

## CLINICAL AND RADIOLOGICAL OUTCOME OF C1 LATERAL MASS AND C2 PEDICLE SCREW INSERTION-A PROSPECTIVE STUDY

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### KEYWORDS

Atlanto-axial  
dislocation,  
Craniovertebral  
junction, C1  
lateral mass, C2  
pedicle, bony  
fusion

### ABSTRACT

**BACKGROUND:** The craniovertebral junction (CVJ) is a complex transition between the skull and the upper cervical spine, the brain and spinal cord respectively. Thus any bony abnormality at the CVJ involves not only the bony structures but also the encompassed nervous system. The atlantoaxial joint (C1-C2 joint) is characterized by a high degree of mobility and little intrinsic stability. Atlantoaxial instability can occur when any part of the components are damaged by trauma, inflammation, neoplasm or congenital defects. The clinical presentation of atlantoaxial instability (C1-C2 instability) varies from mild symptoms such as high posterior cervical pain to severe presentation as different grades of myelopathy.

**MATERIALS AND METHODS:** This prospective study was carried out at the Department of Neurosurgery, Manipal Hospital, Old Airport Road, Bangalore over a period of 4 years (from April 2016 to April 2020). The sample size was 30. All patients admitted were between 18-78 years of age with atlantoaxial instability and underwent posterior C 1 lateral mass and C 2 pedicle screws fixation. The patients were clinically and radiologically assessed post-operatively at 3 months, 6 months and 1 year. Chi-square test or Fischer's exact test was used as test of significance for qualitative data. Mc Nemar's test was used as test of significance for paired qualitative data. Continuous data was represented as mean and standard deviation. Paired t test was the test of significance for paired data such as pre op vs postop for quantitative data.

**RESULTS:** In our study a clinically significant improvement was noted in terms of neck pain and myelopathy according to the Modified Japanese orthopaedic association score (MJOA-score), Nurick's grading and visual analogue scale (VAS) on interval follow up of 3 months, 6 months and 1 year with a significant p value < 0.01 as well as significant bony fusion was noted radiologically according to the X ray and CT fusion criteria used in our study.

**CONCLUSION:** This is one of the few studies where both clinical and radiological outcomes of posterior C1 lateral mass and C2 pedicle screw fixation have been assessed. The fusion rates of this study are comparable to transarticular technique of C1 C2 screw fixation by the CT and X ray fusion criteria where 100 % fusion rates have been reported.

**ABBREVIATIONS:**

CVJ - Craniovertebral junction  
AAD - Atlanto axial dislocation  
CSF - Cerebrospinal fluid  
C1 - Atlas  
C2 - Axis  
C1 - C2 Joint - Atlanto-axial joint  
ROM - Range of motion  
MJOA - Modified Japanese orthopaedic association score  
VAS - Visual analogue scale

**Introduction**

The craniovertebral junction (CVJ) is a complex transition between the skull and the upper cervical spine, the brain and spinal cord respectively [1]. Any abnormality that effects this complex can result in neural compression, vascular compromise and abnormal CSF dynamics. This complex architecture of atlantoaxial complex between upper two vertebrae of the cervical spine, their articular surfaces and several crucial ligaments allows flexion, extension, lateral bending and rotation [2]. The atlantoaxial joint (C1-C2 joint) is characterized by a high degree of mobility and little intrinsic stability [3]. Atlantoaxial instability can occur when any part of the components are damaged by trauma, inflammation, neoplasm or congenital defects [2].

The clinical presentation of atlantoaxial instability (C1-C2 instability) varies from mild symptoms such as high posterior cervical pain to severe presentation as different grades of myelopathy [2]. The diagnosis should be based on proper radiological evaluation such as CT CVJ, X ray CVJ and MRI CVJ [2].

Multiple techniques have been described for C1-C2 fixation. Historically these techniques include either a posterior cable and bone graft, posterior transarticular screws or a combination of both [2]. The technique of C1 lateral mass screw and C2 pedicle screw insertion results in a rigid fixation [4]. It has several advantages over the previously described posterior fixation techniques as it has a minimal risk of vertebral artery (VA) and spinal cord injury [5], the integrity of the C1 or C2 posterior elements is not necessary for stable fixation and this technique allows a reduction in any displacement of the elements of the atlantoaxial complex by repositioning the patient's head or directly manipulating the C1 or C2 screws [6] [7]. The rod-polyaxial screw system has another advantage as it could be incorporated into other fusion constructs, such as occipito-cervico-thoracic systems [8] [9] and also the C1-C2 facet joint is not damaged during the procedure so it could be used in patients requiring temporary fixation such as those with rotatory subluxation [5] [10] [11].

Our single centre prospective study looks at the clinical and radiological outcome following posterior C1 lateral mass and C2 pedicle screw fixation.

**Aims and objectives**

Aim - To study the clinical and radiological outcome in patients with atlanto axial instability who undergo posterior C 1 lateral mass and C 2 pedicle screw fixation.

Objective -1. To assess the patient with preoperative history, examination, and radiological findings and to study the clinical and radiological outcomes in patients who are undergoing posterior atlantoaxial fixation for atlantoaxial instability.

2. To study the effect of the surgical procedure on radiological alignment and clinical outcome.

**Material and methods**

This prospective study was carried out at the Department of Neurosurgery, Manipal Hospital, Bangalore over a period of 4 years (from April 2016 to April 2020). A total of 30 patients were

admitted between 18-78 years of age with atlantoaxial instability who underwent posterior C 1 lateral mass and C 2 pedicle screws fixation.

**Methodology**

All the patients were operated for posterior atlantoaxial (C1- C2) stabilization in the department of Neurosurgery at Manipal Hospital Bangalore. Patients underwent a detailed history of symptoms, demographic analysis, clinical and radiological assessment. A detailed systemic and neurological examination of all the patients was done and recorded. Imaging features like X-ray C-spine (neutral, flexion & extension view), CT scan C-spine, and MRI C-spine were done. The anatomic characteristics of cervicovertebral junction, presence of ventral or dorsal compression and atlantoaxial stability were assessed and recorded. Intra operative fluoroscopic guidance was used. All post-operative events like fresh neurological deficits, infections, pain were recorded. Each patient at the time of admission and discharge was assessed clinically by Nurick’s classification and modified Japanese orthopaedic association score for myelopathy, visual analogue scale (VAS) for severity of pain grading systems. Radiological parameters were assessed by various described craniometric lines. X ray CVJ both flexion and extension lateral views were viewed for reducibility/irreducibility.

**Outcome assessment**

Primary outcome: Neurological improvement and biomechanical stability.  
 Secondary outcome: Degree of fusion achieved radiologically.

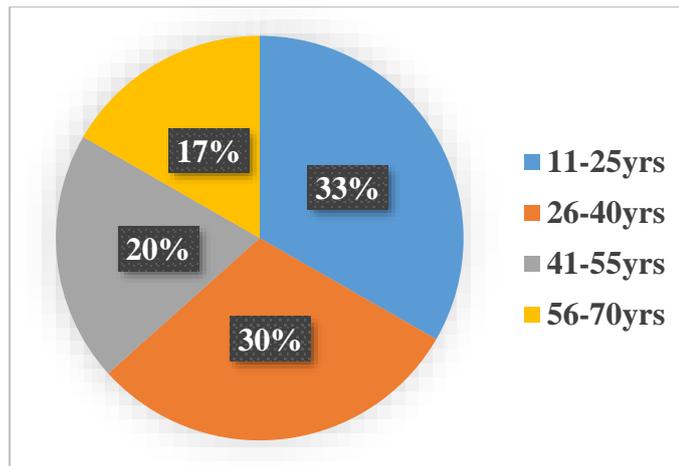
**Results**

**Age** - The maximum number of patients were under the age of 25 years which accounted for 33.3 % of patients and were either of a congenital pathology or traumatic atlanto axial dislocation. Table 1.

Table 1:- Distribution of subjects according to age group.

Age group	Frequency	Percent
11-25yrs	10	33.3
26-40yrs	9	30.0
41-55yrs	6	20.0
56-70yrs	5	16.7
Total	30	100.0

Graph no. 1:- Graph showing distribution of subjects according to age group.

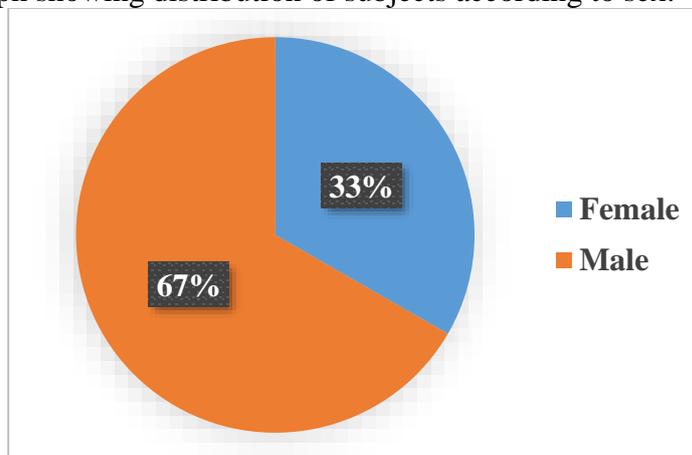


**Gender** - There were 10 (33.3 %) number of females and 20 (66.7%) number of males in this study. Table 2.

Table 2:- Distribution of subjects according to sex.

Sex	Frequency	Percent
Female	10	33.3
Male	20	66.7
Total	30	100.0

Graph no. 2:- Graph showing distribution of subjects according to sex.

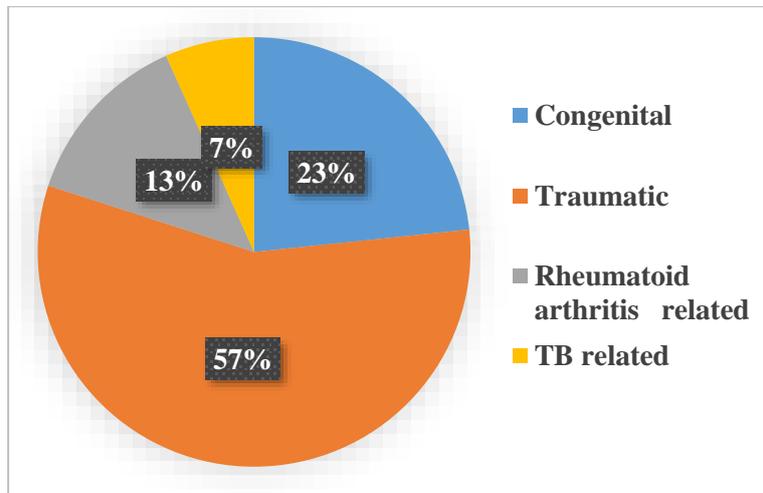


**Cause of AAD** - The congenital causes of AAD were 23.33%, which included 4 patients of os odontoideum, 2 patients of ossiculum terminalis persistens and 1 patient of Downs syndrome. Traumatic cases accounted for 56.67% of patients which included 4 patients of type 2 odontoid fracture, 1 patient of type 3 odontoid fracture and other traumatic AAD without fracture., 4 patients of RA related accounted for 13.33% and 2 TB related patients accounted for 6.67% respectively. Table 3.

Table 3:- Distribution of subjects according to cause of atlantoaxial dislocation.

Atlantoaxial dislocation	Frequency	Percent
Congenital	7	23.33
Traumatic	17	56.67
Rheumatoid arthritis related	4	13.33
TB related	2	6.67
Total	30	100.0

Graph no.3:- Graph showing distribution of subjects according to cause of atlantoaxial dislocation.



#### PRE OPERATIVE MRI FINDINGS

T2-cord hyperintensity at CV junction spinal cord hyperintensity was present in T2-weighted magnetic resonance imaging (MRI) of the CVJ in 6 patients (20 %) cases, syrinx in 1 patient (3.3%). Cord compression was noted in 26 patients (86.7 %). Table 4.

Table 4:- Frequency Distribution of Pre-op MRI finding

	Frequency	Percent
Syrinx	1	3.3
Signal changes T1/T2	6	20
Cord compression	26	86.7

Graph no. 4:- Graph showing Frequency Distribution of Pre-op MRI finding

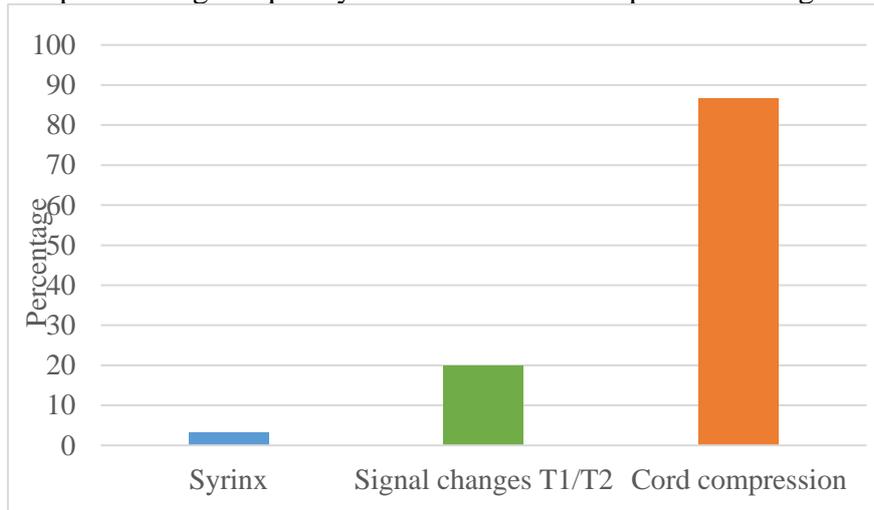


Table 5:- Comparison of pre-op CT finding with post-op CT finding (Atlanto dental interval)

ADI	Pre op		Post op		P value
	N	%	N	%	
Abnormal	27	90.0%	6	20.0%	<0.01
Normal	3	10.0%	24	80.0%	

There was a statistically significant difference between pre-op and post-op with respect to Atlanto dental interval.

Graph no. 5:- Graph showing comparison of pre-op CT finding with post-op CT finding (Atlanto dental interval)

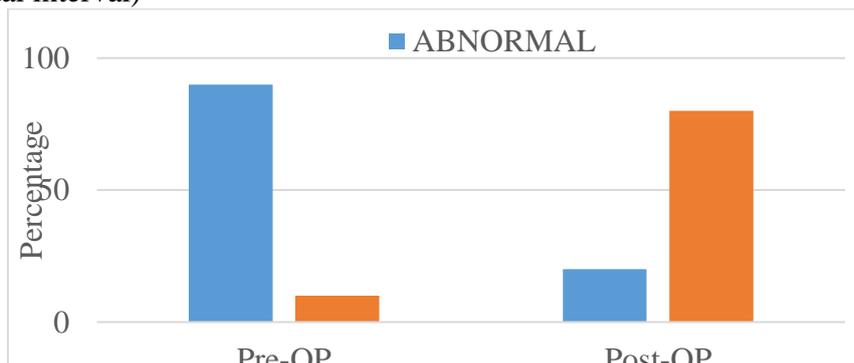


Table 6:- Comparison of pre-op CT finding with post-op CT finding (Chamberlain's line)

Chamberlain's line	Pre op		Post op		P value
	N	%	N	%	
Abnormal	20	66.7%	3	10.0%	<0.01
Normal	10	33.3%	27	90.0%	

There was a statistically significant difference between pre-op and post-op with respect to Chamberlain's line

Graph no. 6:- Graph showing comparison of pre-op CT finding with post-op CT finding Chamberlain's line

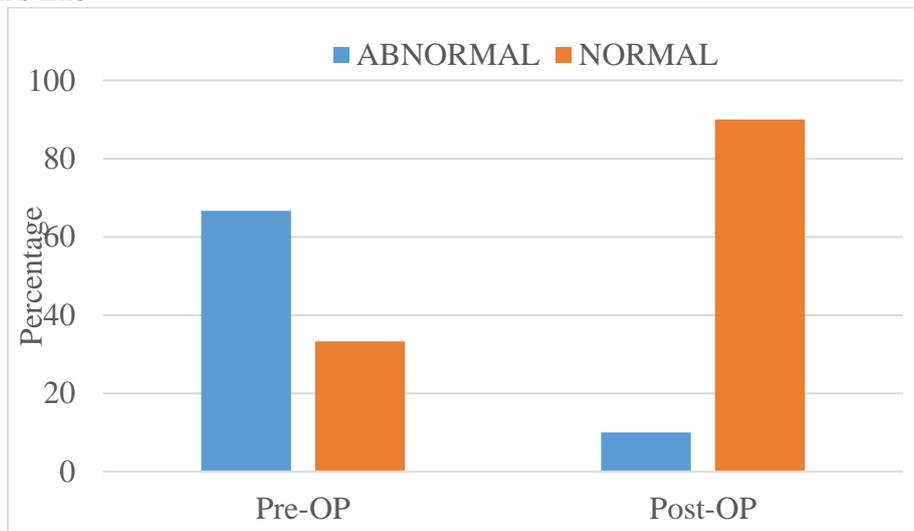


Table 7:- Comparison of pre-op CT finding with post-op Ct finding (Wackenheim clivus canal line)

Wackenheimclivus canal line	Pre op		Post op		P value
	N	%	N	%	
Abnormal	14	46.7%	1	3.3%	<0.01
Normal	16	53.3%	29	96.7%	

There was a statistically significant difference between pre-op and post-op with respect to Wackenheimclivus canal line.

Graph no. 7:- Graph showing comparison of pre-op CT finding with post-op CT finding (Wackenheim clivus canal line)

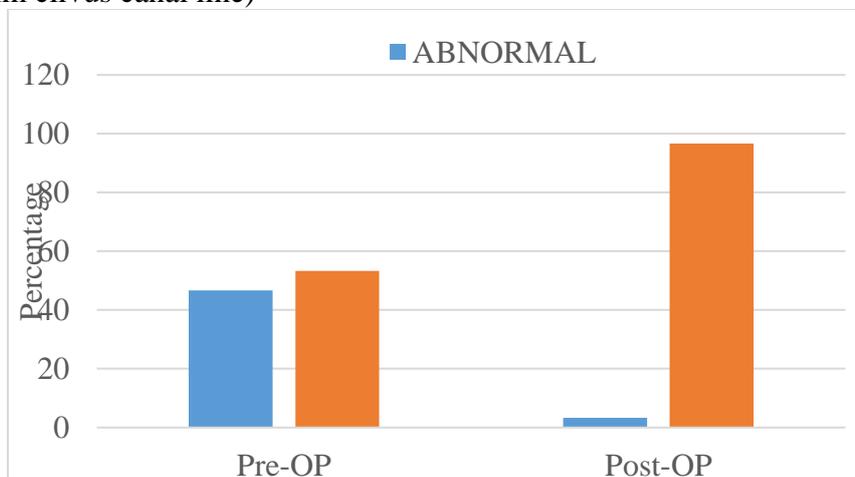


Table 8:- Comparison of pre-op CT finding with post-op CT finding (Mc Raye's line)

Mc Raye's line	Pre op		Post op		P value
	N	%	N	%	
Abnormal	17	56.7%	0	0%	<0.01
Normal	13	43.3%	30	100%	

There was a statistically significant difference between pre-op and post-op with respect to Mc Raye's line

Graph no. 8:- Graph showing comparison of pre-op CT finding with post-op CT finding Mc Raye's line

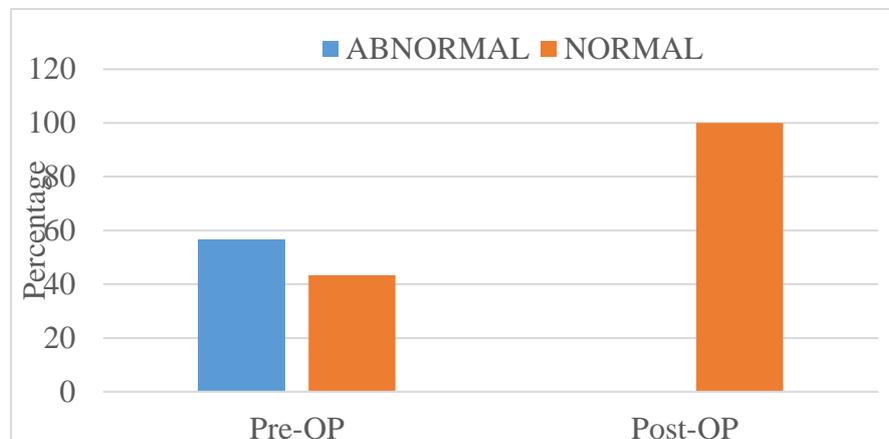


Table 9:- Comparison of pre-op CT finding with post-op CT finding (Mc Gregor's line)

Mc Gregor's line	Pre op		Post op		P value
	N	%	N	%	
Abnormal	15	50.0%	1	3.3%	<0.01
Normal	15	50.0%	29	96.7%	

There was a statistically significant difference between pre-op and post-op with respect to Mc Gregor's line.

Graph no. 9:- Graph showing comparison of pre-op CT finding with post-op CT finding (McGregor's line).

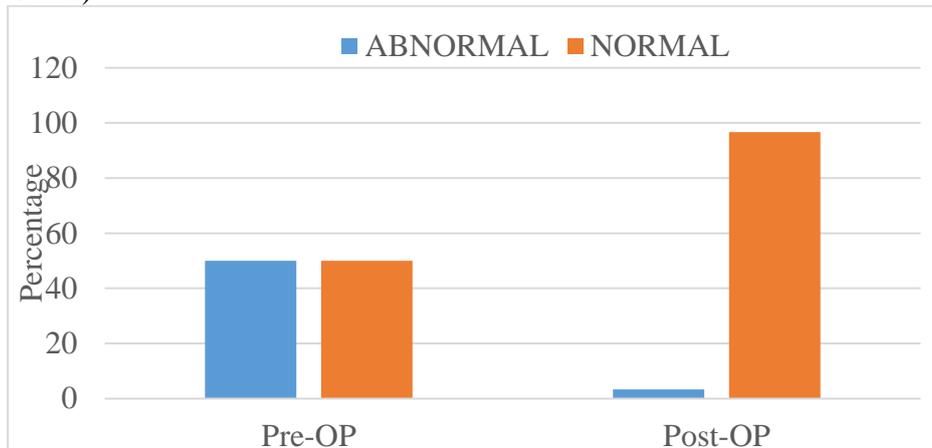
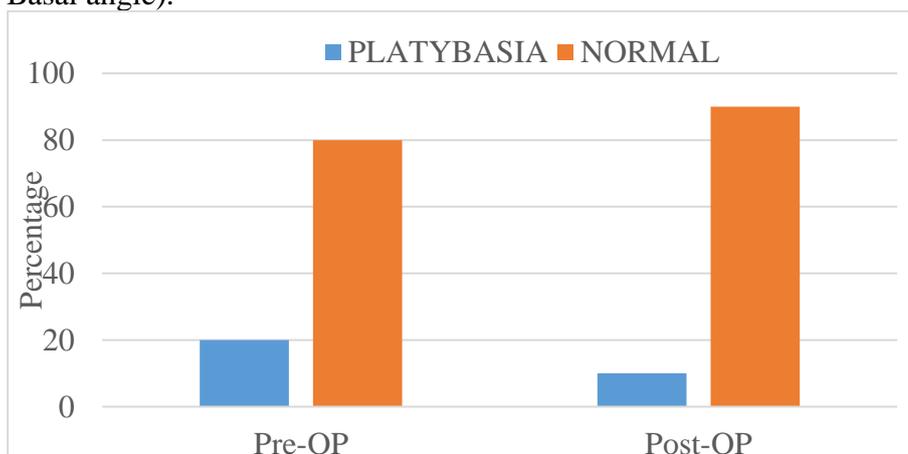


Table 10:- Comparison of pre-op CT finding with post-op CT finding (Welcher Basal angle)

Welcher angle	Basal	Pre op		Post op		P value
		N	%	N	%	
Normal		24	80.0%	27	90.0%	0.278
Platybasia		6	20.0%	3	10.0%	

There was no statistically significant difference between pre-op and post-op with respect to Welcher Basal angle.

Graph no. 10:- Graph showing comparison of pre-op CT finding with post-op CT finding (Welcher Basal angle).



PRE AND POST OPERATIVE CRANIOMETRIC IMAGES

Chamberlain's line -

Preoperative

Postoperative

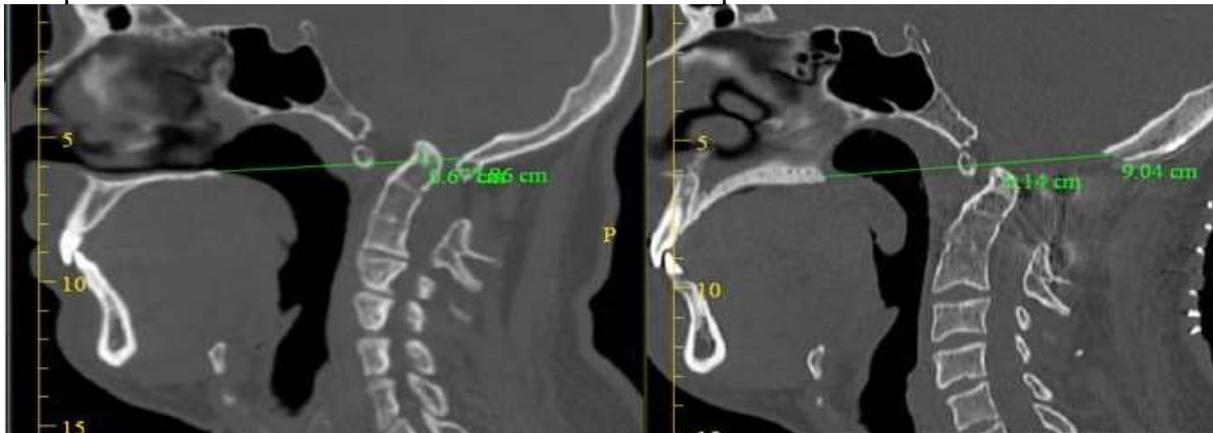


Figure 1.sagittal CT shows excellent realignment of odontoid in relation to Chamberlain's line before and after surgery.

Wackenhiem's clival canal line -

Preoperative

Postoperative



Figure 2.sagittal view CT shows excellent realignment of the odontoid in relation to the wackenhiem's line before and after surgery.

Mc Raye's line -

Preoperative

Postoperative



Figure 3.sagittal view CT showing excellent realignment of the odontoid in relation to the Mc Raye's line before and after surgery.

Atlanto dental interval (ADI) -  
 Preoperative

Postoperative

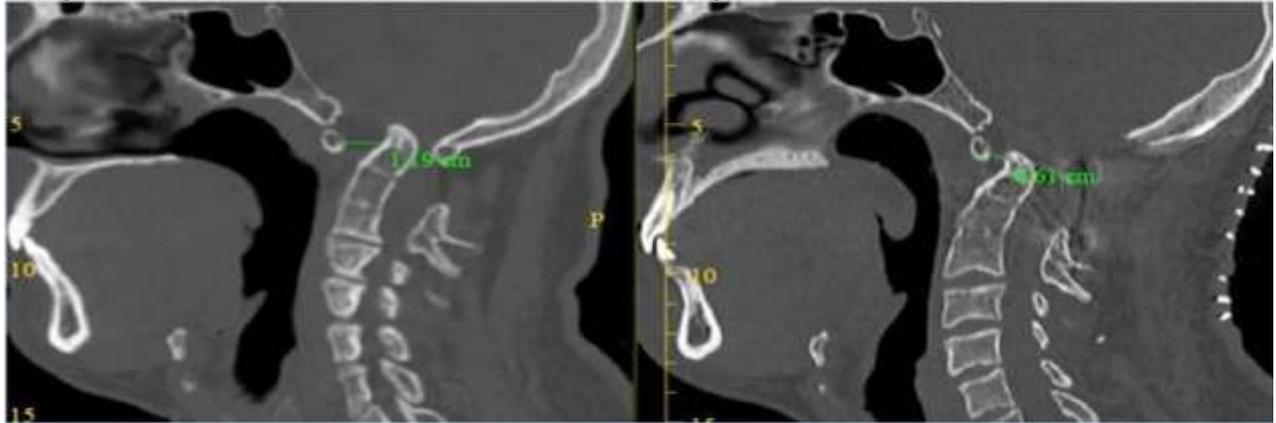


Figure 4. sagittal view CT showing the reduction of atlanto axial distance after surgery.

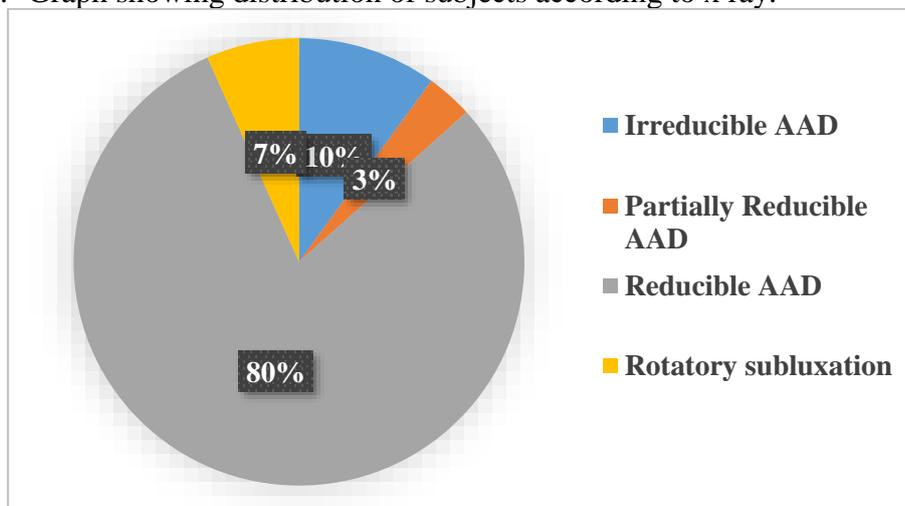
### XRAY CERVICAL SPINE

X ray cervical spine was done in flexion and extension to look for reducibility and irreducibility of AAD.

Table 11:- Distribution of subjects according to x ray.

	Frequency	Percent
Irreducible AAD	3	10.0%
Partially Reducible AAD	1	3.3%
Reducible AAD	24	80.0%
Rotatory subluxation	2	6.7%
Total	30	100.0

Graph no. 11:- Graph showing distribution of subjects according to x ray.



Pre operative X ray (flexion and extension)-



Figure 5.A.B. X ray in flexion and extension showing an increased atlanto dental interval.

### GRADE OF MYELOPATHY PREOPERATIVELY

Total number of patients with mild, moderate and severe pathology were 5, 14, 8 respectively.

Table 12:- Distribution of subjects according to grade of myelopathy

	Frequency	Percent
Mild	5	16.7%
Moderate	14	46.7%
Normal	3	10.0%
Severe	8	26.7%
Total	30	100.0

Graph no.12:- Graph showing distribution of subjects according to grade of myelopathy.

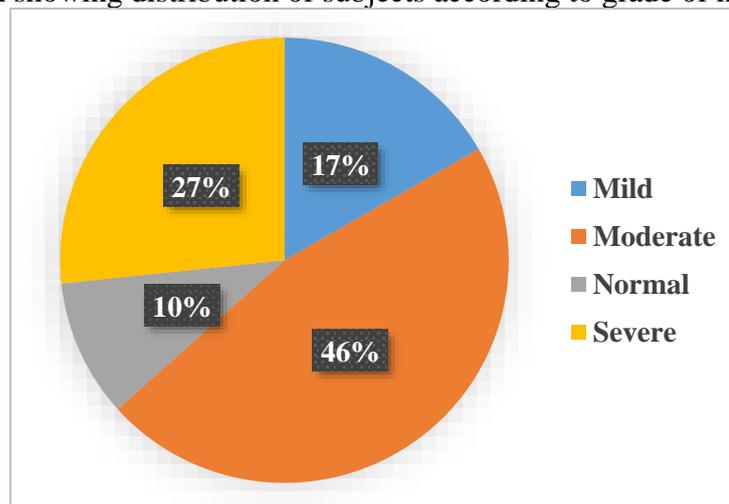


Table 13:- Comparison of Modified Japanese orthopaedic association score pre-op and post-op

	Mean	Std. Deviation	P value
Pre-op	12.63	4.173	<0.01
Post op 3months	14.27	3.493	
Post op 3months	14.27	3.493	<0.01
Post op 6months	15.47	3.037	
Post op 6months	15.47	3.037	0.014
Post op 1year	15.93	2.572	

There was statistically significant difference between pre-op and post op Modified Japanese orthopaedic association score with a significant p value <0.01 at 3 months, p value <0.01 at 6 months and a p value of 0.014 at 1 year.

The preoperative mean value of MJOA score is  $12.63 \pm 4.173$ , Postoperatively mean value of MJOA score at 3rd month, 6th month and 1 year is  $14.27 \pm 3.493$ ,  $15.47 \pm 3.037$  and  $15.93 \pm 2.527$  respectively.

Graph no. 13:-

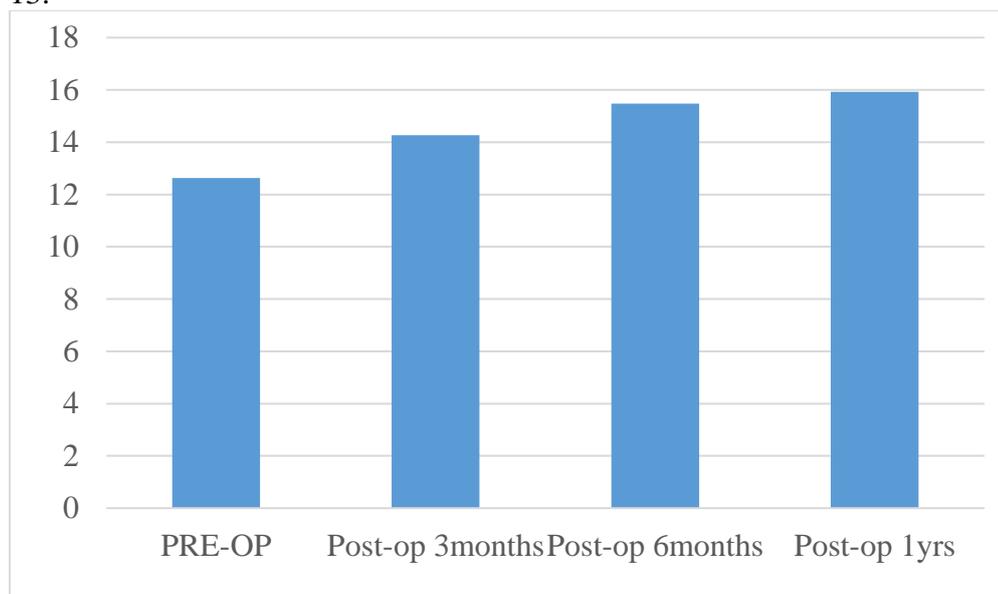


Table 14:- Comparison of Visual Analogue scale pre-op and post-op

	Mean	Std. Deviation	P value
Pre-op	6.93	2.970	<0.01
Post op 3months	2.50	1.306	
Post op 3months	2.50	1.306	<0.01
Post op 6months	1.13	.819	

Post op 6months	1.13	.819	<0.01
Post op 1year	0.43	.568	

There was statistically significant difference between pre-op and post op 3 months 6 months and 1 year Visual Analogue Scale (VAS) with a significant p value < 0.01.

Graph no.14:-

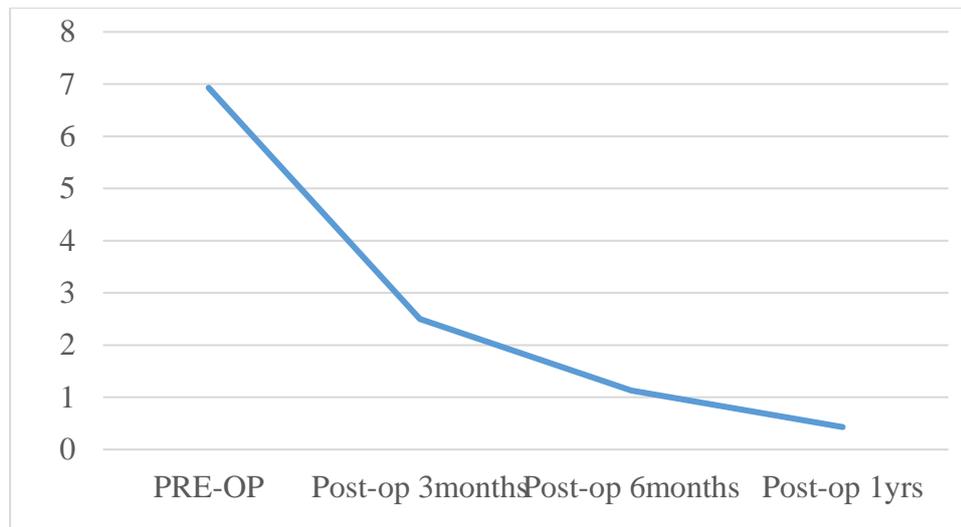


Table 15:- Comparison of Nurick grading pre-op and post-op

	Mean	Std. Deviation	P value
Pre-op	2.67	1.295	<0.01
Post op 3months	1.63	1.351	
Post op 3months	1.63	1.377	<0.01
Post op 6months	1.37	1.351	
Post op 6months	1.37	1.398	<0.01
Post op 1year	1.10	1.377	

There was statistically significant difference between pre-operative and post operative Nurick grading at 3 month, 6 month and 1 year with a significant p value of < 0.01.

The pre operative mean value of Nurick grading was  $2.67 \pm 1.295$  and post op Nurick grading at 3rd month, 6th month and 1 year Nurick grading is  $1.37 \pm 1.377$ ,  $1.10 \pm 1.398$ ,  $1.37 \pm 1.377$  respectively.

Graph no. 15:-

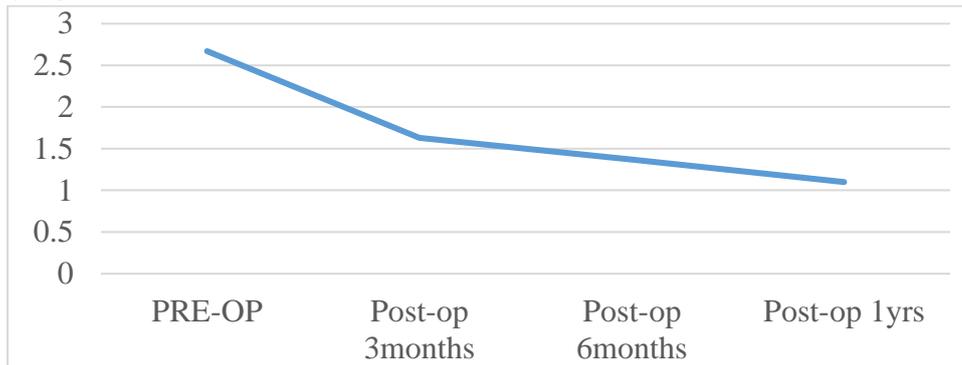


Table 16:- Distribution of subjects according to outcome of grade of myelopathy

	N	%
Improved	25	83.3%
No change	4	13.3%
Slightly Improved	1	3.3%

There were a significant number of patient 25 (83.3 %) in which improvement in myelopathy was noted as compared to the preoperative status. There was no change in the state of myelopathy in 4 patients (13.3 %) and slight improvement in 1 patient (3.3 %)

Graph no.16:- Graph showing distribution of subjects according to outcome of grade of myelopathy

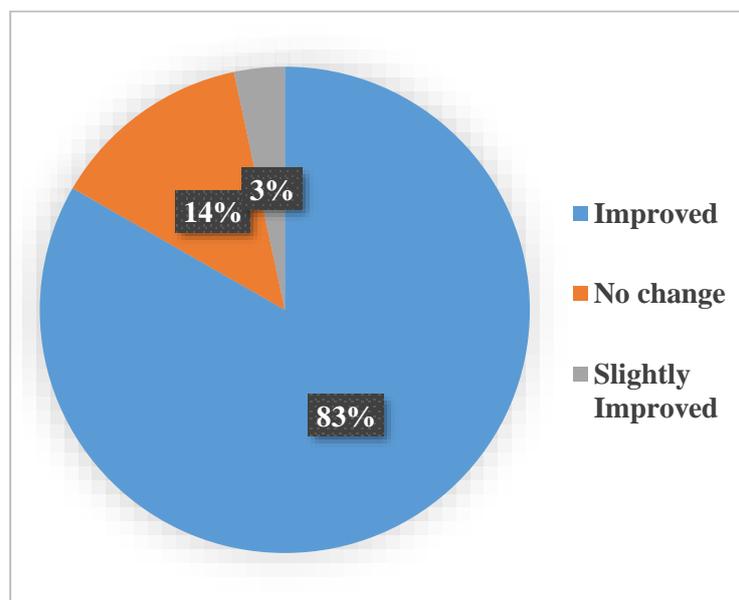
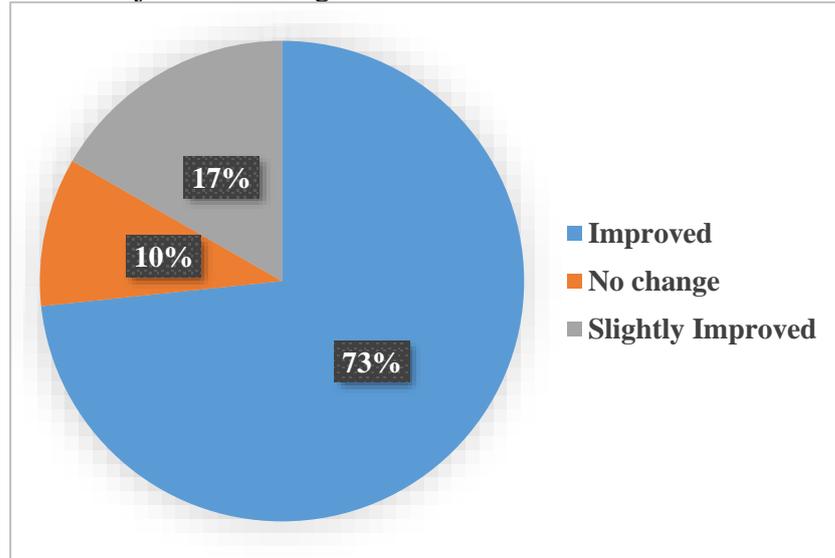


Table 17:- Distribution of subjects according to inference



### BONY FUSION

Bone graft was interposed between the C1-C2 joint after the preparation of the opposing surface to ensure proper bony fusion. On a follow up CT scan or X-ray of these patients after 3 months/6 months/1 year, bony fusion was obtained in all the patients (100.0%), who underwent posterior C 1 lateral mass and C 2 pedicle screw fixation and fusion.

### POST OP X RAY WITH EVIDENCE OF BONY FUSION-

Immedite post op:



Figure 6.A.B. X ray flexion and extension show implants insitu with satisfactory alignment.

Post op - 6 months:



Figure 7.A.B. X ray flexion and extension showing satisfactory alignment, with no abnormal mobility on flexion or extension, bridging trabecular bone noted.

Post op - 1 year:

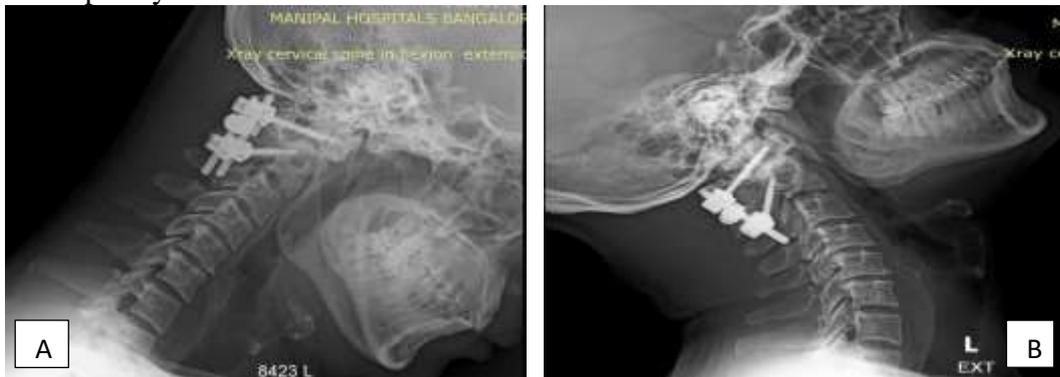


Figure 8.A.B. X ray flexion and extension showing showing maintained alignment with no abnormal mobility on flexion/extension, bridging trabecular bone noted.

#### POST OP CT WITH EVIDENCE OF BONY FUSION-

Post op - 3 months:



Post op - 6 months:



Figure 9.A.sagittal view CT showing evidence of bridging bone across fusion level, lack of lucency across screws and no fracture of the implant. B.showing bony trabeculation across fusion level, lack of lucency across screws and no fracture of the implant.

#### Discussion

Atlanto axial instability is a serious life threatening condition which can occur due to a bony or ligamentous disruption at the atlanto axial joint which can be either due to a congenital anomaly, trauma, or an inflammatory pathology such as rheumatoid arthritis and tuberculosis [12]. The presentation varies from progressive myelopathy, radiculopathy, lower cranial nerve dysfunction, or deformities of the craniocervical region. Any disruption of the atlanto axial joint needs surgical attention with the aim of atlanto axial fusion surgery to restore normal alignment, to ensure adequate decompression, and to achieve structural stability. Because of the high mobility of the C1-C2 motion segment, fusion rates at this level have been substantially lower than those at the subaxial spine. The aim of treatment of atlantoaxial instability is to achieve a solid fusion between C1 and C2, virtually eliminating any motion between them. This is expected to relieve the neck pain and avoid the risk of further neurological deficit.

Several types of atlantoaxial fusion techniques have been described over the years from the earliest no-screw fusion (Gallie, Brooks, and Sonntag) to the two screws fusion (transarticular technique of Magerl and Seemann) and four screws technique (Goel and Harms) with its variations. The no screw techniques have been used for decades and are technically simple to

perform but with high non fusion rates, neurological complications and biomechanical weakness. The two screws technique (transarticular screws) results in a rigid fixation with fusion rate from 87% to 100% but it is technically difficult with risk of vertebral artery injury higher than other techniques. The four screw technique (C1 lateral mass and C2 pedicle screw) which was introduced by Goel and Laheri and then modified by Harms and Melcher with the use of polyaxial screws and rods instead of plates is a simpler technique, with much lower risk of vertebral artery injury and higher fusion rate 100% [13] [14] [15].

The aim of our study was to achieve a clinical and radiological outcome of C1 lateral mass and C2 pedicle screw fixation in atlanto axial instability. In our study the range of age was from 18 -78 years. Although atlantoaxial dislocation can occur at any age, the most common age group affected in our study was below 25 years.

Our study had a dominance of male patients (67% male, 33% female) which is in accordance to similar studies by Ahmed Yehya [16], Yang Xie et al [17], P.Bourdilon et al [18]. The most common clinical presentation was neck pain (76.66 %) and myelopathy (90%) using MJOA-score and one patient with sphincter disturbances. A similar pattern of presentation was found in a study by Ahmed Yehya [19] in which patients had neck pain in (100 %) and followed by myelopathy in (50%) using the JOA-score, grade 1 myelopathy , grade 2 myelopathy in (16.7%) and only 2 patients presented with sphincteric disturbance. In distribution of subjects according to the cause of atlanto axial dislocation, congenital malformation accounted for (23.33 %) in which Os odontoideum was (57.14%), Ossiculum terminalis persistens was (28.57 %) and Downs syndrome was (14.28 %). Trauma accounted for (56.66 %) in which Jeffersons fracture was in (5.88 %), Type 3 odontoid fracture was in (5.88 %), Type 2 odontoid fracture was in (23.52 %), other traumatic AAD not associated with fracture was ( 64.70 %). Rheumatoid arthritis accounted for (13.33 %) and tuberculosis was seen in (6.66 %) which is in partial accordance to the study done by Yang Xie et al [20] in which congenital malformation was in (8 %), Trauma in ( 52 %) and rheumatoid arthritis accounted for (12 %). Another study which was in accordance to our study was by Yonghong Zheng et al [21] revealed a similar higher incidence in trauma (51.16 %), congenital malformation (19.76 %) and rheumatoid arthritis (17.44 %).

Dynamic X ray CVJ, CT CVJ with CT angiography and MRI of the CVJ play an important role in evaluating patients with CVJ disease. Various craniometric lines are clearly identified on CT, and the course of the vertebral artery is ascertained on CT angiography. In our study none of the patients had a high riding vertebral artery on a pre operative CT angiogram which was done in all of our patients. On pre operative MRI, which was done in all of our patients Syrinx was noted in (3.3%), signal changes on T1/T2 sequences in (20%) and cord compression was noted in (86.7%). Vedantam and Rajshekhar [22] noted that T2 signal hyperintensity was associated with poor neurologic outcome in patients with cervical spondylotic myelopathy. Harrop et al [23] observed T2 cord hyperintensity in 35% of patients that were associated with poor outcome after surgery. The majority of patients in our study having T2 cord hyperintensity at the CVJ demonstrated poor outcomes because it represents chronic compression and irreversible myelopathic changes within the cord. We repeated an MRI in patients in which there was no clinical improvement at follow up post surgical procedure and a persistent non resolved T1/T2 signal intensity change was noted.

In our study of 30 patients presenting with atlanto axial instability all underwent posterior C 1 lateral mass and C2 pedicle screw fixation and fusion and were followed up immediately post operatively then at intervals of 3 months, 6 months and 1 year. Follow up was done clinically using scales such as Modified Japanese orthopaedic association score (MJOA), Nuricks grading for myelopathy , Visual analogue scale (VAS) and radiologically by X ray CVJ , CT CVJ and MRI CVJ wherever indicated. In our study pre operative abnormal ADI was (90.0 %) and post operative normal ADI was (80.0 %) with a significant p value <0.01 . We attained

a satisfactory decrease in the atlantodental interval (i.e.,  $\leq 3$  mm in 80% of our patients). In 3 patients, the atlantodental interval was 10.3 mm, 11.9 mm and 11.3 mm preoperatively with mild or moderate myelopathy according to the modified Japanese orthopaedic association score (MJOA- score), and it reduced to 2.3 mm, 6.1 mm and 3.7 mm in the postoperative period and showed good neurologic outcome; the patients were doing well at last follow up. Postoperatively 2 patients had ADI of 5.8 mm and 6.1 mm with moderate and mild myelopathy according to MJOA- score but showed clinical improvement on subsequent follow ups.

#### Craniometric lines -

In our study the pre operative calculation of Chamberlain's line revealed abnormality in (66.7 %) patients and post operatively the line came to normal in (90.0 %) with a significant p value of  $<0.01$ , Wackenheim's clivus canal line revealed abnormality in (46.7 %) and post operatively the line came to normal in (96.7 %) with a significant p value of  $<0.01$ , Mc Raye's line revealed abnormality in (56.7 %) and post operative normal findings were noted in (100 %) of the patients with a significant p value of  $<0.01$ , Mc Gregors line revealed abnormality in (50.0 %) patients and post operative normal findings were noted in (96.7 %) patients with a significant p value  $<0.01$ . There was no statistically significant difference between pre-op and post-op with respect to Welcher Basal angle with a p value of 0.278. Flexion and extension X ray CVJ was done which revealed reducible AAD in (80 %) of the patients.

Neck pain and Myelopathy were most common presentation of the patients in our study and was categorized as mild, moderate and severe according to the Modified Japanese orthopaedic association score, (16.7 %) patients presented with mild myelopathy, (46.7 %) as moderate and (26.7 %) with severe myelopathy, while (10%) did not present with myelopathy. According to MJOA-score the pre operative mean was 12.63 with SD 4.173 and a significant p value of  $<0.01$  and a mean of 14.27 SD 3.493, 15.47 SD 3.037, 15.93 SD 2.572 and a significant p value of  $<0.001$ ,  $<0.001$  and 0.014 at a follow up of 3 months, 6 months and 1 year respectively and according to the visual analogue scale there was a significant improvement in the neck pain with a p value of  $<0.01$  at follow up intervals of 3 month, 6 month and 1 year respectively. Along with MJOA-score Nurick's grading for myelopathy was also applied to our patients with a pre operative mean value of 2.67 SD 1.295 and a significant p value of  $<0.01$  and mean value of 1.63 SD 1.351, 1.37 SD 1.381, 1.10 SD 1.377 with a significant p value of  $<0.01$  at 3 months, 6 months and 1 year respectively. In our study the overall improvement in myelopathy was (83.0 %), slight improvement in myelopathy (3.3 %) and no change in (13.3%) of the patients.

#### Bony fusion -

The X ray and CT criteria which was applied for ascertaining bony fusion in our study is:

##### X RAY:

1. Bridging trabecular bone seen
2. No/minimal motion across fusion level on flexion/extension

##### CT:

1. Bony trabeculation across fusion level
2. Lack of lucency across screws/graft
3. Bridging bone seen
4. No fracture of implant

#### Conclusion

This is one of the few studies where both clinical and radiological outcomes of posterior C1 lateral mass and C2 pedicle screw fixation have been assessed. There was a significant clinical and radiological improvement in the patients and a good bony fusion was achieved assessed by the X ray and CT fusion criteria.

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