Surgical management of a combined fracture of the odontoid process with an atlas posterior arch disruption: A review of four cases


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Summary Four cases of operated odontoid process fractures associated with a fracture of the posterior arch of the atlas are presented. Three types of surgery were performed: atlas–axis fusion, occipitocervical fusion, and odontoid process screw fixation. Based on a literature review and our experience, the therapeutic management is discussed according to the type of odontoid fracture and the presence of neurological involvement, with a reminder that wiring is not indicated when C1 posterior arch continuity is compromised.

Introduction

Associated atlas and axis fractures account for nearly 3% of cervical spine lesions and 12% of upper cervical spine fractures [1]. Frequently associated with neurological impairment, sometimes fatal, this association is reputed to be the source of diagnostic and above all therapeutic problems. In particular, although orthopaedic treatment has long been recommended, today it seems that surgical treatment is often proposed, with no consensus clearly established concerning the technique to use. We have conducted a retrospective study on a series of four patients presenting C1-C2 fractures that were treated surgically: with this experience and a review of the literature, this study aimed to underscore the management issues concerning these lesions, notably relating to the type of surgery that should be proposed to the patient.

Observations

Case No. 1

Patient No. 1, 83 years old, was found in cardiorespiratory arrest requiring resuscitation after falling out of bed (Table 1) (Fig. 1). After sedation had subsided, the exam revealed incomplete tetraparesis predominating in both upper limbs. X-ray and cervical CT demonstrated a type II odontoid fracture according to Anderson and D’Alonzo [2], backward sloping according to Roy-Camille et al. [3], with posterior displacement associated with a fracture of both C1 arches. A cranial halo device was put in place...
with bed traction to reduce posterior displacement. The patient remained intubated with no neurological improvement and rapidly presented decubitus complications. To simplify nursing care, the patient underwent occipitocervical arthrodesis surgery using Roy-Camille plates followed by immobilization with a neck collar. The patient showed no neurological improvement and died 4 months after the surgery.

**Case No. 2**

Patient No. 2, 20 years old, presented cervical spine injury with no neurological impairment resulting from a traffic accident (Fig. 2). X-rays showed a type II forward sloping odontoid fracture with anterior displacement associated with a fracture of the posterior C1 arch. Surgery was performed on the ninth day after injury with C1-C2 arthrodesis with posterior transarticular screws followed by immobilization with a cervical collar for 6 weeks. Postoperative monitoring remained simple. At the last follow-up visit, the fracture was consolidated but showed nonunion: a broken screw flush with the C1-C2 joint, preserving cervical rotational function with no pain or sequelae.

**Case No. 3**

Patient No. 3, a 68-year-old female, suffered a bicycle accident resulting in several fractures: fracture of the 11th left rib with pulmonary contusion, fracture of the seventh thoracic vertebra, fracture of the posterior C1 arch with no displacement, and type II backward

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**Table 1** Summary of the four observations.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (years)</th>
<th>Circumstances of the accident</th>
<th>Type of lesion</th>
<th>Intervention</th>
<th>Follow-up (months)</th>
<th>Consolidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>83</td>
<td>Fall from bed</td>
<td>Type II odontoid fracture, backward sloping fracture of two C1 arcs</td>
<td>Occipitocervical arthrodesis</td>
<td>Death at 4 months</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>Traffic accident</td>
<td>Type II odontoid fracture, forward sloping posterior fracture of C1 arc</td>
<td>C1-C2 posterior transarticular screws</td>
<td>18</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>68</td>
<td>Fall from bicycle</td>
<td>Type II odontoid fracture, backward sloping fracture of posterior C1 arc</td>
<td>Odontoid anterior screws</td>
<td>18</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>87</td>
<td>Fall from bicycle</td>
<td>Type II horizontal odontoid fracture, posterior displacement of the posterior arch of C1</td>
<td>C1-C2 posterior transarticular screws</td>
<td>Death at 2 months</td>
<td></td>
</tr>
</tbody>
</table>

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**Figure 1**  
A. C1 and type II odontoid fracture, reduction with a halo device. B. CT scan: Jefferson fracture (posterior and anterior arch). C. Occipitocervical arthrodesis.
Figure 2  A. CT scan: atlas posterior arch fracture and odontoid fracture. B. Type II odontoid fracture with anterior displacement. C. Posterior C1-C2 transarticular screw fixation.

Case No. 4

Patient No. 4, 87 years of age, presented cranial injury with incomplete tetraplegia predominating in the upper limbs caused by a bicycle accident (Fig. 4). X-rays showed a type II horizontal odontoid fracture [3] with posterior displacement of the posterior arch of C1. A cranial halo traction device was placed, which reduced the displacement, but recovery of neurological function was incomplete, with persistence of brachial diplegia. The patient was intubated for respiratory insufficiency secondary to retropharyngeal hematoma, then underwent surgery on the fourth day: C1-C2 arthrodesis with posterior transarticular screw fixation followed by

Figure 3  A. Type II odontoid fracture and C1 posterior arch fracture, no displacement. B. Loss of fracture alignment with posterior displacement. C. Anterior surgical approach fracture stabilization with a screw: lateral view at 1 year. D. Anterior screw fixation: anteroposterior view at 1 year.
immobilization with a cervical collar. An anterior screw fixation, undoubtedly better adapted, could not be achieved because of the patient’s anatomy: a short neck and a prominent thorax. There was clear neurological improvement, but left upper limb monoplegia persisted with deglutition problems and repeated pulmonary aspiration. The patient died suddenly 2 months after surgery probably from asphyxia due to pulmonary aspiration.

Discussion

The association of atlas and axis fractures accounts for 3% of acute cervical spine lesions and 12% of upper cervical spine lesions [1], 43% of atlas fractures and 16% of axis fractures [4]. They most often involve older subjects with commonplace injuries and are more frequently associated with neurological impairment with possible fatal progression than with isolated C1 or C2 fractures: 80 to 85% mortality at 1.5 months for Fowler et al. [5] and Hanssen and Cabanela [6]. According to Dickman et al. [7], the most frequent lesion association is an atlas fracture combined with type II odontoid fracture because the mechanism usually involved is spinal hyperextension. This was the case for three of our four patients, one having fractured both atlas arches. Despite its frequency, this lesion association has not been extensively reported, which explains the absence of clear treatment consensus. It has been accepted that atlas fracture treatment should be foremost orthopaedic (cervical collar, halo cast, halo vest [5,8]). Thus, for the majority of authors [4,7,9–12], the odontoid fracture orients the therapeutic strategy.

Orthopaedic treatment is indicated in cases of fracture at the base that has not displaced and is stable [13]. Different treatment modalities have been discussed: rigid immobilization using a cervical collar with occipitofrontal, sternal, and chin support, or traction followed by immobilization using a rigid orthosis that keeps the head in traction such as a halo-type cast [4,7,9–12]. Cranial traction can also be used temporarily in an emergency situation with an odontoid process fracture presenting substantial displacement to align the spinal column and decompress the spinal cord while waiting for surgical treatment.

However, it is now accepted that with a type II Anderson and D’Alonzo [2] fracture of the base of the odontoid, where the risk of nonunion is particularly high, surgical treatment is often indicated, notably with displaced unstable fractures because of the risk of nonunion, or in a patient with neurological complications [14]. Yet, the possibility of a solution retaining the continuity of the posterior C1 arch contraindicates wiring the posterior C1 and C2 arches.

To prevent this pitfall, several techniques can be used, based on the evaluation of the risk of displacement using the Roy-Camille classification [3]:

- with backward sloping or horizontal fractures, anterior screw fixation of the odontoid can be indicated (case No. 2) [4,11]. For Apostolidis et al. [15] and Agrillo and Mastronardi [16], anterior screw fixation of the odontoid fracture can be secured by anterior atlantoaxial arthrodesis using bilateral transarticular screw fixation: this is a triple anterior screw fixation. The low number of cases and the technical difficulties of this technique are underscored by the authors, however;
- in case of a forward sloping fracture, anterior screw fixation is not indicated. Posterior surgery is preferable but without wiring. Posterior transarticular C1-C2 screw fixation (cases No. 3 and 4) can be used [11]. In a young patient, the contribution of a graft is debatable, because once consolidation is achieved, removal of the screws restores a certain atlantoaxial mobility;
- finally, a rescue solution can be used: occipitocervical fixation. This technique has been proposed by several authors [4,9]. It seems to be reserved for patients presenting a rupture of the C1 ring with great C1-C2 instability (C1
separation fracture with transverse ligament rupture and occipitocervical or C1-C2 dislocation) or when there are major neurological complications (case No. 1). This intervention allows the patient to be mobilized and facilitates emergency care.

In our series, we were able to systematically avoid wiring by using techniques governed by the C2 fracture line and its displacement as well as the patient’s condition. Only two patients survived, with the two others probably dying directly from the neurological problems resulting from the accident. In these patients presenting serious neurological complications, or because of the needs of nursing and emergency care, we believe that a solid occipitocervical fixation should be rapidly indicated, with or without grafting, which has the advantage of obviating the need for external immobilization. Otherwise, orthopaedic treatment should be indicated for a stable C2 fracture that has not displaced and has not shown neurological problems. If the fracture has displaced, the orientation of the C2 fracture line, as described by Roy-Camille [3], will orient the choice of anterior or posterior surgery, with or without a halo device beforehand. Knowledge of the practice of the different types of C1-C2 and C2 screw fixations is indispensable.

**Conclusion**

Associated atlas–axis fractures are frequent (12% of upper cervical spine fractures), particularly in the elderly subject. The incidence of neurological problems is higher in these associated fractures than in isolated fractures. The association of C1 posterior arch and type II odontoid fracture seems to be the most frequent. In the majority of cases, the odontoid process fracture of the axis determines the management strategy. As for isolated atlas and axis fractures, the association of C1 and C2 fractures can be successfully treated with external immobilization alone provided that the odontoid fracture is stable and has displaced only slightly. If surgery is indicated, the solution for atlas ring continuity contraindicates wiring and therefore the surgeon can choose among three solutions: C1-C2 arthrodesis with transarticular screw fixation, anterior screw fixation of C2 or occipitocervical fixation.

**References**