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Comparative analysis of clinical outcomes of surgically stabilised atlanto-axial instability with various surgical methods

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Abstract

Objectives: The atlanto-axial segment consists of the atlas and axis forming a complex transitional structure bridging the occiput and cervical spine. The functional result of the joint is to provide support for the occiput and greatest range of motion and flexibility possible while maintaining stability. The main objective of the study is to assess clinical changes post surgery of atlanto-axial instability fixation comparing impact of various surgical methods.

Materials and Methods: Single centred prospective study with sample size of 50. Demographic data, detailed history of symptoms and other co-morbidities were recorded. The anatomic characteristics of cervicovertebral junction, presence of compression and atlantoaxial instability evaluated. Operative details, types of approach, method of fixation chosen-transarticular screws, screw and rod fixation (SRF), occipitocervical plating and combination of transarticular screws on one side and SRF other side noted. Comparison was done based on demographic data, clinical features and neurological status pre and post operatively.

Results: Mean age was 30.22 years, ranging from 7 to 71 years with majority belonged to 11-20 years age-group (17/50, 34%). Majority of the patients had a congenital cause for instability (22/50, 44%), 17 of the 50 patients (34%) had co-morbidities with Down's syndrome being most common. Most common symptom being quadriparesis followed by neck pain. Most common procedure done was C1-C2 Screw plus rod fixation followed by trans-articular screw. Mean Nuricks grading was 3.32±1.09 pre-operatively with significant change was noted at 3 months post-op follow-up 2.84±1.21 ($p<0.05$).

Conclusion: There is significant co-relation between pre-operative neurological status and functional post-operatively. No significant difference was seen in rate of fusion with respect to method of fixation and functional outcome in relation to method of fixation. Rate of fusion is directly associated with the quality of bone at the articular surfaces of C1-C2 facet joints.

Keywords: Atlanto-axial instability, Nuricks grading, Frankel classification, Grob *et al.* classification

Introduction

Atlanto-axial segment is the most complex transitional structure providing support for the occiput along with greatest range of motion and flexibility possible while maintaining stability. Atlanto-axial instability is treated surgically by different techniques [1].

Fusion of C1-C2 segment is indicated in instabilities caused by congenital instability, traumatic fractures and fracture-dislocations, degenerative osteoarthritis, traumatic ligamentous injuries, infections, tumours and metastasis.

Posterior atlanto-axial fusion can be achieved through various methods to improve the clinical outcomes due to instability like decreased pain, reduced deformity and also prevent the further neurological deterioration and possibly improve it by decompression

The posterior fusion done using internal fixation provides proper post operative alignment, adequate stability and optimum fusion rates hence alleviating the clinical outcomes with no need of significant post operative immobilisation [2]. This comes with cost of decreased range of motion which is the greatest at this segment.

The current study was done to assess the indications and comparing the clinical outcomes of the fusion of atlanto-axial instability using various techniques.

Materials and Methods

All the patients undergoing surgery in the Department of orthopedics in our institute from November 2016 to August 2019 were included in the study.

Inclusion criteria

1. Post traumatic atlanto-axial instability.
2. Congenital atlanto-axial instability
3. Atlanto-axial instability secondary to degenerative arthritis.
4. Atlanto axial instability with Atlanto Dense Interval (ADI) >3mm was taken as minimum criteria to be included in the study.

Exclusion criteria

1. Previously operated C1-C2 instability.
2. Associated thoracic anomalies like kyphosis.
3. Atlanto-axial instability associated absent C1-C2 elements.

Detailed history including demographic data, symptoms and the co-morbidities were noted down.

Pre-operative and Post-operative assessment including neurological assessment, pain assessment, infections and other systemic events were noted. Pre and post operative imaging including X-ray cervical spine (neutral, flexion and extension views), CT cervical spine, MRI cervical spine were done.

Various details like anatomy and anomalies of atlanto-axial joint, presence and extent of instability, site of compression, course of vertebral artery were noted.

Intra operative details including position, type of approach whether anterior or posterior or combined, type of fixation used like transarticular screws, screw and rod fixation (SRF), occipitocervical plating and combination of transarticular screws on one side and SRF other side and the reason for choosing the method was noted. Fluoroscopy was used to aid the surgery.

Each patient was assessed at the time of admission, at 2 weeks, 3 months, 6 months and 1 year post surgery using Nuricks classification of myelopathy based on gait abnormality and Frankel classification grading system. Each patient was assessed as per the Grob *et al.* classification at 6 months and 12 months post surgery.

Grob *et al.* classification

- Objective Rating.
 - Good (No pain, solid bony fusion).
 - Fair (moderate pain, solid bony fusion).
 - Bad (severe pain, non-union).
- Subjective Rating.
 - Good (No pain causing no restriction of activity)
 - Fair (Periods of pain, working capacity reduced)
 - Bad (Permanent severe pain, disability).

Sample cases

Case 1

17 year old male/ 6 month history, insidious onset unsteady gait, spasticity in all 4 limbs, Right hand grip Grade 3/5, Hoffmann strongly positive.



Fig 1: Pre-operative radiographs and MRI

Patient was treated with closed reduction and instrumented fixation with C1+C2 screw rod fixation.

6 month follow-up



Fig 2: 6 months follow up radiographs and MRI

Reduction maintained and good union seen. Clinically mild instability in gait and hyper-reflexia seen. Bilateral handgrip 5/5

1 year follow up

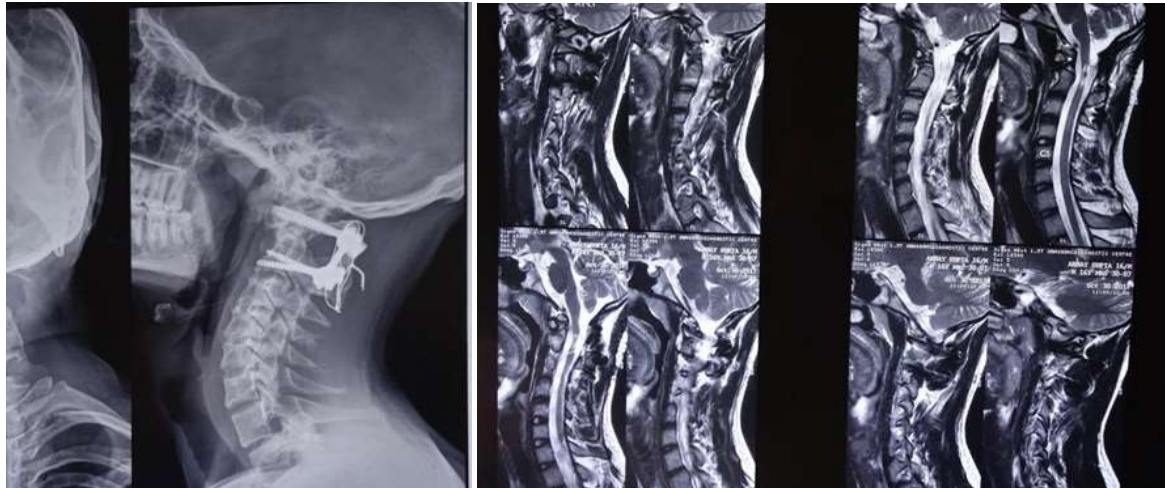


Fig 3: 1 year follow up radiographs and MRI

There was persistent unsteady gait and hypertonia, reduction was well maintained and solid fusion seen. MRI showed myelomalacia changes

Case 2

60y/F/diabetic with 1 year history of occipital headache and 6 months bilateral handgrip weakness 3/5. spastic gait with hoffmann positive

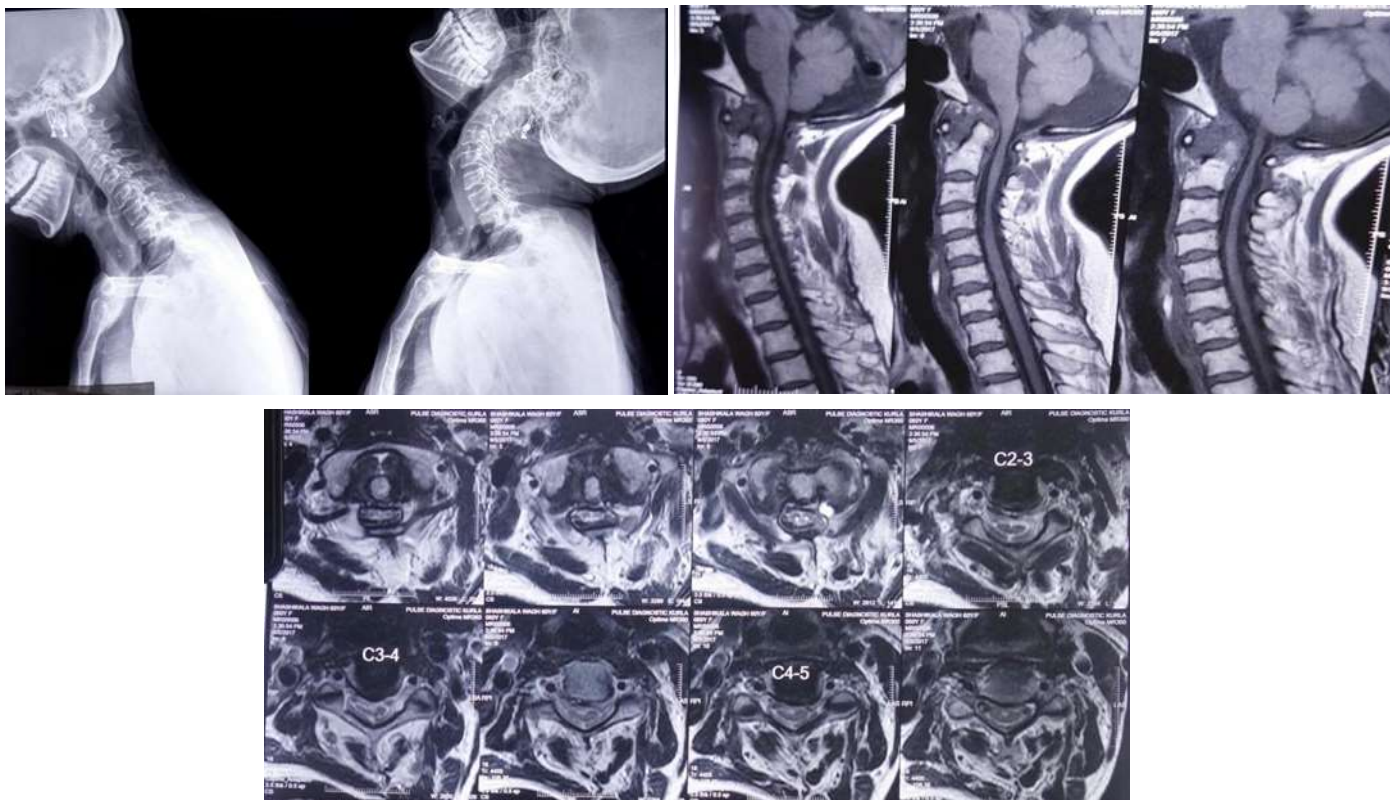


Fig 4: Pre operative radiographs and MRI

Patient was operated with C1-C2 trans-articular screw fixation.

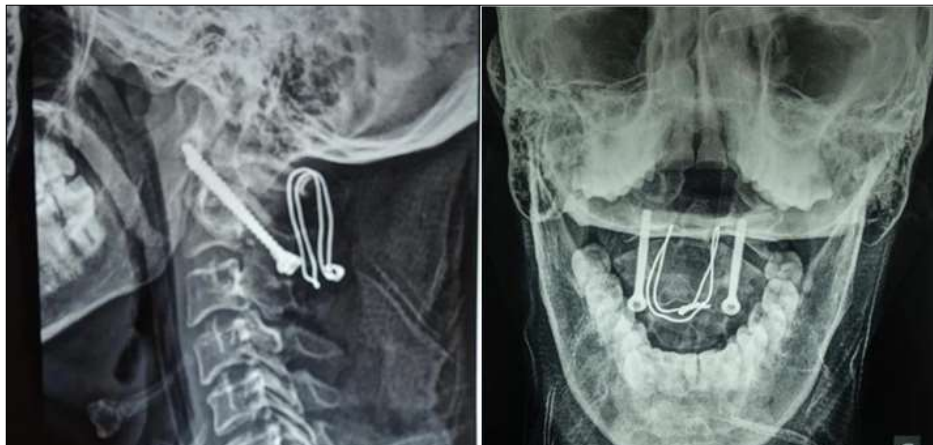


Fig 5: Post Operative radiographs

6 months follow up

Patient was relieved of occipital headache, regained hand grip, gait and tone was normal. Reduction was maintained and solid fusion seen.



Fig 6: 6 month follow up Radiographs

1 year follow up

Patient was normal clinically and neurologically. Reduction

well maintained with



Fig 7: 1 year follow up Radiographs

Results

50 patients (25 male and 25 female) were enrolled in the study with age ranging from 7 to 71years with mean age being 30.22 years. Majority of the patients belonged to 11-20 years age-group (17/50, 34%) and 17 were under 13 years of age.

Majority of the patients in this study had a congenital cause for instability (22/50, 44%), 17 of the 50 patients (34%) were diagnosed with comorbidities with most common being Down’s syndrome in 10 patients (20%).

Clinically most common symptom being quadriparesis

followed by neck pain.

The most common method of fixation was C1-C2 Screw plus rod fixation done in 16 patients (32%) followed by trans-articular screw (11/50, 22%), hybrid method (10/50, 20%), occipito-cervical type of fixation (9/50, 18%) and C2 laminar screw fixation (4/50, 8%). C2 laminar screw was studied as a separate entity and also a subtype of C1-C2 screw plus rod fixation. Average operative time for each procedure was 3hrs and blood loss ranging between 200ml to 500ml.

Post operatively no patient developed cranial nerve palsies, no occipital headache due to C2 ganglion irritation by implant,

no vertebral artery injury, no dural leak, 1 patient developed peri-operative infection which was promptly treated with antibiotics and dressings. There was no mortality. The mean Nuricks grading (Table 1) was 3.32±1.09 pre-operatively and was found that for C1-C2 screw and rod fixation and hybrid method group the mean Nurick's grade

score decreased significantly over the period of follow-up ($p < 0.05$), while for the occipito-cervical group, sublaminar group and transarticular group the change was seen only numerically over the follow-up period and it was not statistically significant ($p > 0.05$)

Table 1: Mean Nurick's Grade for patients by method of fixation (n=50)

Time of assessment	Type of Fixation					Irrespective of method
	C1-C2 Screw + Rod (n=16)	Hybrid (n=10)	Occipito-cervical (n=9)	C2 laminar screw (n=4)	Transarticular screw (n=11)	
Pre-op	3.32±1.09					
Post-op (immediate)	3.31 ± 1.07	2.7 ± 0.82	2.77 ± 1.31	4.5 ± 0.57	3.72 ± 1	3.28±1.12
2-week Post-operative	3.18 ± 1.10	2.5 ± 0.97	2.67 ± 1.22	4.25 ± 0.5	3.63 ± 1.12	3.14±1.16
3-month Post-operative	2.81 ± 1.27	2.31 ± 0.82	2.44 ± 1.42	3.5 ± 1	3.45 ± 1.12	2.84±1.21
6-month Post-operative	2.43 ± 1.31	1.7 ± 0.81	2 ± 1.58	3.25 ± 1.25	3 ± 1.48	2.40±1.37
1-year Post-operative	2 ± 1.59	1.6 ± 0.84	1.33 ± 1.58	2.25 ± 2.06	2.72 ± 1.42	1.98±1.49

Most of patients belonged to non-functional motor and functional motor power group C or group D (18 patients each, 36%) according to Frankel classification (Table 2) meaning there was significant weakness in majority of the patients.

There was improvement in the grading for the patients, with 21 patients belonging to grade D and 15 belonging to grade E at 1-year follow-up (near normal function and normal function respectively).

Table 2: Frankel's Grade for patients by method of fixation (n=50)

Time of assessment	Type of Fixation					Total
	C1-C2 Screw + Rod (n=16)	Hybrid (n=10)	Occipito-cervical (n=9)	C2 laminar screw (n=4)	Transarticular screw (n=11)	
Pre-operative	A = 1 B = 1 C = 9 D = 5	A = 0 B = 0 C = 6 D = 4	A = 1 B = 2 C = 0 D = 5 E = 1	A = 1 B = 1 C = 2	A = 3 B = 3 C = 1 D = 4	A = 6 B = 7 C = 18 D = 18 E = 1
Post-op (immediate)	A = 1 B = 1 C = 8 D = 6	A = 0 B = 0 C = 6 D = 4	A = 1 B = 2 C = 1 D = 4 E = 1	A = 1 B = 1 C = 2	A = 3 B = 3 C = 1 D = 4	A = 6 B = 7 C = 18 D = 18 E = 1
2-week Post-operative	A = 1 B = 1 C = 4 D = 10	A = 0 B = 0 C = 5 D = 5	A = 1 B = 1 C = 1 D = 5 E = 1	A = 1 B = 1 C = 2	A = 1 B = 4 C = 2 D = 4	A = 4 B = 7 C = 14 D = 24 E = 1
3-month Post-operative	A = 1 B = 1 C = 4 D = 9 E = 1	A = 0 B = 0 C = 4 D = 6	A = 1 B = 0 C = 1 D = 6 E = 1	A = 1 B = 0 C = 2 D = 1	A = 0 B = 2 C = 3 D = 6	A = 3 B = 3 C = 14 D = 28 E = 2
6-month Post-operative	A = 1 B = 1 C = 4 D = 7 E = 3	A = 0 B = 0 C = 2 D = 7 E = 1	A = 1 B = 0 C = 0 D = 5 E = 3	A = 1 B = 0 C = 2 D = 1	A = 0 B = 1 C = 4 D = 6	A = 3 B = 2 C = 12 D = 26 E = 7
1-year Post-operative	A = 1 B = 1 C = 4 D = 5 E = 5	A = 0 B = 0 C = 1 D = 7 E = 2	A = 1 B = 0 C = 0 D = 2 E = 6	A = 1 B = 0 C = 0 D = 2 E = 1	A = 0 B = 1 C = 4 D = 5 E = 1	A = 3 B = 2 C = 9 D = 21 E = 15

On Grob *et al.* objective grading, majority of patients (34/50, 68%) showed a fair grade at 6-month follow-up. At 1-year follow-up, 33 of the 50 patients showed a good grade at 1

year on objective scoring. Only 1 patient showed a bad grade on objective scoring at 1-year follow up.

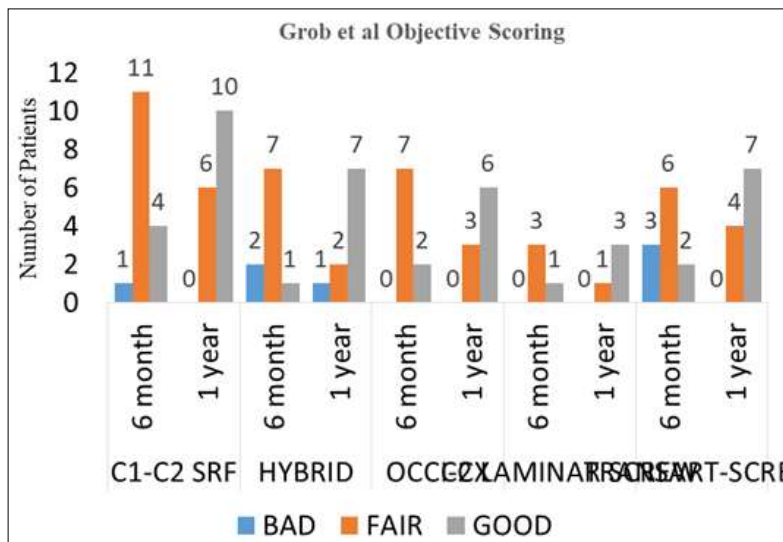


Fig 8: Grob et al. objective scoring

On Grob et al. subjective grading, 62% of patients showed a fair grade at 6-month follow-up. However, at 1-year follow-

up, 60% patients showed a good grade at 1 year on subjective scoring. 4 patients showed a bad grade at 1-year follow u

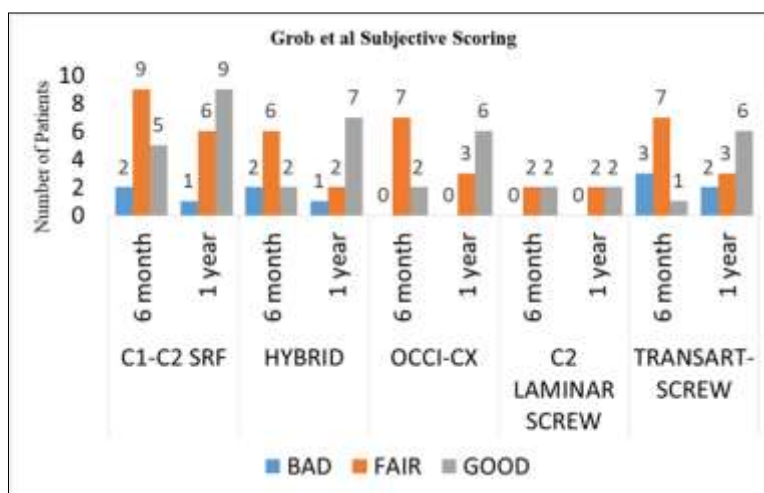


Fig 9: Grob et al. subjective scoring

Discussion

Age distribution - In our study the average age incidence of the patients was 30.22 + 19.98 years with most patients

between 11-20 years. 17 patients were of paediatric age group. In comparison to various studies the age incidence was as follows

Table 3: Showing various studies and their mean age of sample

Study	Mean Age
Bohlman, et al. [1]	47 years
Haid RW, Subarc, et al. [3]	44 years
Harms J, et al. [4]	49 years
Sarat P, et al. [5]	27.25 years

Sex distribution- In our study the sex ratio was equal with 25 male and 25 female patients. Few of the studies showed male

preponderance and few showed female. So there is no gender association seen.

Table 4: Showing gender distribution of various studies

Study	Male	Female
Harms J, et al. [4]	19	18
Coyne T.J, et al. [6]	23	9
Sarat P, et al. [3]	87	61
Gong Shuhui, et al. [7]	17	23
Fung M, et al. [8]	4	19
Reddy, et al. [9]	7	10

Etiology - Majority of the patients in this study had a congenital cause and diagnosis (22/50, 44%). This is in accordance with Reddy A, *et al.* [9], Visocchi.M, *et al.* [10]. In comparison, majority of the studies showed trauma as the most common cause of AAD as seen in Dickman, Sonntag *et al.* [11], Coyne T.J, *et al.* [6], Zidan I, *et al.* [12], Stillerman C, *et al.* [3], Liang M, *et al.* [13]

Clinical features-Most common symptom at presentation was weakness in upper and lower limb with increased tone and upper motor neuron signs seen in all patients. This was followed by neck pain in 73% of the patients, occipital headache in 68% and sensory abnormalities in 60%. Other symptoms included vertigo, tinnitus and nystagmus. Fielding *et al.* found that neurological complaints were present in twenty-four patients, cord compression in 6 patients, while 4 had nerve-root irritation. Pain and limitation of motion of the neck were present in 29 patients. 14 patients were asymptomatic [14]. Clark C reported that in 9 patients, the chief complaint was pain in the neck and in 9 it was occipital aches. 9 patients had no appreciable pain and instability was diagnosed on screening radiographs. Additional symptoms included subjective cervical crepitus in 13, weakness of upper extremities in 5, Progressive muscular weakness in 2, radicular pain in 8, paraesthesias of upper extremity in 8, transient quadriparesis in 1, weakness of lower extremity in 1, and dysphasia in 1 [15].

Nuricks grading

In our study, it was seen that mean Nuricks grading was 3.32 ± 1.09 with no significant change noted immediate post operative period. It was 2.84 ± 1.21 at 3 months follow up. Significant change was noted at 3 months follow up which further improved till the end of the study. This is accordance with study by Sarat P, *et al.* [5], Gong Shuhui, *et al.* [7], there was significant improvement in Nuricks grading which was seen in subsequent follow up. All the studies showed statistically significant improvement in Nuricks grading and there were also no worsening in grading all along the follow up.

Frankels grading

In our study it was found that pre-operatively majority of the patients belonged to either group C or group D but many belonged to grade A and B as well. However, as the follow-up was done, there was improvement in the grading for the patients, with majority of patients belonging to grade D followed by grade E at 1-year follow-up. Visocchi M, *et al.* [10] noted that after mean follow up of 51 months, majority of them had grade E and only 2 had grade D. Zidan I, *et al.*, who also noted that majority of them showed either improvement to grade E or stayed static to Grade D [12]. A study by Saro A, *et al.* [16], 3 patients had grade D on Frankel grading and all 3 patients showed postoperative improvement to grade E. A study by Reddy A M *et al.*, majority of the patients had shown improvement to grade E followed by grade D [9]. None of the studies showed deterioration in grading over the study period similar to our study.

Grob *et al.* classification

1. Objective grading.-Best results seen with Trans-articular screw fixation where at 6 months, most of the patients had good bony fusion and at the end of one year most of them showed solid bony union. At the end of 1 year, all the techniques showed good solid bony fusion and there was no loss of reduction. At the end of 6 months trans-articular screw

technique had max number of cases with pending union showing sparse signs of union but all the cases showed union at 1 year. Only 1 case of non-union was seen hybrid fixation where trans-articular showed union but the C1-C2 screw + Rod showed no sign of union. Which was a case of Koch's spine with erosion inferior surface of right lateral mass of C1 which went on to unite after 16 months of surgery. Jurgen Harms and Robert P [17], F. De Iure, R. Donthineni *et al.* [18] after using C1-C2 screw+ rod fixation saw that all patients demonstrated evidence of solid fusion at the end of follow up. Similarly Coyne, T. J., Fehlings, M.G. *et al.* [6], Stillerman, C. B., & Wilson, J.A [22], Muh-li Liang *et al.* [13], Mitchell Fung *et al.* [8], noted that all the AAD fixed with trans articular screws showed solid union at the end of follow up period. Reddy AM *et al.* [6] noted 100% fusion was seen in AADs fixed with C1-C2 screw + Rod, occipito-cervical fusion. Zidan I *et al.* [12], Gong Shuhui, Liu Jiagang *et al.* [7], Dasari R *et al.* [20], fixed AAD with occipito-cervical plating and a solid fusion was achieved in maximum patients at the end of follow up as noted in our study too.

2. Subjective grading-Majority of patients showed a fair grade at 6-month follow-up. However, maximum patients showed a good grade at 1 year on subjective scoring. 4 patients showed a bad grade at 1-year follow up who after further follow up, 2 of them showed improvement to fair scaling after 16 months. All the 4 patients had grade A or B power (quadriplegia/quadriparesis at presentation). Both C1-C2 screw + Rod fixation and Trans-articular screw showed maximum conversion from fair grade to good functional outcome. Similarly the C2 laminar screw with C1 screw+ Rod fixation showed good functional outcomes. This in accordance with majority of the studies which showed significant relief in pain and improved the quality of living of the patients like Stillerman, C. B., & Wilson, J. A. [19], Reddy AM *et al.* [9], Dasari R *et al.* [20], Muh-li Liang *et al.* [13], Mitchell Fung, *et al.* [8]. In a study by F. De Iure, R. Donthineni, *et al.* [18] few patients had intermittent neck pain even after bony fusion was noted but it did not interfere with daily activities.

Conclusion

Atlanto-axial dislocation is more commonly associated with congenital causes. The restoring of ADI is utmost important and all the methods used to fix provided similar stability and maintained the reduction. There is significant co-relation between pre-operative neurological status and functional recovery meaning worse the neurology, longer time to recover. Also the clinical outcome was directly proportional to the adequacy of decompression and stability provided. There is no one superior method of fixation providing better clinical outcome and the method chosen depends on anatomical variations, integrity of the joints and surgeon's familiarity with the technique. Rate of fusion is directly associated with the quality of bone at the articular surfaces of C1-C2 facet joints.

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