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 tibial 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.

KEYWORDS atlantoaxial dislocation; open reduction; transoral odontoidectomy; posterior occipitocervical fusion; cerebrospinal fluid leakage; infection
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. Traumatic posterior atlantoaxial dislocation is always caused by odontoid fracture or atlantoaxial ligament ruptures. Dislocation without fracture is rare. Such an impact would tend to cause severe distraction of the cord, resulting in immediate death. Thus, it might well be missed in a routine postmortem examination, 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.

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. described three phases of closed reduction, including dispersion, rearrangement, and...
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. A case of redislocation after closed reduction was reported in Sun et al.’s study, where 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. Anterior transarticular screw and posterior pedicle screw fixation also provided sufficient local stability. 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. 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.
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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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).
| Case No. | Authors & Year | Country | Sex | Age (yrs) | Injury | LOC | ND | NDR | Reduction | TAT | Instrumented Fusion | FU |
|----------|----------------|---------|-----|-----------|--------|-----|-----|-----|------------|-----|---------------------|----|
| 1        | Haralson & Boyd, 1969<sup>1</sup> | United States | M   | 30        | TA     | Yes | Yes | Yes | Closed     | 8 days | Pst cervical wiring | 1 yr |
| 2        | Sassard et al., 1974<sup>2</sup> | United States | F   | 20        | TA     | Yes | Yes | Yes | Closed     | 9 days | No                  | 10 yrs |
| 3        | Patzakis et al., 1974<sup>3</sup> | United States | M   | 37        | TA     | UK  | None | Needless | Closed | UK            | 3 yrs |
| 4        | Fox & Jerez, 1977<sup>4</sup> | 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<sup>5</sup> | United States | M   | 22        | TA     | No  | None | Needless | Closed | 2 days | Pst cervical wiring | UK |
| 6        | Wong et al., 1991<sup>6</sup> | United States | M   | 23        | TA     | Yes | Yes | Yes | Closed     | <24 hrs | Pst cervical wiring | 7 yrs |
| 7        | Sud et al., 2002<sup>7</sup> | India | M   | 38        | TA     | No  | Yes | Yes | Open | UK | Partial odontoidectomy & pst screw fixation | 3 mos |
| 8        | Yoon et al., 2003<sup>8</sup> | Korea | M   | 64        | TA     | Yes | Yes | Yes | Closed | 6 days | Atlantoaxial transarticular screw fixation & interspinous wiring | 6 mos |
| 9        | Neumann et al., 2003<sup>9</sup> | Germany | M   | 22        | TA     | Yes | None | Needless | Closed | UK | No                  | 2 yrs |
| 10       | Zhou et al., 2003<sup>10</sup> | China | M   | 26        | TA     | Yes | Yes | Yes | Open | 47 days | Transoral odontoidectomy & pst screw fixation | 4 mos |
| 11       | Chaudhary et al., 2008<sup>11</sup> | India | F   | 35        | Falling | UK  | Yes | Yes | Closed | UK | No                  | 6 mos |
| 12       | Amirjamshidi et al., 2009<sup>12</sup> | Iran | M   | 31        | TA     | Yes | Yes | Yes | Open | 30 days | Transoral odontoidectomy but pst screw fixation failed | 6 mos |
| 13       | Huang et al., 2009<sup>13</sup> | China | M   | 30        | TA     | Yes | None | Needless | Closed | 2 hrs | No                  | 2 yrs |
| 14       | Jiang et al., 2010<sup>14</sup> | China | M   | 48        | TA     | Yes | None | Needless | Open | 1 day | Transoral odontoidectomy & anterior transarticular screw fixation | 21 mos |
| 15       | Zhen et al., 2011<sup>15</sup> | China | M   | 44        | EQ    | Yes | None | Needless | Open | 11 days | Transoral partial odontoidectomy & pst cervical wiring | UK |
| 16       | Kambali et al., 2013<sup>16</sup> | India | M   | 32        | TA     | No  | None | Needless | Closed | UK | Posterolateral pedicle screw fixation w/ fusion | 9 mos |
| 17       | Hu et al., 2015<sup>17</sup> | China | M   | 50        | TA     | Yes | None | Needless | Open | 9 hrs | Transoral odontoidectomy & pst pedicle screw fixation | 15 mos |

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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 |
|----------|----------------|---------|-----|-----------|--------|-----|----|-----|------------|-----|---------------------|----|
| 18       | Yu et al., 2015 | 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 | China   | M   | 54        | TA     | Yes | Yes | Yes | Open       | 4 days  | Endoscope-assisted transcervical approach partial odontoidectomy & pst pedicle screw fixation | 1 yr  |
| 20       | Song et al., 2017| China   | M   | 58        | TA     | Yes | Yes | Yes | Closed     | 3 days  | Pst pedicle screw fixation | 10 mos |
| 21       | Ning et al., 2018 | China   | M   | 52        | TA     | No  | None | Needless | Open     | 2 days  | Transoral odontoidectomy & pst pedicle screw fixation | 6 mos |
| 22       | Peterson et al., 2020 | United States | M   | 39        | TA     | UK  | Yes | Yes | Closed     | <1 day  | Occipitocervical fusion | UK |
| 23       | Sun et al., 2021 | China   | F   | 45        | TA     | Yes | Yes | Incomplete | Closed   | 3 hrs  | Pst pedicle screw fixation | 1 yr  |
| 24       | Li et al., 2022 | 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.
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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, Miao, Su. Critical revision of the article: Cheng, Liu, Miao, Su. Final approval of the article: Cheng, Liu, Miao, Su. Administrative/technical/material support: Cheng. Study supervision: Cheng.

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