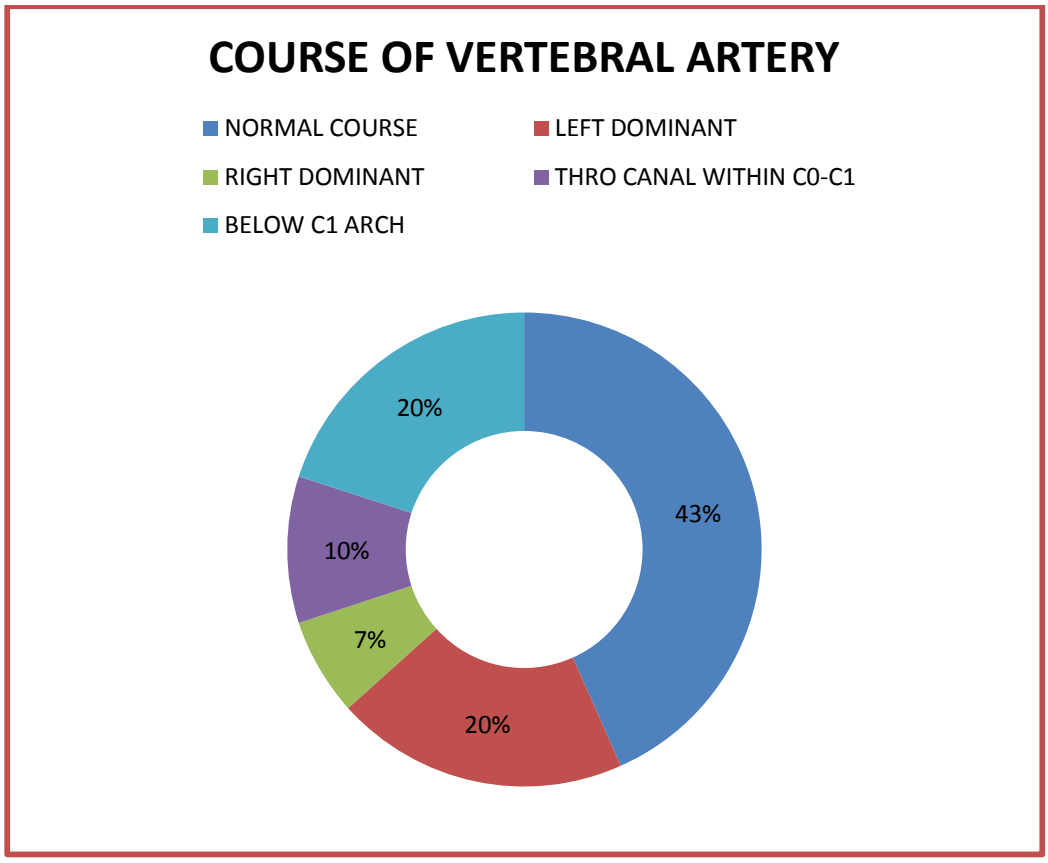
P value – 0.375 No significant effect on sex in CT/MRI impression except basilar invagination which is commonly seen in males


CT/MRI IMPRESSION
SEX MALE
SEX FEMALE
16
3
2
2
1
0
1
0
0
0
2
1
0
1
1
0
BASILAR INVAGINATION
OCCIPITALISATION OF ATLAS
ARNOLD CHIARI MALFORMATION
ATLANTO AXIAL DISLOCATION
PLATYBASIA
BI WITH OA
BI WITH ACM
BI WITH PLATYBASIA

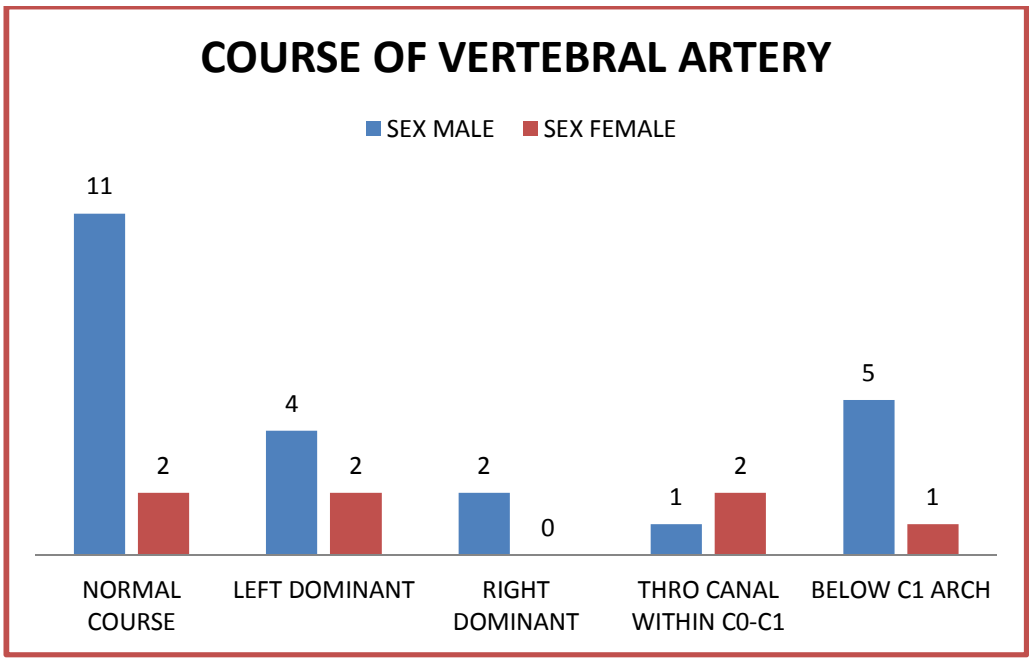
COURSE OF VERTEBRAL ARTERY

Out of 30 patients, 13 patients had normal course of vertebral artery.8 patients had variant course of vertebral artery.Abnoraml course of vertebral artery noted in V3 segment which was passing through canal within C0-C1 complex and below C1 arch (posterior to the occpitalised C1 lateral mass)seen in 3 patients(10%) and 6patients (20%) respectively

COURSE OF VERTEBRAL ARTERY	NO OF PATIENTS	PERCENTAGE
NORMAL COURSE	13	43%
LEFT DOMINANT	6	20%
RIGHT DOMINANT	2	7%
THROUGH CANAL WITHIN C0-C1	3	10%
BELOW C1 ARCH & POSTERIOR TO C1 LATERALISED MASS	6	20%

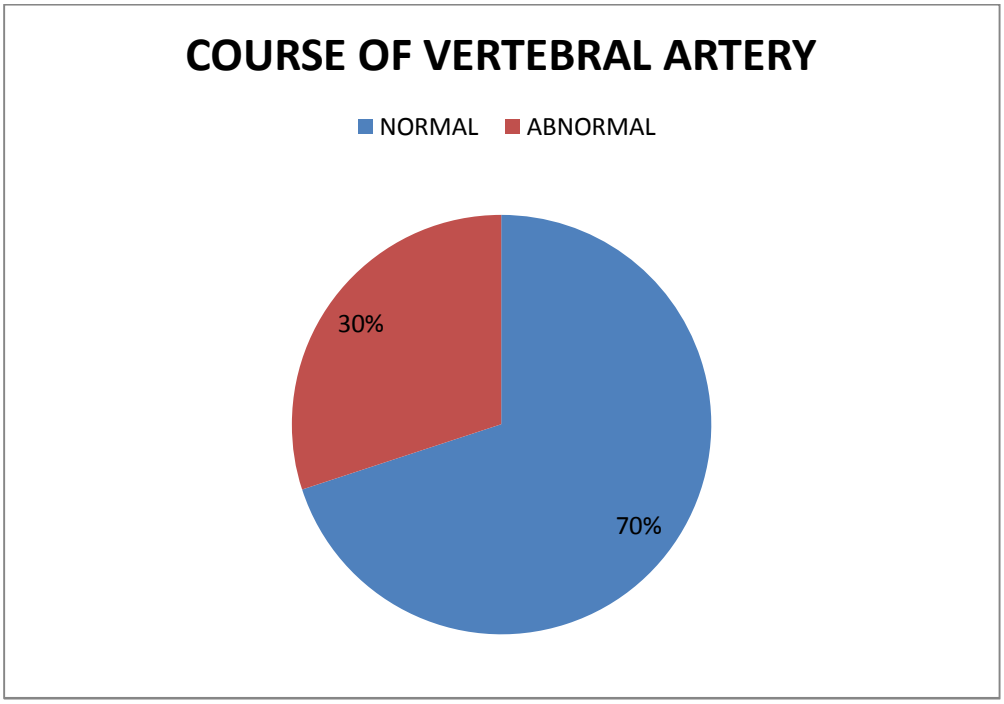

COURSE OF VERTEBRAL ARTERY
NORMAL COURSE
LEFT DOMINANT
RIGHT DOMINANT
THRO CANAL WITHIN C0-C1
BELOW C1 ARCH
20%
43%
10%
7%
20%

COURSE OF VERTEBRAL ARTERY	SEX	
	MALE	FEMALE
NORMAL COURSE	11	2
LEFT DOMINANT	4	2
RIGHT DOMINANT	2	0
THROUGH CANAL WITHIN C0-C1	1	2
BELOW C1 ARCH & POSTERIOR TO C1 LATERALISED MASS	5	1



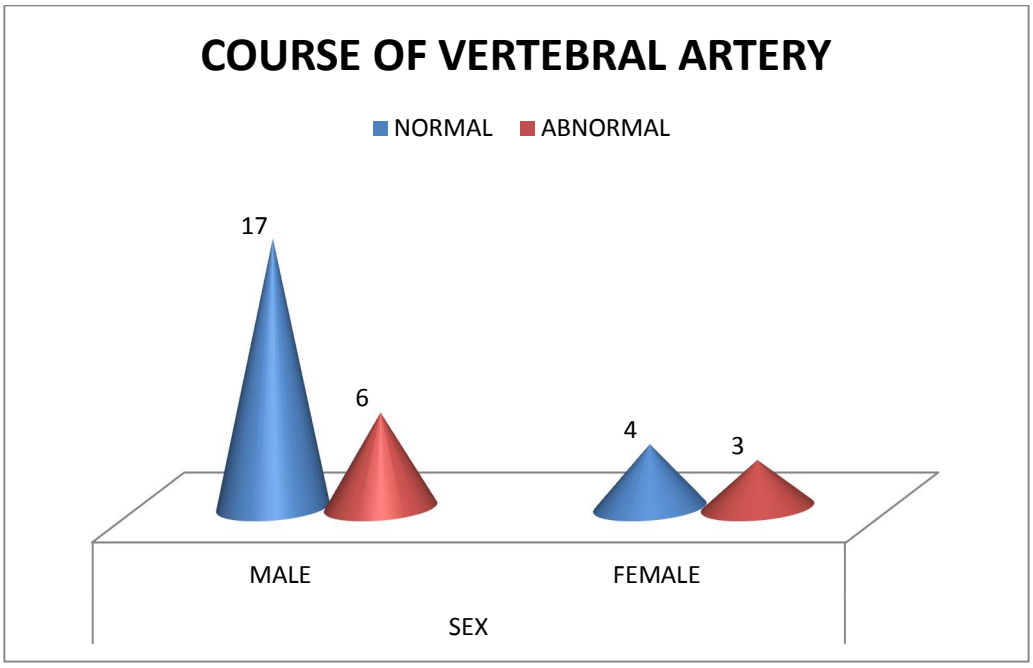
COURSE OF VERTEBRAL ARTERY

COURSE OF VERTEBRAL ARTERY	NO OF PATIENTS	PERCENTAGE
NORMAL	21	70%
ABNORMAL	9	30%



Abnormal course of the vertebral artery was documented in 9 patients out of 30 patients which accounted for about 30% in congenital CVJ anomalies.

COURSE OF VERTEBRAL ARTERY	SEX	
	MALE	FEMALE
NORMAL	17	4
ABNORMAL	6	3



Abnormal course of vertebral artery was found to be predominatly involving in male population about 20%

P value – 0.034 Abnormal course significantly seen in male.

DISCUSSION

The CV Junction Anomalies were equally distributed in young as well as elderly individuals. CVJ anomalies were distributed 49% in less than 40 years and 51% in elderly population. The prevalence of CVJ anomalies were predominantly seen in male population. Males were contributing 77% in the incidence of CVJ anomalies in our study. Among the congenital Anomalies, the bony anomalies (94% as isolated cases and 3% as combined one) were commoner than the soft tissue anomalies (3% as isolated case and 3% as combined one).

Basilar Invagination(80%) was the most common congenital bony anomaly and the Arnold Chiari malformation (6%) was the most common soft tissue anomaly. These results were well comparable to the studies previously done worldwide, as described in the literature. CT scan and MRI cervical spine including CVJ were the important tool to diagnose and to tailor the surgical management. About 30% of patients had abnormal course o f the vertebral artery. The preoperative imaging of angiographic study of vertebral artery was well correlated with the final surgical outcome and showed statistical significance.

We observed 4 variety of bony anomalies namely basilar invagination,occipitalisation of atlas,atlanto axial dislocation and platybasia. Solitary soft tissue anomaly like Arnold Chiari malformation had been observed .Among 30 patients 5 cases were presented with multiple anomalies as combination of either multiple bony anomalies or bony & soft tissue anomalies.Those combined anomalies mostly presented with basilar invagination.

The Craniometric assessment showed abnormal Mc Rae's line , Chamberlain's line , McGregor's line , bimastoid line, digastric line,Wackenheim Clivus Canal Line in 80% patients with basilar invagination.

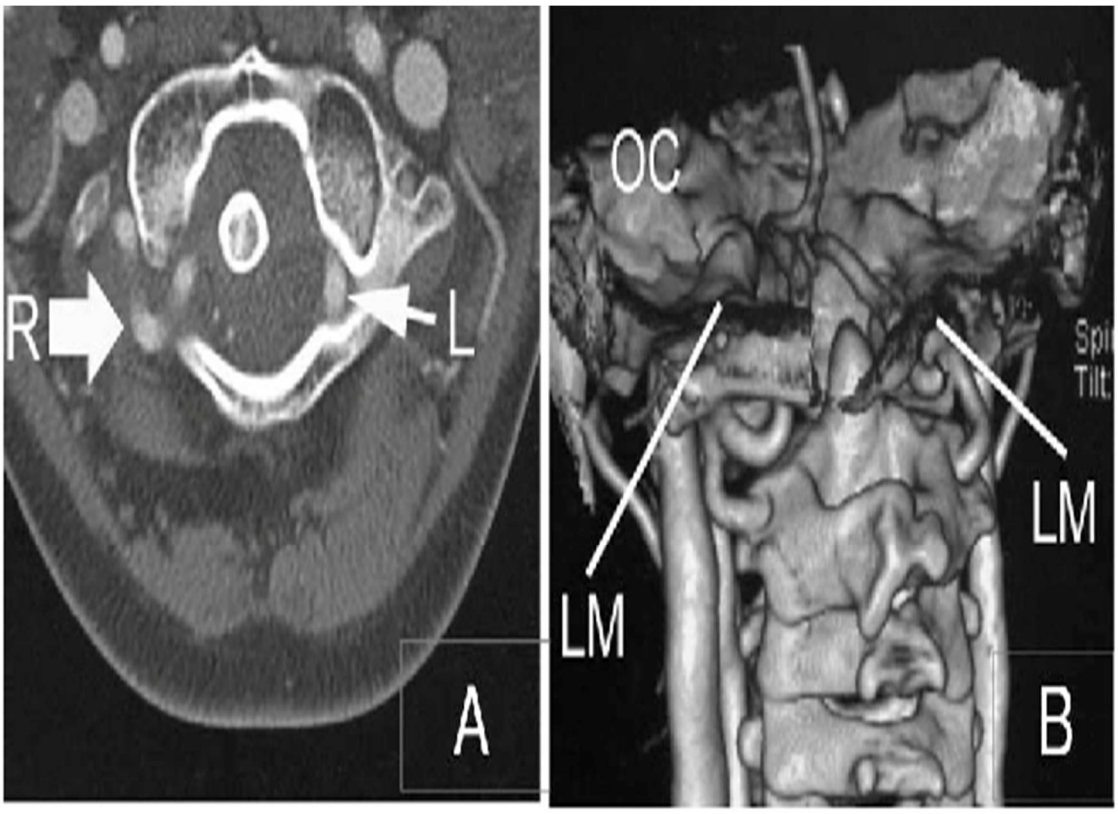
Out of 30 patients , 24 patients are presented with basilar invagination which includes 19 males and 5 females. Out of 24 cases ,5 of them were being presented with other associated anomalies like occipitalisation of atlas,platybasia and Arnold Chiari malformation. In our study, occipitalisation of atlas was being the one most commonly associated anomaly with basilar invagination in about 3 cases .remaining were platybasia and Arnold Chiari malformation.

Abnormal clivus canal angle (<143 degree) was seen in 8 patients that account ted for20% . It was associated with occipitalisation of atlas and platybasia .Out of 30 patients, 7 patients were presented with occipitalisation of atlas which includes 4 males and 3 females.Out of 7 cases, 3 cases were associated with basilar invagination. solitary platybasia(3%) showed flattening of skull which was also seen associated with basilar invagination.

Abnormal atlanto dental interval (>3mm) was observed in one case which favoured the diagnosis of spontaneous Atlanto-Axial Dislocation which was seen about 3%.

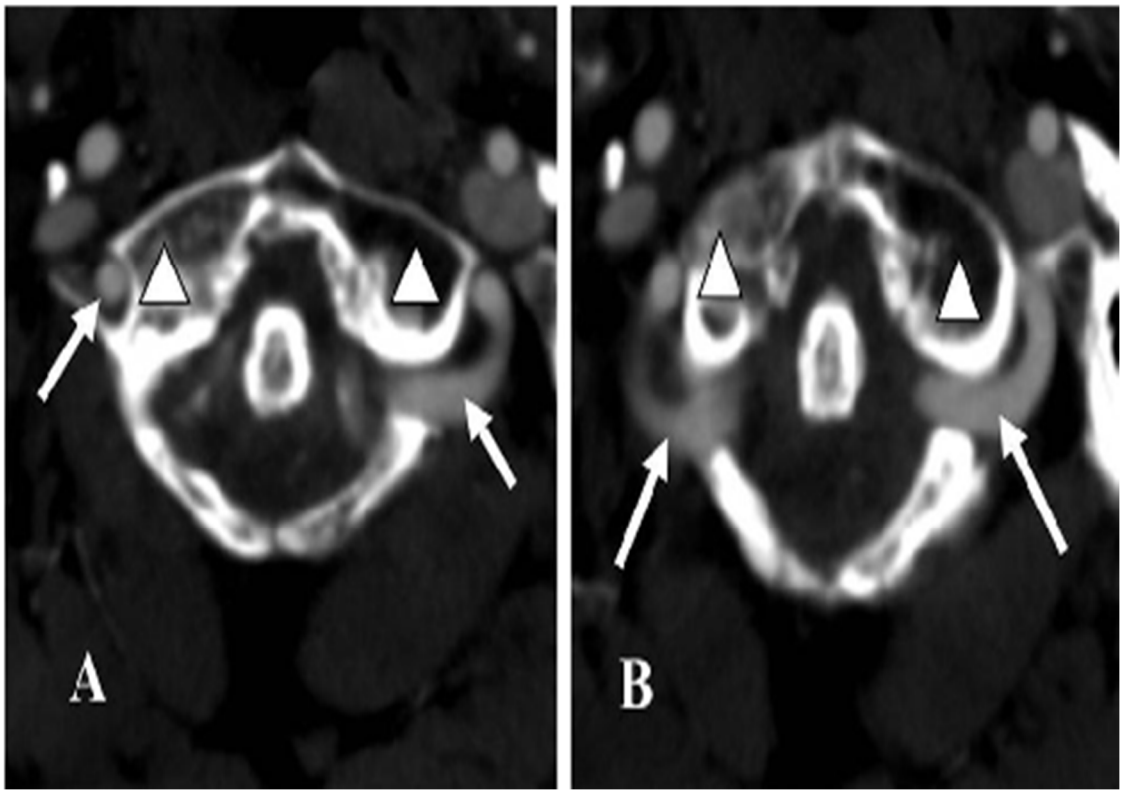
Abnormal cerebello tonsil herniation(> 5mm) was noted in 2 cases as isolated one and combined one.It was associated with basilar in vagination. It favoured diagnosis of Arnold –Chiari malformation type1 that involving about 6 % .There was no association with meningocele/ encephalocele seen.

Abnormal course of V3 segment of vertebral artery was noted about 30% of CVJ cases.It was most commonly associated with bony anomaly especially in occipitalisation of atlas. There are 2 types of abnormal course was being noticed .

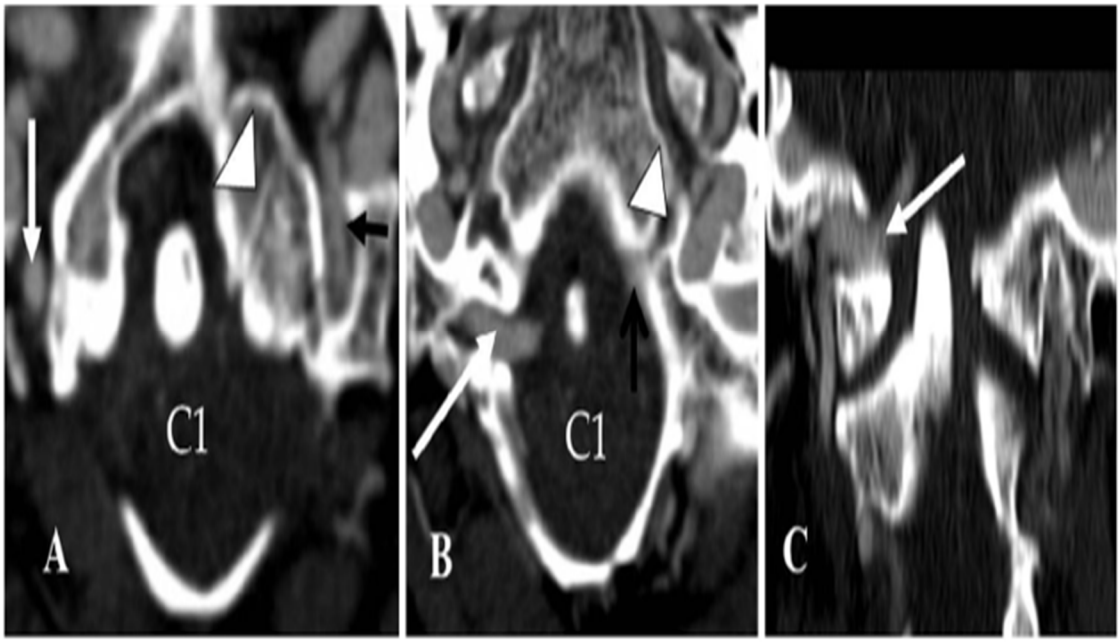


Case no 27: Axial & VR images of CVJ shows course of vertebral artery seen below C1 arch and posterior to occipitalised C1 lateral mass.

The passage of V3 segment of vertebral artery was seen through C0-C1 fusion complex(10%) or below C1 arch and posterior to occipitalised lateral mass(20%) .They were associated with multiple anomalies in most of the cases.



Case no 19 : axial sections(A&B) of CT Vertebral angiography shows V3 segment of vertebral artery is seen passing below and posterior to the fusion of C0-C1complex in case of occipitalisation of atlas.



Case no 30 : figure A (axial),B(coronal) and C(saggital) images of CT vertebral angiography;the right vertebral artery is seen passing through C0-C1 fusion complex in case of occipitalisation of atlas with basilar invagination.

Cranio-vertebral junction is was anatomically complex area and can be elaborated in detail by using CT,MRI and CT Vertebral angiography. this study helps the surgeon to better appreciate the anatomy and select the best surgical approach, thereby avoiding iatrogenic injuries and improving surgical outcomes.

CONCLUSION

1) Among all the Craniovertebral Junction anomalies, bony anomalies were more commonly seen than soft tissue anomalies.
2) Most of the CVJ anomalies were predominantly seen in males.
3) Cranio vertebral junction were equally distributed in all age groups.
4) Basilar invagination was the most common bony abnormality detected in our study.
5) Anomalies of CVJ can occur as isolated one or in combination with basilar invagination.
6) Computed Tomography was the primary modality to evaluate the bony CVJ anomalies.
7) MRI was the primary modality to evaluate the soft tissue CVJ anomalies.
8) Abnormal course of the vertebral artery was noted in 30% of CVJ cases hence the importance of pre-operative assessment of vertebral artery by doing three dimensional computed tomography angiography to minimize iatrogenic injuries.

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PROFORMA

NAME :

AGE :

SEX :

COMPLAINTS :

GENERAL EXAMINATION :

LOCAL EXAMINATION :

CT FINDINGS :

MRI FINDINGS :

CRANIO METRIC ASSESSMENT :

CT VERTEBRAL ANGIOGRATHY FINDINGS :

KEY TO MASTER CHART

AGE

0-10 -0
11-20 -1
21-30 -2
31-40 -3
41-50 -4
51-60 -5
61-70 -6

SEX

0-MALE
1-FEMALE

CHAMBERLAIN'S LINE(CL)

0- < 3mm
1- >3mm

McGregor's LINE(McG)

0- <5mm
1- >5mm

McRae's LINE (McR)

0-Tip Of Dens seen below this line
1- Tip Of Dens seen above this line

BIMASTOID LINE(BML)

0- Tip Of Dens <10mm to this line
1- Tip Of Dens >10mm to this line

WACKENHEIM'S LINE

0- Tip Of Dens Ventral & tangential to this line
1- Tip Of Dens Transects this line - 1

DIGASTRIC LINE(DL)

0- Tip Of Dens 11-21mm below to this line
1- Tip Of Dens >21mm

CLIVUS CANAL ANGLE(CCA)

0-Normal (> 143 degree)
1 –abnormal(<143 degree)

OTHERS

0-Nil
1-cerebellar tonsil herniation >5mm
2-increased Atlanto Dens Interval(ADI)>3mm
3-Flattening of base of skull

CT/MR IMPRESSION

0-Basilar invagination

1-Occipitalisation of atlas

2-Arnold Chiari Malformation 1

3-Atlanto axial dislocation

4-Platybasia

COURSE OF VERTEBRAL ARTERY

0-Normal Course

1-Left Dominant (normal variant)

2-Right Dominant (normal variant)

3-Passing Through Canal Within C0-C1 Fused Complex (abnormal course)

4-Below C1 Arch (abnormal course)

ஒப்புதல் படிவம்

நோயாளியின் பெயர் : பாலினம்: வயது:

பெற்றோர் பெயர் :

முகவரி:

அரசு கோவை மருத்துவக் கல்லூரியில் கதிரியிக்கத்துறையில் பட்ட மேற்படிப்பு பயிலும் மாணவர் **மரு.கார்த்திக்** அவர்கள் மேற்கொள்ளும் **தலை, கழுத்து இணைப்பு பகுதியில் பிறப்பு குறைபாடு (சிவி ஜங்சன் அனாமலி)** தொடர்பான பரிசோதனை பற்றிய ஆய்வில் செய்முறை மற்றும் அனைத்து விளக்கங்களையும் கேட்டுக் கொண்டு எனது சந்தேகங்களை தெரிவுபடுத்திக் கொண்டேன் என்பதை தெரிவித்துக் கொள்கிறேன்.

இந்த ஆய்வில் நான் முழு சம்மதத்துடனும், சுயசிந்தனையுடனும் கலந்து கொள்ள சம்மதிக்கிறேன்.

இந்த ஆய்வில் என்னைப் பற்றிய அனைத்து விவரங்கள் பாதுகாக்கப்படுவதுடன் இதன் முடிவுகள் ஆய்விதழில் வெளியிடப்படுவதில் ஆட்சேபணை இல்லை என்பதை தெரிவித்துக் கொள்கிறேன். எந்த நேரத்திலும் இந்த ஆய்விலிருந்து நான் விலகிக் கொள்ள எனக்கு உரிமை உண்டு என்பதையும் அறிவேன்.

இடம்:

தேதி: கையொப்பம்/ரேகை

INSTITUTIONAL HUMAN ETHICS COMMITTEE
COIMBATORE MEDICAL COLLEGE, COIMBATOR – 14

EC Reg No. ECR/892/Inst/TN/2016
Telephone No: 0422 – 2574375/76
Fax : 0422 – 2574377

CERTIFICATE OF APPROVAL

To
Dr.Karthick M
Post Graduate,
Department of Radiology,
Coimbatore Medical College & Hospital,
Coimbatore -18.

Dear Dr.Karthick M

The Institutional Ethics Committee of Coimbatore Medical College, reviewed and discussed your application for approval of the proposal entitled "**Imaging Evaluation of Suspected Cranio – Vertebral Junction Anomalies Using CT, MRI & CT Vertebral Angiography.**" No.039/2017.

The following members of Ethics Committee were present in the meeting held on 23.11.2017.conducted at MM - II Seminar Hall, Coimbatore Medical College Hospital Coimbatore-18.

1	Dr.S.Ramalingam MD, Dean, PSG IMS&R, Cbe	Chairman
2	Dr.Usha MD., Professor of General Medicine, CMCH, Cbe	Member Secretary
3	Dr.R.Manonmani MD., Professor of O&G, CMCH, Cbe	Clinicians
4	Dr.N.Renganathan MS., Professor of General Surgery, CMCH,Cbe	Clinicians
5	Dr.Sudha Ramalingam MD., Professor of SPM, PSG IMS&R, Cbe	Clinicians
6	Dr.R. Shanmugavadivu MD., Professor of Physiology, CMC, Cbe	Basic Medical Scientist
7	Dr.N. Shanthi MD., Professor of Pharmacology, CMC, Cbe	Basic Medical Scientist
8	Dr.A.Dhanalakshmi MD., Assoc. Professor of Pathology, CMC,Cbe	Basic Medical Scientist
9	Dr.L.Madhan MD., Professor of Pharmacology, CMC, Cbe	Basic Medical Scientist
10	Dr.N.Paramasivan MD., Professor of Pharmacology, Sri Ramakrishna Dental College, Coimbatore	Basic Medical Scientist
11	Mrs.A.Sharmila BA., BL., Advocate	Legal Expert
12	Dr.K.P.Sampath Kumar M.Pharm, Ph.D., Asst. Prof. of Pharmacy, CMC, Cbe	Scientific Member
13	Dr.G.Vani Ganesh M.Sc.,Ph.D., Tutor in Medical Surgical Nursing, CMCH, Cbe	Scientific Member
14	Mr.V. Balasubramani MA,MA,MBA,LLB,M.Phil,PG.D.M, DLLAL, Chief Executive, Avinashilingam JSS Self Finance Courses, Cbe	Social Worker
15	Mr.V.A.Shahul Hameed, +2	Lay-Person

We approve the Proposal to be conducted in its presented form.

Sd/Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL HUMAN ETHICS COMMITTE
COIMBATORE MEDICAL COL
COIMBATORE

CONSENT FORM

Yourself Mr/Mrs/Ms ..... are being asked to be a participant in the research study titled " **IMAGING EVALUATION OF SUSPECTED CRANIO-VERTEBAL JUNCTION ANOMALIES USING CT, MRI & CT VERTEBRAL ANGIOGRAPHY**" in Coimbatore Medical College and Hospital, Coimbatore, conducted by Dr.M. Karthick, Post Graduate student in the department of Radiodiagnosis, Coimbatore Medical College and Hospital. You satisfy eligibility as per the inclusion criteria. You can ask any queries you may have before agreeing to participate.

PURPOSE OF RESEARCH:

The purpose of the study is to document the importance of "**CRANIO-VERTEBAL JUNCTION ANOMALIES USING CT, MRI & CT VERTEBRAL ANGIOGRAPHY**"

PROCEDURES INVOLVED:

Non contrast and contrast CT are performed. The contrast used is iohexol.

PRIVACY AND CONFIDENTIALITY:

Privacy of individuals will be respected and any information provided will be kept confidential.

AUTHORISATION TO PUBLISH RESULTS:

Results of the study may be published for scientific purposes and/or presented to scientific groups; however you will not be identified.

STATEMENT OF CONSENT:

I ..... voluntarily give my consent to participate in this study. I have read the consent form/it has been read to me. The study has been fully explained to me and I understand that I am entitled to explanations regarding the study as and when necessary.

.....

Signature /Left thumb impression of patient/legal guardian of the child with date

.....Signature of witness with date.

s.no	age	sex	craniometry								CT/MR FINDINGS	COURSE OF VERTEBRAL ARTERY
			CL	McG	McR	BML	DL	WL	CCA	OTHERS		
1	3	1	1	1	1	1	1	1	0	0	0+2	1
2	1	0	0	0	0	0	0	0	0	1	2	2
3	6	0	1	1	1	1	1	1	0	0	0	0
4	4	1	0	0	0	0	0	0	1	0	1	3
5	2	0	1	1	1	1	1	1	0	0	0	0
6	6	0	1	1	1	1	1	1	0	0	0	0
7	2	0	1	1	1	1	1	1	0	0	0	1
8	5	0	1	1	1	1	1	1	0	0	0	0
9	3	0	1	1	1	1	1	1	0	0	0	0
10	5	0	1	1	1	1	1	1	0	0	0	0
11	1	0	1	1	1	1	1	1	0	0	0	1
12	4	0	1	1	1	1	1	1	1	0	0+1	4
13	4	0	1	1	1	1	1	1	0	0	0	1

14	6	0	1	1	1	1	1	1	0	0	0	0
15	5	1	1	1	1	1	1	1	0	0	0	0
16	3	0	1	1	1	1	1	1	0	0	0	0
17	5	0	1	1	1	1	1	1	1	3	0+4	4
18	6	1	1	1	1	1	1	1	0	0	0	0
19	4	1	0	0	0	0	0	0	1	0	1	4
20	3	1	1	1	1	1	1	1	0	0	0	0
21	6	0	1	1	1	1	1	1	0	0	0	0
22	2	0	0	0	0	0	0	0	0	2	3	4
23	2	1	1	1	1	1	1	1	0	0	0	0
24	2	0	1	1	1	1	1	1	0	0	0	1
25	3	0	1	1	1	1	1	1	1	0	0+1	3
26	3	0	1	1	1	1	1	1	0	0	0	2
27	5	0	0	0	0	0	0	0	1	0	1	4
28	4	0	1	1	1	1	1	1	0	0	0	1
29	3	0	0	0	0	0	0	0	1	0	1	4
30	2	0	1	1	1	1	1	1	1	0	0+1	3