

Reduction techniques in the management of atlantoaxial subluxation

Arjun Shetty^{1,2}, Anil Kumar¹, Arjun Chacko¹, Sachin Guthe¹, Abhishek R Kini³

ABSTRACT

Background: The traditional approach to atlantoaxial subluxation which is irreducible after traction is transoral decompression and reduction or odontoid excision and posterior fixation. Transoral approach is associated with comorbidities. However using a posterior approach a combination of atlantoaxial joint space release and a variety of manipulation procedures, optimal or near optimal reduction can be achieved. We analysed our results in this study based on above procedure.

Materials and Methods: 66 cases treated over a 5 year period were evaluated retrospectively. Three cases treated by occipito cervical fusion were not included in the study. The remaining 63 cases were classified into three types. All except two cases were subjected to primary posterior C1-C2 joint space dissection and release followed by on table manipulation which was tailored to treat the type of atlantoaxial subluxation. Optimal or near optimal reduction was possible in all cases. An anterior transoral decompression was needed only in two cases where a bony growth (callus) between the C1 anterior arch and the odontoid precluded reduction by posterior manipulation. All cases then underwent posterior fusion and fixation procedures. Patients were neurologically and radiologically evaluated at regular followups to assess fusion and stability for a minimum period of 6 months.

Results: Of the 63 cases who underwent posterior manipulation, 49 cases achieved optimum reduction and the remaining 14 cases showed near optimal reduction. Two cases expired in the postoperative period. None of the remaining cases showed neurological worsening after the procedure. Evaluation at 6 months after surgery revealed good stability and fusion in all except three cases.

Conclusion: Atlantoaxial joint release and manipulation can be used to achieve reduction in most cases of atlantoaxial subluxation, obviating the need of transoral odontoid excision.

Key words: Atlantoaxial joint release, atlantoaxial subluxation, cervical spine injuries

INTRODUCTION

The traditional management of atlantoaxial instability, deemed irreducible after traction is transoral odontoid excision followed by a posterior fixation.¹

An intimate knowledge of the microsurgical anatomy of the atlantoaxial region and increased experience with surgical techniques to expose and manipulate the atlantoaxial joint spaces now enable the spinal surgeon to

manipulate the atlantoaxial spinal complex and achieve reduction in most cases of atlanto-axial sub-luxation obviating the need for a transoral procedure²⁻⁴ and its associated co-morbidities.

We have retrospectively analyzed atlantoaxial instability treated by using a combination of C1-C2 joint release and manipulation of the atlanto-axial complex. All cases primarily approached posteriorly. The functional and radiological outcomes were evaluated.

MATERIALS AND METHODS

66 cases of atlantoaxial instability were diagnosed and treated at our institute between 2005 and 2010. All patients presented in casualty with suspected cervical spine injury and concussive head injury were subjected to X-rays of the cervical spine. In cases with pain in cervical area, restricted neck movement and neurological deficit with apparently normal cervical X-ray, active lateral flexion and extension films were used to assess instability indicated by an atlanto-dens interval (ADI) of more than 3 mm or a posterior atlanto-dens interval (PADI) of less than 19 mm. X-ray open

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mouth view was used to assess lateral mass overhang and look for overlapping of the facets (winking sign)^{5,6} which would indicate a rotatory subluxation.

All the patients were subjected to magnetic resonance imaging (MRI) of cervical spine. The associated congenital anomalies were noted as well in all cases. The cases in which C1 lateral mass-C2 transpedicular stabilization was considered, were also subjected to computed tomography (CT) scans to assess odontoid separation, the feasibility of placement of the screws and the proximity to the foramen transversarium.⁶ CT angiogram was performed in cases where C1-C2 intraarticular fixation or C1 lateral mass-C2 transpedicular screw was used to assess the vertebral artery.⁷⁻¹⁰

The time interval between the injury and presentation varied from 1 to 97 days (mean = 12.8 days). Of these 66 cases, 3 cases in which destruction of C1 lateral mass, C1-C2 joints and posterior elements prevented C1-C2 fixation were subjected to occipito cervical fixation and were not included in the study. Of the remaining 63 cases, 49 were males and 14 were females. Their age ranged from 6 to 68 years. 39 cases were posttraumatic while 16 were associated with congenital abnormalities and 8 cases were associated with degenerative spine disease. All patients underwent detailed neurologic evaluation on admission and were graded on the American spinal injury association (ASIA) impairment scale (AIS). Following evaluation of radiological images, we divided the atlantoaxial subluxations into three basic types [Figures 1a-d].

Type A (n=33)

There is a forward translation of C1 over C2 causing an increase in the ADI with a reduction of the PADI. There is no significant increase in the C1-C2 interspinous distance

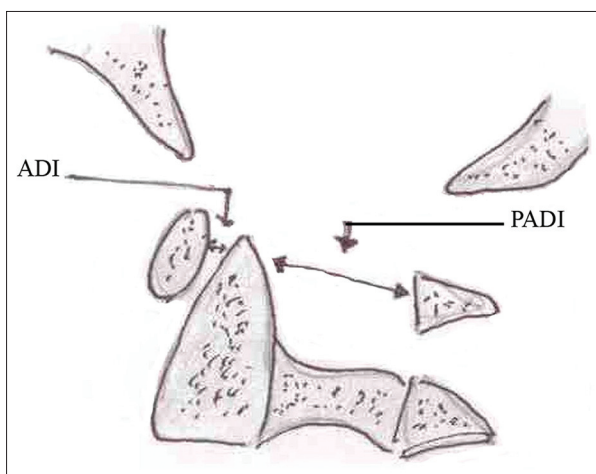


Figure 1a: A line diagram showing normal cranio-cervical junction (ADI: Atlanto-Dens Interval, PADI: Posterior atlanto-dens Interval)

(ISD) though there is a minimal anterior inferior angulation C2 body.¹⁰ These constitute the classical posttraumatic atlantoaxial subluxations.

Type B (n=23)

There is forward translation of C1 over C2 associated with an odontoid fracture and an intact transverse ligament. In this case, the ADI is not increased. However, the dens-opisthion distance is increased and the basion C1 arch distance is decreased altering the Power's ratio. There is no significant increase in the C1-C2 interspinous distance [Figure 2a-d].

Type C (n=7)

The C2 moves posteriorly and superiorly in the sagittal plane and the C1 arch goes downward and forward causing an increase in the ADI and increase in the C1-C2 interspinous distance, both of which may be increased on flexion [Figures 3a-d].

All 63 cases were immobilized preoperatively with a Philadelphia cervical collar. No attempt was made preoperatively to achieve reduction using skeletal traction. In two cases, a large bony mass possibly a callus was present between the C1 arch and the odontoid process which would have prevented reduction of the C1-C2 subluxation. Both these cases were subjected to a transoral decompression. In one case, only the C1 arch and callus were excised. While in other case, odontoidectomy was also performed. In both cases, posterior fixation was done as a second procedure. In all the remaining cases, a primary posterior approach was used to achieve reduction and fixation.

Manipulation reduction techniques

The patient is positioned prone on a radiolucent table and the occipito C1-C2 complex is exposed through a midline

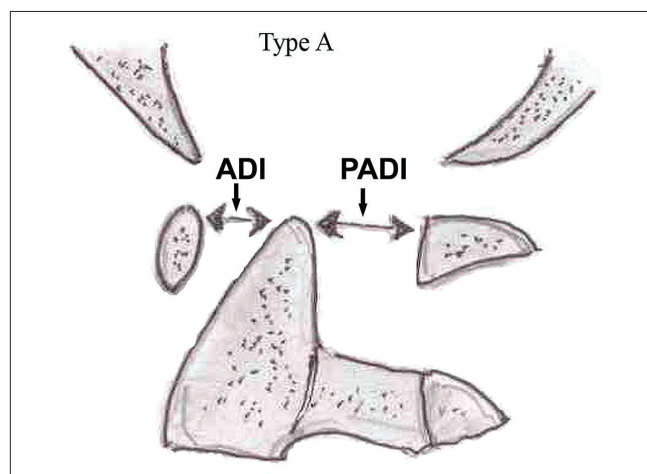


Figure 1b: A line diagram showing type A Atlantoaxial subluxation – increased ADI, decreased PADI

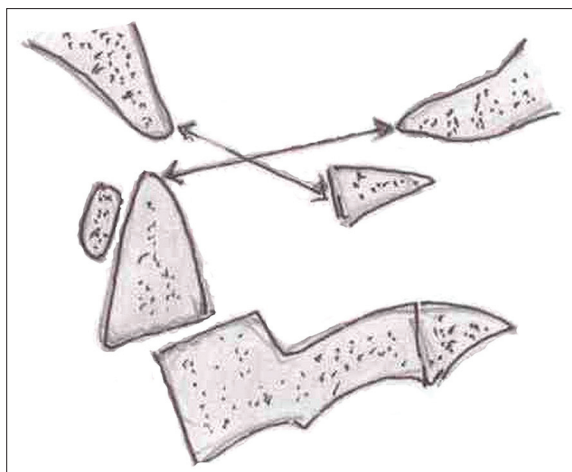


Figure 1c: A line diagram showing type B atlantoaxial subluxation – Increased odontoid-opiston distance, decreased basion-C1 arch distance, altered power's ratio

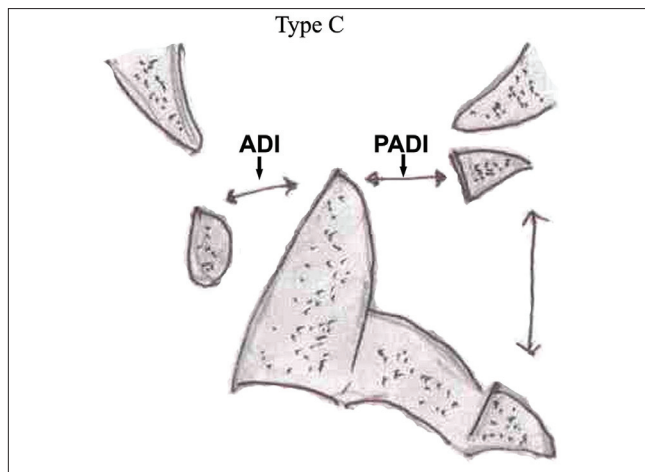


Figure 1d: A line diagram showing type C atlantoaxial subluxation – Increased atlanto-dens interval (ADI), decreased posterior atlanto-dens interval (PADI), increased Interspinous distance

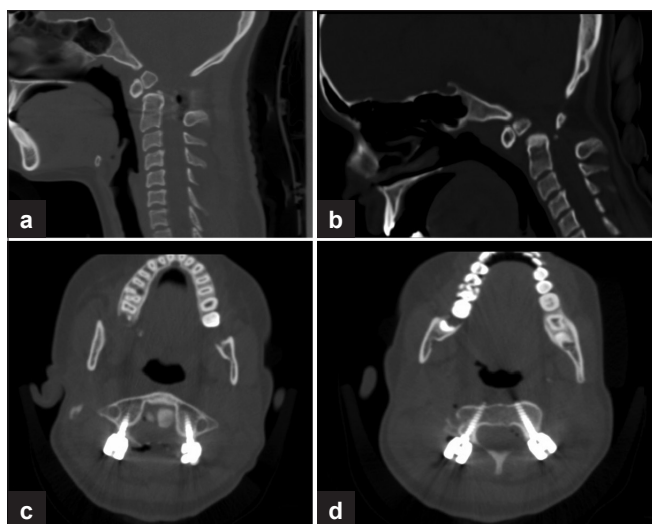


Figure 2: Preoperative CT (sagittal) showing (a) atlantoaxial subluxation with odontoid fracture. (Type B) (b) Postoperative CT (sagittal) showing reduced atlantoaxial subluxation. (c) Postoperative CT (axial) showing screw positioning in C1 (Atlas) (d) Postoperative CT (axial) showing screw positioning in C2 (Axis)

incision. The C1-C2 joint capsule was opened widely and the joint space curetted out as completely as possible. The C2 root was cut whenever the surgeon felt it is necessary to provide a better field for decompression of the joint. Once the joint cavity was freed, a thin vertebral spreader and chisel was used to distract the joint and assess the mobility. Manipulation was attempted only after the joint spaces were noted to be adequately free.

In type A and B subluxations, the reduction technique we perform is as follows:^{11,12} A 21G wire loop is passed under the posterior arch of C1. Under fluoroscopic guidance, the wire loop is used to exert traction on the C1 arch in a posterior direction where the assistant applies pressure on

C2 spinous process in an anterior and upward direction. The reduction is achieved after which a fixation and fusion procedure is performed.

In cases with type C subluxation, a modified reduction procedure is adopted. In these cases, the interspinous ligaments between C1-C2 and the muscles attached to the C2-C3 posterior elements are dissected to allow movement at C2-C3 interspinous region after which the C1 arch is manipulated downward and backward using the sublaminar wire loop. Simultaneously, a vertebral spreader is placed between C2-C3 laminae and the interspinous space distracted under fluoroscopy till reduction is achieved following which fixation of C1-C2 is performed.

On table evaluation of reduction in type A and type C, subluxations was considered optimal if ADI was less than 3 mm and near optimal if ADI was 3-5 mm.¹³ In cases with type B subluxation, the alignment of odontoid with the C2 body produced a good indicator of reduction. The Power's ratio being difficult to measure on fluoroscopy during surgery, we have taken an odontoid displacement distance² of 0-2 mm as optimal reduction and 2-4 mm as near optimal reduction.¹³ In cases where reduction was near optimal, the posterior arch of C1 was excised to provide adequate decompression.

Posterior fusion was done with intraarticular bone grafts in all cases. This was supplemented with interspinous grafts (Gallie fusion) in 10 cases. Fixation was done using transarticular C1-C2 screws. In 45 cases bilateral C1 lateral mass C2 transpedicular screws and in 8 cases unilateral C1 lateral mass C2 transpedicular screws were used as vascular and bony anomalies prevented bilateral fixation.¹⁴ Of the two cases subjected to a transoral decompression

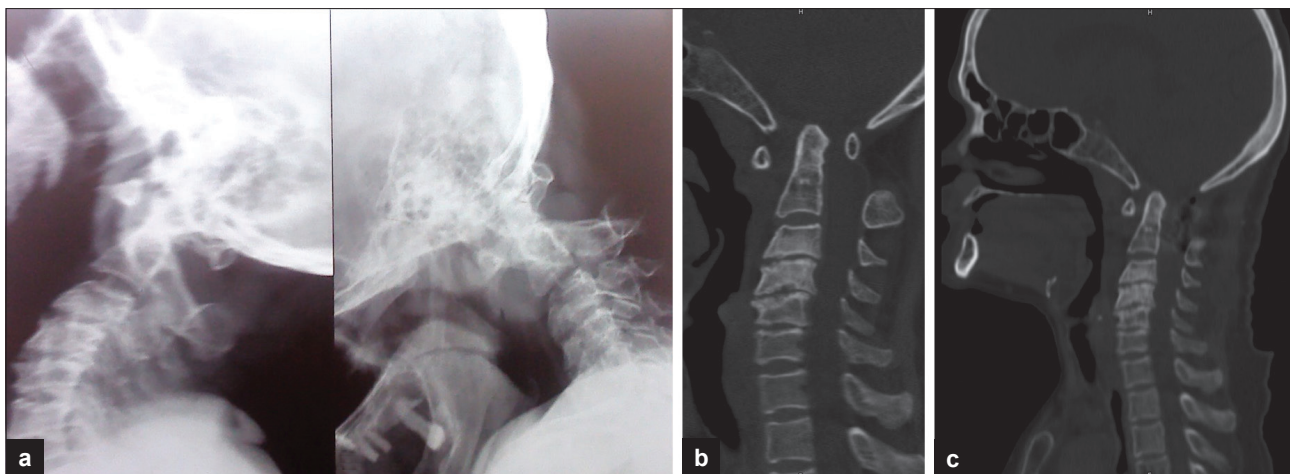


Figure 3: (a) Preoperative flexion extension radiographs showing atlantoaxial subluxation (Type C). (b) Preoperative CT (sagittal) showing atlantoaxial subluxation (Type C). (c) Postoperative CT (sagittal) showing reduced atlantoaxial subluxation (Type C)

one patient underwent C1 lateral mass C2 transpedicular fixation. In the second case, C1-C2 fixation could not be done as the patient developed hypotension on table hence an intraspinous iliac bone graft was used to distract the C2 spinous process from the subaxial spinous processes to achieve and maintain reduction.

Postoperatively all patients were subjected to flexion extension X-rays of cervical spine. Type B cases were also subjected to open mouth x rays. Neurological assessment and grading as per ASIA impairment scale (AIS) was performed. Radiological and neurological evaluation was repeated at 6 weeks, 3 months, 6 months, 1 year and on yearly basis subsequently.

The C1-C2 complex was considered stable if there was no movement between the C1 posterior arch and C2 spinous process on lateral flexion extension films. Fusion was considered to be achieved if trabecular continuity existed between the intraarticular spaces and between the C1 posterior arch and C2 in cases subjected to a Gallie fusion.¹¹

All patients were mobilized to sitting position on the third postoperative day. Patients with neurological deficit or minimal neurological deficit were ambulated after a week on a halo brace and continued the brace for 6 weeks. Patients who could not be ambulated were managed with a Philadelphia collar for 6 weeks.

RESULTS

Postoperative radiological and neurological evaluation was possible in all 61 cases at 6 months (2 mortalities in the postoperative period). The mean followup was 3.3 years (range 6 months-4 years). Two years followup was possible in 43 cases. None of our patients showed

neurological deterioration following manipulation and fixation procedures postoperatively [Table 1].

Optimum reduction was achieved in 26 cases of type A (78.7%), 19 cases of type B (82.6%) and 5 cases of type C (71.4%). Reduction was near-optimal in 7 cases of type A, 4 cases of type B and 2 cases of type C [Table 2]. Reduction was noted to be optimal in 36 of the 45 cases treated with bilateral C1 lateral mass C2 transpedicular fixation, 6 out of the 8 cases treated with C1- C2 trans-articular fixation and 7 of the 8 cases treated with unilateral C1 lateral mass-C2 transpedicular fixation [Table 3].

Evaluation at 6 months revealed good stability and fusion in 42 of the 44 cases managed with bilateral C1-C2 lateral mass fixation (one patient expired in the immediate postoperative period and could not be assessed), 7 out of 8 cases treated with trans-articular C1-C2 fixation and all cases treated by unilateral C1 lateral mass C2 transpedicular fixation showed good stability and fusion at 6 months [Table 3].

Two cases treated with bilateral C1 lateral mass C2 transpedicular fixation were noted to have failure of fixation on followup as evidenced by backing out of the left C2 screw in one case and both C1 and C2 screws on the right side in another (Grade 2 transgression). One case treated with trans-articular C1-C2 screw fixation presented with partial backing out of screws, this patient was noted to have osteoporotic bone. All three cases had achieved near-optimal reduction and showed abnormal mobility on lateral flexion extension films at 6 months. The patients treated by trans-articular fixation underwent reexploration with replacement of screws and augmentation with sub-laminar wires and Gallie fusion. The other 2 patients refused further intervention.

There were two mortalities in our series; both were of a poor neurological grade (AIS B) preoperatively. One patient who underwent initial transoral decompression developed hemodynamic changes during the posterior instrumentation procedure and expired postoperatively (7th day). Another patient treated with bilateral C1-C2 lateral mass transpedicular screws also had polytrauma including thoracic injuries and expired on the 3rd postoperative day. Seven cases developed pneumonitis in the postoperative period; of these, four patients required further tracheostomy and ventilator care. Of the four patients who underwent tracheostomy, two cases had lower cranial nerve dysfunction preoperatively.

On table vertebral artery injury noted in one patient treated with bilateral C1 lateral mass C2 transpedicular fixation and two cases where unilateral fixation was done. This needed local compression to achieve hemostasis and no

Table 1: Neurological evaluation

ASIA grade	Total cases	A	B	C	D	E
Type A						
On admission	33	9	8			16
Postoperative	33	9	6	2		16
At 6 months	32	7	4	4		17
At 2 years	25	6	3	3		13
Type B						
On admission	23	2	6	4		11
Postoperative	23	2	6	4		11
At 6 months	23	1	2	9		11
At 2 years	14	1	2	5		6
Type C						
On admission	7	1	3	1		2
Postoperative	7	1	3	1		2
At 6 months	6		1	3		2
At 2 years	4			2		2

Table 2: Postoperative radiological evaluation

AAD type	Total cases	Optimal reduction (%)	Near-optimal reduction (%)
A	33	26 (78.7)	7 (21.3)
B	23	19 (82.6)	4 (17.3)
C	7	5 (71.4)	2 (28.6)

Table 3: Radiological evaluation of various surgical options carried out in this series

Procedure	No.	Optimal reduction	Near-optimal reduction	Adequate stabilization at 6 months
Bilateral C1 lateral mass C2 transpedicular fixation and intraarticular fusion	38	31	7	35 of 37 one died postoperatively
Bilateral C1 lateral mass C2 transpedicular fixation, intraarticular and galle fusion	7	5	2	7
Unilateral C1 lateral mass C2 transpedicular fixation, intraarticular fusion	8	7	1	8
C1-C2 trans-articular fixation with intraarticular fusion	5	4	1	4
C1-C2 trans-articular fixation with intraarticular fusion and galle fusion	3	2	1	3
Trans-odontoid excision C1-C2 lateral mass fixation and intraarticular fixation	1		1	1
Transoral decompression and intraspinal graft and wiring	1		1	Patient died in the postoperative period

neurological consequences were noted in all these three cases. Graft site infection was noted in three cases and deep venous thrombosis in two cases. One patient developed an occipital bed sore which was treated with a rotation flap.

DISCUSSION

The management of atlantoaxial subluxation traditionally has been based on the ability to achieve reduction using preoperative skeletal traction. Reducible subluxations being managed by posterior fixation procedure and irreducible subluxations being subjected to an internal transoral odontoid excision followed by posterior fixation often in a sub-optimal position.¹ While the transoral odontoid excision does remove the main compressive element, the procedure itself can be associated with significant morbidity and in addition the excision of odontoid along with the fact that posterior fixation is often done in the sub-optimal position can result in significant restriction of neck movement.

The excision of the odontoid process also presents problems while performing the posterior stabilization procedure. The inability to visualize the odontoid on fluoroscopy makes accurate passage of trans-articular C1 C2 screws difficult. Also, the degree of reduction achieved is difficult to assess on fluoroscopy in patients in whom the odontoid has been excised. The risk of vertebral artery injury is also higher in cases where trans-articular screws are placed in sub-optimally reduced subluxations following transoral odontoid excision.¹⁵

In cases who have undergone transoral odontoid excision the length of C1 lateral mass screw is difficult to assess and anterior transgression of screws beyond the lateral mass can result in the carotid artery injury.¹⁵ However, the traction effect of the rod-screw construct aids in the reduction of atlantoaxial subluxation unlike in trans-articular fixation.¹⁶

As mentioned earlier we have divided atlantoaxial subluxation into three types. Types A, B are essentially translation type of injuries and are more commonly found

following trauma. In type A, the transverse ligament is incompetent allowing the odontoid to sublunate back. These cases tend to be amenable to reduction using the manipulation process mentioned earlier.¹² In type B subluxations, the transverse ligament is intact however the odontoid is fractured and the fractured segment sub-luxates along with the C1 vertebra over the C2 narrowing the PADI unlike in type A subluxations however the ADI stays constant. In type B subluxations where reduction is achieved on extension by exertion of transoral pressure on the C1 arch odontoid complex, it is possible to achieve stabilization by placing a trans-odontoid screw in the fractured odontoid process. While this procedure effectively restricts the translation of C1 over C2, there is the possibility of rotational movement; hence, at present we continue to treat type B fractures with posterior reduction and fixation as in type A fractures and utilize trans-odontoid screws only in fractures not associated with instability.^{17,18}

Type C subluxations are more commonly found associated with degenerative and congenital craniovertebral pathologies. But can be associated with traumatic injuries also. In this type of subluxations, the C2 body is rotated backward in the sagittal plane unhindered by an incompetent transverse ligament. This movement is associated with two important anatomical changes: firstly, odontoid rotates backward and upward and subsequently causes neural compression. In some cases, this upward rotational migration of the odontoid may cause basilar invagination. Secondly, there is increased C1-C2 interspinous distance with a decrease in C2-C3 interspinous distance. In some long standing cases, fibrous or osseous union of C2-C3 spinous processes may be noted. In type C subluxation in addition to release of C1-C2 joint spaces, separation of the osseoligamentous attachments between the C2 and C3 posterior elements is needed following which C2-C3 interspinous distraction is used to rock the C2 vertebra anteriorly; consequently, the odontoid will rotate anteriorly and downward which achieves both reduction and relief of neural compression.

Goel *et al.*,^{15,16} have classified basilar invagination into type A and B and have postulated that type A basilar invagination may be associated with a fixed atlantoaxial subluxation possibly posttraumatic in which the odontoid is tilted horizontally with an increased omega angle. This is similar to the type C subluxation which we describe. Goel has reported excellent reduction of subluxation and basilar invagination following distraction of the atlantoaxial joints.^{19,20}

Using a combination of atlantoaxial joint release and the manipulation procedures discussed we have been able to achieve complete or near complete reduction in all but two

cases treated by us in the last 5 years. In these two cases, the presence of a bony lesion (possibly callus) interposed between the anterior arch of C1 and the odontoid precluding any possibility of a primary posterior reduction. Both cases underwent a primary transoral decompression. We have found that excision of the C1 arch and the callus alone was enough obviating the need to excise the odontoid which can be manipulated back into normal position during the second posterior fixation procedure.

To conclude, C1-C2 joint space dissection combined with manipulation of the C1-C2 complex can be safely used to achieve optimal and near optimal reduction in most cases of atlantoaxial instability. Transoral decompression can be avoided in most cases but may be required in cases where osseous growth between the odontoid and C1 anterior arch prevent reduction by posterior manipulation.

REFERENCES

1. Menezes AH. Craniovertebral junction database analysis: incidence, classification, presentation and treatment algorithms. *Childs Nerv Syst* 2008;24:1101-8.
2. Goel A, Laheri V. Plate and screw fixation for atlantoaxial subluxation. *Acta Neurochir (Wien)* 1994;129:47-53.
3. Goel A, Shah P, Dange N, Kulkarni AG. Techniques in the treatment of craniovertebral instability. *Neurol India* 2005;53:525-33.
4. Harms J, Meicher RP. Posterior C1-C2 fusion with poly axial screw and rod fixation. *Spine (Phila Pa 1976)* 2001;26:2467-71.
5. Dickman CA, Manmourian A, Sontag VK, Drayer BP. MRI of the Transverse Atlantal ligament for the evaluation of Atlanto axial instability. *J Neurosurg* 1991;75:221-7.
6. Ellis GL. Imaging of Atlas and Axis. *Emerg Med North Am Clin* 1991;9:919-32.
7. Paramore CG, Dickman CA, Sontag VK. The anatomical suitability of the C1-2 complex for trans articular screw fixation. *J Neurosurg* 1996;85:221-4.
8. Goel A, Gupta S. Vertebral artery injury with trans articular screw. *J Neurosurg* 1999;90:376-7.
9. Wright NM, Laurysen C. Vertebral artery injury in C1-C2 trans articular screw fixation: Results of a survey of AANS/CNS section of disorder of spine and peripheral nerves. *J Neurosurg* 1998;88:634-40.
10. Shetty A, Kini AR, Prabhu J. Odontoid fractures a retrospective analysis of 53 cases. *Indian J Orthop* 2009;43:352-60.
11. Madawi AA, Casey AT, Solanki GA, Tuite G, Veres R, Crockard HA. Radiological and anatomical evaluation of atlantoaxial transarticular screw fixation technique. *J Neurosurg* 1997;86:961-8.
12. Bono CM, Vaccaro AR, Fehling M, Fisher C, Dvorak M, Ludwig S, *et al.* Measurement techniques for upper spine injuries – Consensus Statement of Spine Trauma Study group. *Sine (Phila-PA. 1976)* 2007;32:593-600.
13. Shetty A, Kini AR, Gupta A, Kumar A, Upadhyaya S. Management of traumatic atlantoaxial instability: A retrospective study of eight cases. *Indian J Orthop* 2012;46:86-91.
14. Karaikovic EE, Yingsakmongkol W, Griffiths HJ, Gaines RW. Possible complication of anterior perforation of vertebral body using cervical pedicle screws. *J Spinal Disord Tech* 2002;15:75-8.

15. Abumi K, Takada T, Shono Y, Kaneda K, Fujiya M. Posterior occipitocervical reconstruction using cervical pedicle screws and plate-rod systems. *Spine (Phila Pa 1976)* 1999;24:1425-34.
16. Aebi M, Etter C, Coscia M. Fracture of the odontoid process: Treatment with anterior screw fixation. *Spine (Phila Pa 1976)* 1989;14:1065-70.
17. Julien TD, Frankel B, Traynelis VC, Ryken TC. Evidence based analysis of odontoid fracture management. *Neurosurg Focus* 2000;8:e1.
18. Goel A. Atlanto axial joint jamming as a treatment for atlantoaxial dislocation: A preliminary report. *J Neurosurg Spine* 2007;7:90-4.
19. Goel, Shah A, Rajan S. Vertical mobile and reducible atlantoaxial dislocation: Clinical article. *J Neurosurg Spine* 2009;11:9-14.
20. Goel A, Bhatjiwale M, Desai K. Basilar invagination a study based on 190 surgically treated patients. *J Neurosurg* 1998;88:962-8.

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