

Traumatic posterior atlantoaxial dislocation without fracture of the odontoid process: illustrative case

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BACKGROUND Traumatic posterior atlantoaxial dislocation without fracture of the odontoid process is extremely rare. Only 24 cases have been documented since the first patient was reported by Haralson and Boyd in 1969. Although various treatment strategies are reported, no consensus has been yielded.

OBSERVATIONS A 58-year-old man experienced loss of consciousness and breathing difficulties after being struck by a car from behind. An immediate computed tomography scan showed subarachnoid hemorrhage, a posterior atlantoaxial dislocation without C1–2 fracture, and a right tibiofibular fracture. After the patient's respiration and hemodynamics were stabilized, closed reduction was attempted. However, this strategy failed due to unbearable neck pain and quadriplegia, resulting in surgical intervention with transoral odontoidectomy and posterior occipitocervical fusion. The patient developed postoperative central nervous system infection. After anti-infective and drainage treatment, the infection was controlled. At 1-year follow-up, the patient did not complain of special discomfort and was generally in good condition.

LESSONS The authors report their experience with transoral odontoidectomy and concomitant posterior occipitocervical fusion in a case of posterior atlantoaxial dislocation without related fracture. Although these procedures are highly feasible and effective, particular attention should be paid to their complications, such as postoperative infection.

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KEYWORDS atlantoaxial dislocation; open reduction; transoral odontoidectomy; posterior occipitocervical fusion; cerebrospinal fluid leakage; infection

Traumatic posterior atlantoaxial dislocation without fracture of the odontoid process is a rare cervical hyperextension injury. Only 24 cases have been reported in the literature.^{1–22} In this report, we describe a patient with posterior atlantoaxial dislocation without odontoid process fracture after a traffic accident, presenting with 1 week of consciousness loss and persistent limb weakness. Our case was treated by transoral odontoidectomy and posterior occipitocervical fusion after closed reduction failure, which was different from any previously reported case. In addition, a review of the literature is included.

Illustrative Case

History and Closed Reduction Attempt

A 58-year-old male who was involved in a traffic accident was admitted to the local hospital. On examination, he was unconscious

and had breathing difficulty. His Glasgow Coma Scale (GCS) score was 5, and his American Spinal Cord Injury Association Impairment Scale (AIS) grade was C. Aside from subarachnoid hemorrhage, traumatic wet lung, and right tibiofibular fracture, computed tomography (CT) mainly showed posterior atlantoaxial dislocation and rotation and ventral translocation of the odontoid process without fractures (Fig. 1A–C). Further magnetic resonance imaging (MRI) examination revealed an avulsion of the transverse ligament and deviation of the neural axis without intramedullary signal change (Fig. 1D and E). The patient received intensive life support, including tracheotomy and continuous skull traction with 3-kg power in the critical care unit. Upon stabilization, he was transferred to our medical center for further management. At that time, the patient's GCS score was 15, and his AIS grade was E. Closed reduction at the power of 6 kg failed because of unbearable neck pain,

ABBREVIATIONS AIS = American Spinal Cord Injury Association Impairment Scale; CSF = cerebrospinal fluid; CT = computed tomography; GCS = Glasgow Coma Scale; MRI = magnetic resonance imaging.

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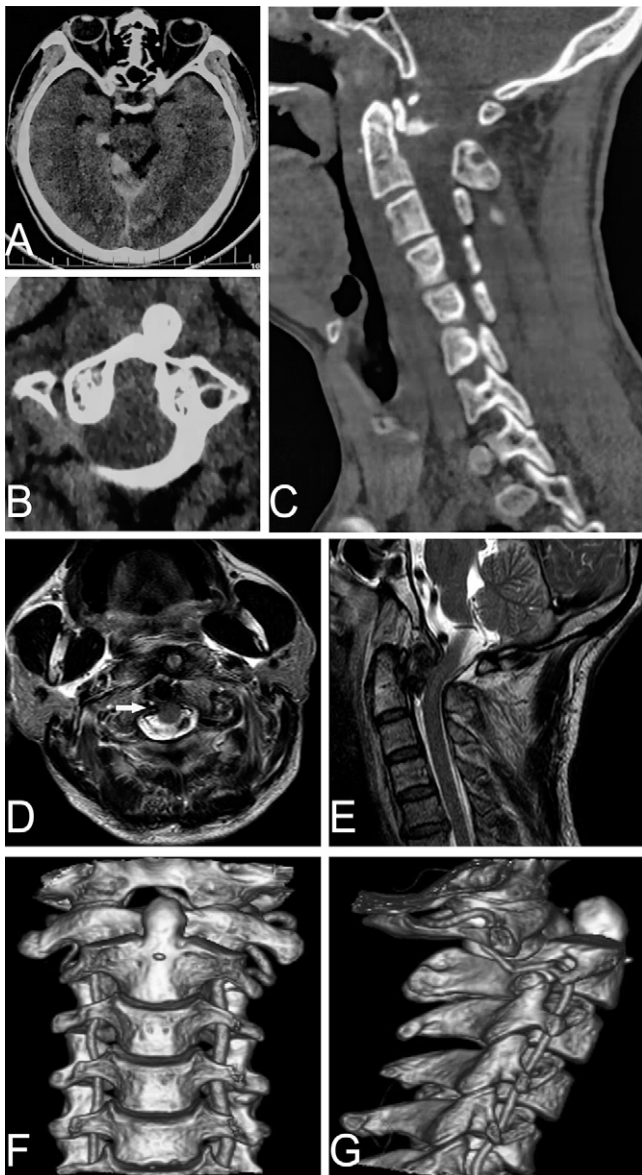


FIG. 1. CT showed intracranial subarachnoid hemorrhage (A) and ventral translocation of the odontoid process but without fractures (B and C). MRI (D and E) revealed an avulsion of the transverse ligament (white arrow) and deviation of the neural axis with no intramedullary signal change. Three-dimensional CT angiography confirmed that the right vertebral artery was strained and angulated (F and G).

dizziness, and severe numbness of the upper limbs. CT angiography further confirmed tensioning and angulation of his right vertebral artery (Fig. 1F and G).

Surgical Description

Concomitant surgery of transoral odontoidectomy and posterior occipitocervical fusion was planned. During the odontoidectomy, cerebrospinal fluid (CSF) leakage occurred after removal of the odontoid process due to severe scar adhesions around it. Biological protein glue was used to seal the leak. After performing odontoidectomy, we tried to reduce the dislocation through gradual manual traction. However, when

traction strength was increased to 7 kg, the patient developed transient hypotension and bradycardia. Intraoperative X-ray fluoroscopy showed that the posteriorly dislocated atlas had moved forward significantly, with the stump of the odontoid process stuck under the anterior arch of the atlas, but no anatomical reduction had been achieved (Fig. 2B). To increase stability, the patient was shifted to a prone position, and he received posterior occipitocervical fusion with a polyaxial screw and rod system (Fig. 2C). Spinal cord monitoring was not available during the procedures.

There was no new neurological dysfunction after surgery. Acceptable alignment of the atlantoaxial junction was achieved from the postoperative sagittal CT reconstructions (Fig. 3A). Compared with before the operation, the course of the right vertebral artery had returned to normal according to the three-dimensional CT angiography reconstructions (Fig. 3B). An MRI scan after the operation confirmed relief of spinal cord compression (Fig. 3C).

Postoperative Infection

Four days after surgery, the patient had a postoperative fever. CSF tests confirmed antibiotic-sensitive *Klebsiella pneumoniae* infection. External ventricular and lumbar drainage were applied, and tigecycline and amikacin were used for anti-infective therapy.

Discharge and Follow-Up

On the 29th day after surgery, the patient was discharged to a local rehabilitation hospital with completely normal temperature and negative bacterial culture of the CSF. At the 3-month follow-up, bony fusion between the lateral joints of C1–2 and between the root of the resected odontoid process and the anterior arch of the atlas was identified on CT scans (Fig. 4A and B). However, MRI revealed an arachnoid cyst lying posterior to the cervical cord at level C1–2 without corresponding clinical symptoms (Fig. 4C and D). Therefore, we did not perform the second operation on the patient. At 12 months after surgery, CT scans showed more solid bony fusion than that at 3 months (Fig. 4E–G). MRI showed no significant size change of the cyst compared with the previous one (Fig. 4H), and the patient did not complain of special discomfort and was generally in good condition.

Discussion

Observations

The stability of the atlantoaxial complex is mainly provided by the odontoid process interlocking in the osseoligamentous ring formed by the anterior arch of the atlas ventrally and the transverse ligament dorsally.¹⁰ The primary movement of the atlantoaxial complex is axial rotation, and the flexion-extension movement is quite limited by the anterior arch and the posterior cruciate ligaments.^{23,24} Traumatic posterior atlantoaxial dislocation is always caused by odontoid fracture or atlantoaxial ligament ruptures.²⁵ Dislocation without fracture is rare. Such an impact would tend to cause severe distraction of the cord, resulting in immediate death.^{26,27} Thus, it might well be missed in a routine postmortem examination,^{7,28} and it is likely that the incidence is higher than reported. The severe rotary hyperextension of the neck with variable amounts of distraction has been proposed as the probable mechanism.¹

Twenty-four cases of this rare posterior atlantoaxial dislocation have been reported in the literature (Table 1). Both “closed reduction” and “open reduction” have been used. Wong et al.⁶ described three phases of closed reduction, including dispersion, rearrangement, and

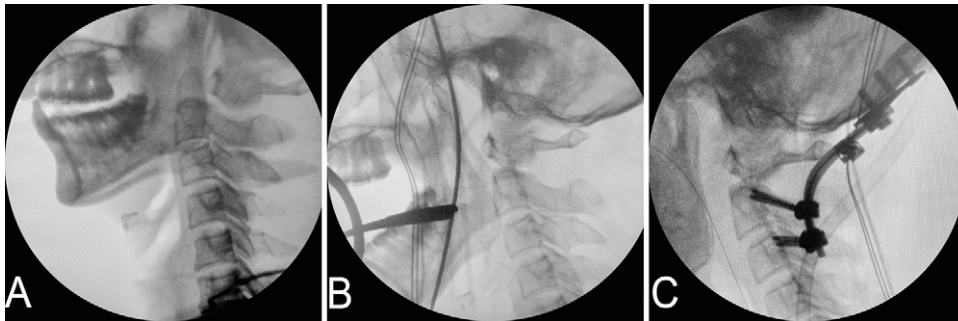


FIG. 2. Intraoperative X-ray fluoroscopy showed posterior dislocation of the atlas (A). After odontoidectomy and manual traction were attempted, the posterior dislocation of the atlas had moved forward significantly, but no anatomical reduction had been achieved (B). To increase stability, posterior occipitocervical fusion was performed (C).

release. Closed reduction under C-arm fluoroscopic guidance is usually successful and safe. The timing and power of traction are essential. In the literature, most cases of successful closed reduction were initiated within 10 days. Power of 3 kg to 9 kg was stated to be effective in reduction. However, in our case, the skull traction started at 41 days after injury. Such a delay may result in scar adhesion at the epicenter, making it difficult to determine the proper power. Power of 6 kg was intolerable to our patient due to severe dizziness, neck pain, and upper limb numbness. In addition, the integrity of the transverse ligament is critical for local stabilization. Fixation and fusion are required when the ligament is torn, even if closed reduction has been successful.^{8,29} In Sun et al.'s²¹ case, a redislocation after closed reduction was reported as the transverse ligament was ruptured. Taking these into consideration, a surgical strategy was chosen.

Odontoidectomy with fusion is recommended in such cases, the approach has yet standardized. Biomechanical research supports posterior C1–2 pedicle screws because they afford greater stiffness and a higher fusion rate without the need for postoperative halo vest immobilization in the screw system.^{14,30,31} Anterior transarticular screw and posterior pedicle screw fixation also provided sufficient local stability.¹² In our case, during traction reduction after odontoidectomy, the patient had a transient decrease of heart rate, forcing us to stop the reduction. Intraoperative X-ray fluoroscopy showed that the atlantoaxial joint had not achieved anatomical

reduction. Therefore, we had to use posterior occipitocervical fusion to achieve greater stability.

CSF leak and secondary infectious meningitis are serious complications of a transoral approach.^{32,33} In our case, the patient developed central nervous system infection postoperatively, and bacterial culture of CSF confirmed *K. pneumoniae* infection. We think there were three reasons for this: (1) Transoral odontoidectomy is not an aseptic operation; (2) before surgery, the patient received long-term treatment in the intensive care unit, underwent tracheotomy, and developed pneumonia; and (3) CSF exudation occurred during the operation. Among them, CSF leakage was the primary cause, which was related to scar tissue adhesions around the atlantoaxial joint caused by the significant delay in the patient's surgical timing after trauma. Fortunately, *K. pneumoniae* detected in the patient's CSF was not antibiotic-resistant, and the infection was finally cured after antibiotic treatment combined with paraventriculostomy and lumbar cistern drainage. MRI follow-up at 3 months after surgery showed that the CSF signal between the anterior arch of atlas and the epistropheus had disappeared and that an arachnoid cyst was lying posterior to the cervical cord at level C1–2 but with no corresponding clinical symptoms. It was considered that infection caused the arachnoid adhesion, leading to the formation of local cysts. At the 12-month follow-up, MRI showed no significant difference in the size of the dorsal spinal cyst and also no significant change in the morphology of the spinal cord

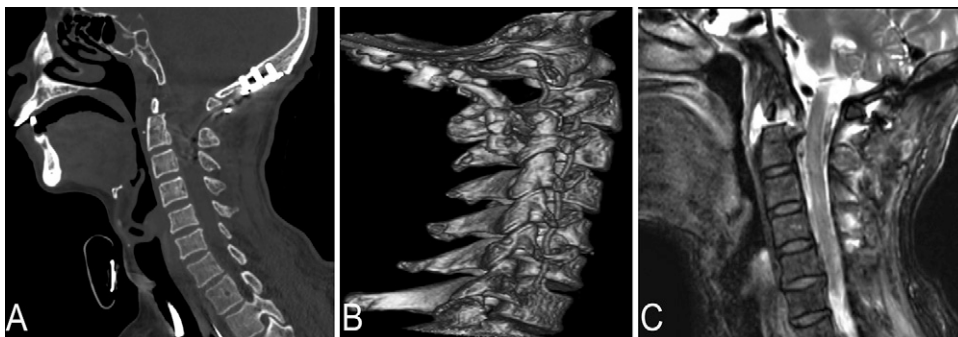


FIG. 3. Acceptable alignment of the atlantoaxial junction was shown on the postoperative sagittal CT reconstruction (A). Compared with preoperatively, the course of the right vertebral artery had returned to normal according to three-dimensional CT angiography (B). MRI after the operation confirmed that spinal cord compression was relieved (C).

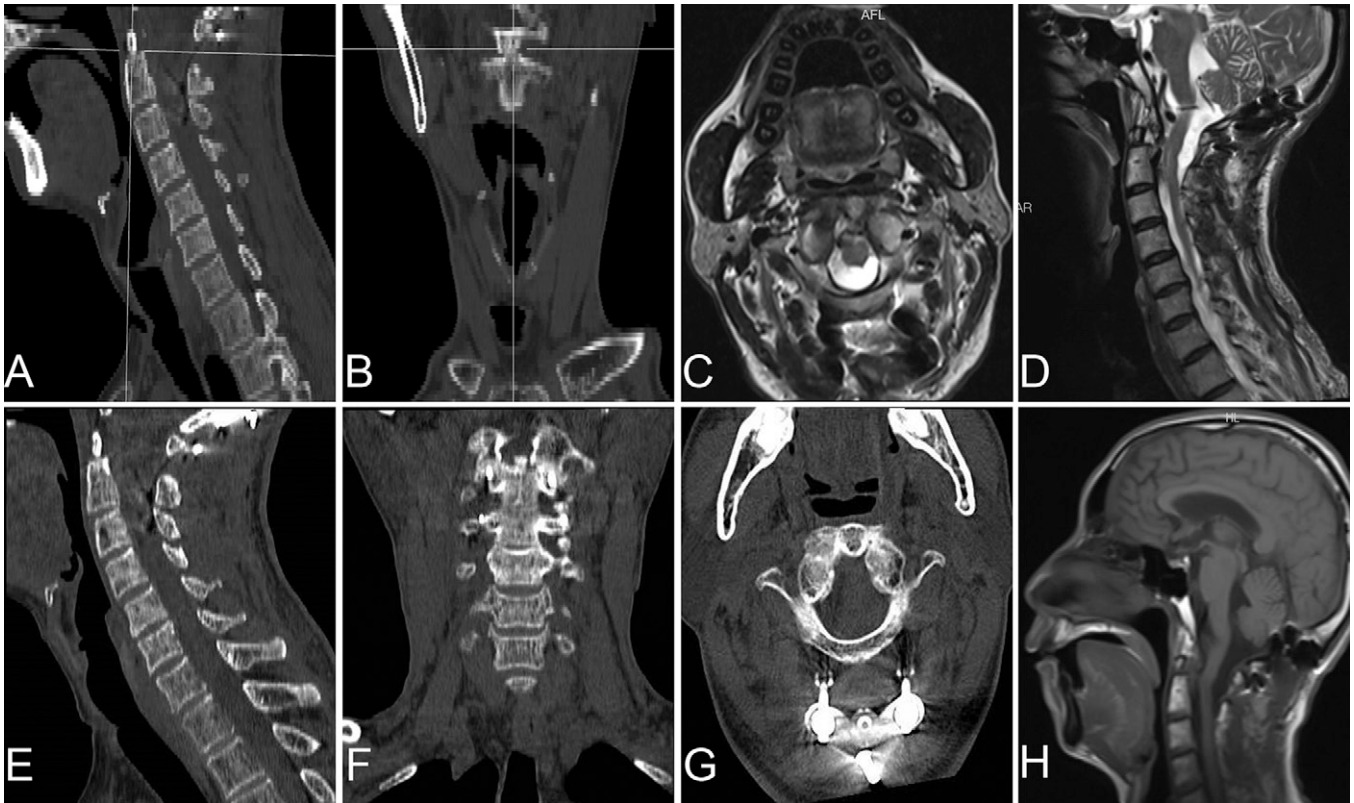


FIG. 4. At the 3-month follow-up, CT revealed bony fusion between the lateral joints of C1–2 and between the root of the resected odontoid process and the anterior arch of C1 (**A and B**). MRI showed an arachnoid cyst lying posterior to the cervical cord at the level of C1–2 (**C and D**). At the 12-month follow-up, CT showed more solid bony fusion than at 3 months (**E–G**). MRI showed that the size of the cyst had no significant changes compared with the previous scan (**H**).

itself compared with that at 3 months. Most important, the patient did not complain of special discomfort during follow-up. Therefore, no further treatment of the cyst was performed.

Lessons

Posterior dislocation without any associated fracture of the odontoid is a rare medical circumstance. Once the patient's circulation is stable, closed reduction should be performed as soon as possible. If anatomical reduction is not achieved by closed reduction, open reduction and fusion should be considered. We report that transoral odontoidectomy and posterior occipitocervical fusion were feasible and effective to restore local stability, but a personalized strategy should be considered. In addition, much effort should be made to prevent CSF leakage, infection, and other postoperative complications.

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References

- Haralson RH 3rd, Boyd HB. Posterior dislocation of the atlas on the axis without fracture. Report of a case. *J Bone Joint Surg Am.* 1969;51(3):561–566.
- Patzakis MJ, Knopf A, Elfering M, Hoffer M, Harvey JP Jr. Posterior dislocation of the atlas on the axis; a case report. *J Bone Joint Surg Am.* 1974;56(6):1260–1262.
- Sassard WR, Heinig CF, Pitts WR. Posterior atlanto-axial dislocation without fracture. Case report with successful conservative treatment. *J Bone Joint Surg Am.* 1974;56(3):625–628.
- Fox JL, Jerez A. An unusual atlanto-axial dislocation. Case report. *J Neurosurg.* 1977;47(1):115–118.
- Jamshidi S, Dennis MW, Azzam C, Karim N. Traumatic posterior atlantoaxial dislocation without neurological deficit: case report. *Neurosurgery.* 1983;12(2):211–213.
- Wong DA, Mack RP, Craigmile TK. Traumatic atlantoaxial dislocation without fracture of the odontoid. *Spine (Phila Pa 1976).* 1991; 16(5):587–589.
- Sud S, Chaturvedi S, Buxi TB, Singh S. Posterior atlantoaxial dislocation without associated fracture. *Skeletal Radiol.* 2002;31(9): 529–531.
- Neumann U, Urbanski H, Riedel K. Posterior atlantoaxial dislocation without fracture of the odontoid. A case report. *J Bone Joint Surg Am.* 2003;85(7):1343–1346.
- Yoon DH, Yang KH, Kim KN, Oh SH. Posterior atlantoaxial dislocation without fracture. Case report. *J Neurosurg.* 2003;98(1)(suppl):73–76.
- Chaudhary R, Chaudhary K, Metkar U, Rathod A, Raut A, Sanghvi D. Posterior atlantoaxial dislocation without odontoid fracture. *Skeletal Radiol.* 2008;37(4):361–366.
- Amirjamshidi A, Abbassioun K, Khazenifar M, Esmailijah A. Traumatic rotary posterior dislocation of the atlas on the axis without fracture. Report of a case and review of literature. *Surg Neurol.* 2009;71(1): 92–98.
- Jiang LS, Shen L, Wang W, Wu H, Dai LY. Posterior atlantoaxial dislocation without fracture and neurologic deficit: a case report and the review of literature. *Eur Spine J.* 2010;19(suppl 2):S118–S123.

TABLE 1. Summary of published cases involving posterior atlantoaxial dislocation without fracture of the odontoid process

Case No.	Authors & Year	Country	Sex	Age (yrs)	Injury	LOC	ND	NDR	Reduction	TAT	Instrumented Fusion	FU
1	Haralson & Boyd, 1969 ¹	United States	M	30	TA	Yes	Yes	Yes	Closed	8 days	Pst cervical wiring	1 yr
2	Sassard et al., 1974 ³	United States	F	20	TA	Yes	Yes	Yes	Closed	9 days	No	10 yrs
3	Patzakis et al., 1974 ²	United States	M	37	TA	UK	None	Needless	Closed	UK	No	3 yrs
4	Fox & Jerez, 1977 ⁴	Nicaragua	M	65	TA	Yes	Yes	Yes	Open	4 days	Transoral odontoidectomy anterior atlas arch resection & pst cervical wiring	UK
5	Jamshidi et al., 1983 ⁵	United States	M	22	TA	No	None	Needless	Closed	2 days	Pst cervical wiring	UK
6	Wong et al., 1991 ⁶	United States	M	23	TA	Yes	Yes	Yes	Closed	<24 hrs	Pst cervical wiring	7 yrs
7	Sud et al., 2002 ⁷	India	M	38	TA	No	Yes	Yes	Open	UK	Partial odontoidectomy & pst screw fixation	3 mos
8	Yoon et al., 2003 ⁸	Korea	M	64	TA	Yes	Yes	Yes	Closed	6 days	Atlantoaxial transarticular screw fixation & interspinous wiring	6 mos
9	Neumann et al., 2003 ⁹	Germany	M	22	TA	Yes	None	Needless	Closed	UK	No	2 yrs
10	Zhou et al., 2003 ³⁴	China	M	26	TA	Yes	Yes	Yes	Open	47 days	Transoral odontoidectomy & pst screw fixation	4 mos
11	Chaudhary et al., 2008 ¹⁰	India	F	35	Falling	UK	Yes	Yes	Closed	UK	No	6 mos
12	Amirjamshidi et al., 2009 ¹¹	Iran	M	31	TA	Yes	Yes	Yes	Open	30 days	Transoral odontoidectomy but pst screw fixation failed	6 mos
13	Huang et al., 2009 ³⁵	China	M	30	TA	Yes	None	Needless	Closed	2 hrs	No	2 yrs
14	Jiang et al., 2010 ¹²	China	M	48	TA	Yes	None	Needless	Open	1 day	Transoral odontoidectomy & anterior transarticular screw fixation	21 mos
15	Zhen et al., 2011 ¹³	China	M	44	EQ	Yes	None	Needless	Open	11 days	Transoral partial odontoidectomy & pst cervical wiring	UK
16	Kambali et al., 2013 ¹⁴	India	M	32	TA	No	None	Needless	Closed	UK	Posterolateral pedicle screw fixation w/ fusion	9 mos
17	Hu et al., 2015 ¹⁵	China	M	50	TA	Yes	None	Needless	Open	9 hrs	Transoral odontoidectomy & pst pedicle screw fixation	15 mos

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Case No.	Authors & Year	Country	Sex	Age (yrs)	Injury	LOC	ND	NDR	Reduction	TAT	Instrumented Fusion	FU
18	Yu et al., 2015 ¹⁷	China	M	43	Falling	Yes	Yes	Yes	Open	24 days	Partial odontoidectomy transarticular lag screws fixation & pst pedicle screw fixation	20 mos
19	Xu et al., 2015 ¹⁶	China	M	54	TA	Yes	Yes	Yes	Open	4 days	Endoscope-assisted transcranial approach partial odontoidectomy & pst pedicle screw fixation	1 yr
20	Song et al., 2017 ¹⁸	China	M	58	TA	Yes	Yes	Yes	Closed	3 days	Pst pedicle screw fixation	10 mos
21	Ning et al., 2018 ¹⁹	China	M	52	TA	No	None	Needless	Open	2 days	Transoral odontoidectomy & pst pedicle screw fixation	6 mos
22	Peterson et al., 2020 ²⁰	United States	M	39	TA	UK	Yes	Yes	Closed	<1 day	Occipitocervical fusion	UK
23	Sun et al., 2021 ²¹	China	F	45	TA	Yes	Yes	Incomplete	Closed	3 hrs	Pst pedicle screw fixation	1 yr
24	Li et al., 2022 ²²	China	F	54	TA	Yes	Yes	Yes	Closed	1 day	Pst pedicle screw fixation	2 yrs

EQ = earthquake; FU = follow-up; LOC = loss of consciousness; ND = neurologic deficit; NDR = neurologic deficit recovery; pst = posterior; TA = traffic accident; TAT = time after trauma; UK = unknown.

13. Zhen P, Lan X, Yang LW. Traumatic posterior atlantoaxial dislocation without associated fracture and neurological deficit. *Arch Orthop Trauma Surg.* 2011;131(5):681–685.
14. Kambali M, Anand HV, Priyamargavi H, Varma RB. Traumatic posterior atlantoaxial dislocation without related fractures of C1-C2. *Indian J Orthop.* 2013;47(6):624–629. Retracted in: *Indian J Orthop.* 2014;48(3):246.
15. Hu D, Yang X, Wang J. Traumatic posterior atlantoaxial dislocation without fracture of odontoid process: a case report and systematic analysis of 19 cases. *J Orthop Trauma.* 2015;29(9):e342–e345.
16. Xu Y, Li F, Guan H, Xiong W. Traumatic posterior atlantoaxial dislocation without associated fracture but with neurological deficit: a case report and literature review. *Medicine (Baltimore).* 2015; 94(43):e1768.
17. Yu HM, Malhotra K, Butler JS, et al. Anterior and posterior fixation for delayed treatment of posterior atlantoaxial dislocation without fracture. *BMJ Case Rep.* 2015;2015:bcr2015212436.
18. Song R, Fan D, Wu H, et al. Management of unusual atlantoaxial dislocation. *Spine (Phila Pa 1976).* 2017;42(8):573–577.
19. Ning S, Yang S, Ding W, Ma T, Wu Z. Posterior atlantoaxial dislocation without fracture or neurological symptoms treated by transoral-posterior approach surgery: a case report and literature review. *Eur Spine J.* 2019;28(suppl 2):37–40.
20. Peterson R, Burkhardt E, Sin A. Traumatic atlantoaxial dislocation without neurologic deficit. *World Neurosurg.* 2020;140:188–190.
21. Sun YH, Wang L, Ren JT, Wang SX, Jiao ZD, Fang J. Early reoccurrence of traumatic posterior atlantoaxial dislocation without fracture: a case report. *World J Clin Cases.* 2021;9(6):1461–1468.
22. Li C, Li L, Li Z, Mei Y, Huang S. Surgical management for posterior atlantoaxial dislocation without fracture and atlantoaxial dynamic test to confirm the integrity of the transverse ligament: a case report. *Orthop Surg.* 2022;14(2):451–455.
23. Meng C, Yang S, Wang P. Research on biomechanics properties of occipito-atlantoaxial complex by finite element method. Article in Chinese. *Sheng Wu Yi Xue Gong Cheng Xue Za Zhi.* 2010;27(5): 1173–1177.
24. Bogduk N, Mercer S. Biomechanics of the cervical spine. I: Normal kinematics. *Clin Biomech (Bristol, Avon).* 2000;15(9):633–648.
25. Jain VK. Atlantoaxial dislocation. *Neurol India.* 2012;60(1):9–17.
26. Lopez AJ, Scheer JK, Leibl KE, Smith ZA, Dlouhy BJ, Dahdaleh NS. Anatomy and biomechanics of the craniovertebral junction. *Neurosurg Focus.* 2015;38(4):E2.
27. Steinmetz MP, Mroz TE, Benzel EC. Craniovertebral junction: biomechanical considerations. *Neurosurgery.* 2010;66(3 suppl): 7–12.
28. Carroll EA, Gordon B, Sweeney CA, Joy S, Connolly PJ. Traumatic atlantoaxial distraction injury: a case report. *Spine (Phila Pa 1976).* 2001;26(4):454–457.
29. Dickman CA, Mamourian A, Sonntag VK, Drayer BP. Magnetic resonance imaging of the transverse atlantal ligament for the evaluation of atlantoaxial instability. *J Neurosurg.* 1991;75(2): 221–227.
30. Menendez JA, Wright NM. Techniques of posterior C1-C2 stabilization. *Neurosurgery.* 2007;60(1 Suppl 1):S103–S111.
31. Lapsiwala SB, Anderson PA, Oza A, Resnick DK. Biomechanical comparison of four C1 to C2 rigid fixative techniques: anterior transarticular, posterior transarticular, C1 to C2 pedicle, and C1 to C2 intralaminar screws. *Neurosurgery.* 2006;58(3): 516–521.
32. Li W, Wang B, Feng X, Hua W, Yang C. Preoperative management and postoperative complications associated with transoral decompression for the upper cervical spine. *BMC Musculoskelet Disord.* 2022;23(1):128.
33. Amelot A, Terrier LM, Lot G. Craniovertebral junction transoral approach: predictive factors of complications. *World Neurosurg.* 2018;110:568–574.
34. Zhou HT, Wang C, Yan M, Dang GT. Traumatic posterior dislocation of atlas with intact odontoid process: a case report and literature review. *Chinese Journal of Spine and Spinal Cord.* 2003;13(12): 757–758.
35. Huang S, Hou TS, Zhao X, He SS. A case of traumatic atlantoaxial posterior dislocation without odontoid fracture. *Chinese Journal of Trauma.* 2009;25(7):605.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Cheng, Liu, Miao, Su. Acquisition of data: Cheng, Liu, Miao, Su. Analysis and interpretation of data: Cheng, Liu, Miao, Su. Drafting the article: Cheng, Liu, Li. Critically revising the article: Cheng, Li. Reviewed submitted version of manuscript: Cheng. Approved the final version of the manuscript on behalf of all authors: Cheng. Statistical analysis: Cheng, Liu, Su. Administrative/technical/material support: Cheng. Study supervision: Cheng.

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