



Surgical treatment of odontoid fractures with C1 hook and C2 pedicle screw construct

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A number of approaches have been attempted to address the treatment of acute odontoid fractures, spanning from conservative treatment with an external orthotic device to posterior C1-C2 arthrodesis or anterior screw fixation. The current report describes stabilisation of such fractures with a C1 supralaminar hook and a C2 pars interarticularis screw construct. Two patients with odontoid fracture were treated by this technique. Two-year follow-up of both patients revealed complete union without complications. The authors stress that this technique avoids the hazards of C1 lateral mass screws.

Keywords : acute odontoid fractures ; posterior stabilisation ; C1 hook ; C2 screw construct.

INTRODUCTION

Odontoid fractures account for 9% to 15% of all cervical spine fractures in the adult population (24,34,35). These injuries usually result from low-energy impacts, such as falls, in the elderly, or high-energy impacts, such as motor vehicle accidents, in the young and middle aged (18,27,30). Moreover, odontoid fractures are the most common individual cervical spine fractures for persons older than 70 years and are the most common of all spinal fractures for persons aged > 80 years, with evidence of increasing incidence in this population (32). There are equal male-to-female distributions in both older populations. Type II fractures,

according to the classification of Anderson and D'Alonzo (1), form the majority ; type I and III fractures are less common (3).

The C1-C2 segment is responsible for the greater part of the cervical rotation (36). It is well documented that this area is unique from a biomechanical standpoint and that it is inherently predisposed to trauma (6). The treatment of such injuries requires a thorough knowledge of the regional anatomy and mastery of the available surgical stabilising techniques (6).

In a key article in 1974, Anderson and D'Alonzo (1) proposed a classification system that distinguishes three different types of fractures with distinct rates of healing. Type I fractures are through the upper portion of the odontoid process

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and are thought to occur by avulsion of the apical and/or alar ligaments. Type II fractures occur at the base of the odontoid, between the level of the transverse ligament and the C2 vertebral body. Type III fractures extend into the vertebral body. It is widely accepted that type II and type III odontoid fractures represent highly unstable entities (6).

The mechanism responsible for odontoid fractures is generally agreed to be hyperextension or hyperflexion of the cervical spine. The frequency of associated neurological injury is variable among multiple studies, ranging from 2% to 27% (7,11,19,26,33). However, when present, it is usually catastrophic or fatal because of its high level.

A number of approaches have been attempted to address this potentially disabling injury, spanning from conservative treatment with an external orthotic device, to posterior C1-C2 arthrodesis or anterior screw fixation (6,12). Among the surgical techniques, C1-C2 posterior wiring and fusion, C1-C2 posterior transarticular screws, C1 lateral mass and C2 pedicle screws, posterior clamping techniques, and anterior screw fixation have achieved higher fusion rates than conservative treatment (6,12).

The current report describes a new surgical technique for the stabilisation of odontoid fractures in which the stabilisation is provided by a C1 supralaminar hook and a C2 pedicle screw construct.

CASE 1

A 28-year-old man was admitted after a high-speed motor vehicle accident. The patient was agitated and combative with associated maxillofacial trauma, rib fractures, pulmonary contusions, and bilateral haemopneumothorax. He complained of neck pain. The cervical range of motion was limited, but neurological symptoms were absent.

Plain radiographs of the cervical spine (fig 1) and a CT-scan of the cervical spine showed a type II odontoid fracture as described by Anderson and D'Alonzo (1), with posterior displacement. The patient was kept in a rigid collar, and placed on a kinematic bed to avoid unnecessary logrolling and handling of the neck, because maxillofacial, chest



Fig. 1. — Case 1 : 28-year-old man injured in a high-speed motor vehicle accident. Plain radiograph, lateral view, showing the odontoid fracture type II.

and pulmonary injuries precluded the use of a halo-vest for preoperative stabilisation.

Once the patient was stable from a cardiopulmonary point of view, an MRI-scan of the cervical spine was obtained, which clearly demonstrated a highly unstable injury of C2, associated with ligamentous disruption.

The patient's general condition did not allow surgery during the first 6 weeks after the accident. After that period a C1-C2 fusion, using a C1 supralaminar hook and a C2 pedicle screw-rod construct, was performed. The patient was positioned prone with the neck flexed and the head in a Mayfield three-point fixation device. Lateral intraoperative fluoroscopy was used to realign the odontoid process. An incision was made that extended from theinion down to the spinous process C7. The posterior arch of C1 was freed subperiosteally, approximately 1-1.5 cm lateral to the midline, so as to avoid the vertebral artery. Subsequently, the pars interarticularis of C2, as well as the C1-C2 facets, were exposed. Both the lateral and medial aspects of the facets were identified. First 3.5-mm titanium



Fig. 2. — Case 1 : (a) Plain radiograph, AP view, two years after surgery ; (b) Plain radiograph, lateral view, two years after surgery.

cortical screws were inserted into the C2 pedicles. Subsequently, supralaminar hooks were anchored on C1. Finally, two rods connected the hooks and the screws. The laminae and the spinous processes C1 and C2 were then decorticated. Autogenous spongy bone grafts were applied.

Postoperatively, the patient remained neurologically intact. He was discharged 3 days later. At that time he was independently ambulatory. He wore a Philadelphia collar for 3 months. At follow-up, two years later, plain radiographs (fig 2) and a CT-scan showed union of the fracture and complete fusion. The patient remained independent and free of complications ever since.

CASE 2

A 65-year-old woman was seen after a motor vehicle accident. Physical examination showed tenderness in the upper cervical area. The patient was reluctant to move the neck in any direction but was neurologically intact.

Plain radiographs and a CT-scan of the cervical spine showed a type III odontoid fracture with

anterior displacement. The patient was operated upon immediately. The same technique was used. Alignment of the odontoid was achieved with appropriate manipulation of the neck under fluoroscopic guidance.

The postoperative care was the same as explained in Case 1. At follow-up, two years later, plain radiographs and a CT-scan showed union of the fracture and complete fusion. The patient remained independent and free of complications.

DISCUSSION

Fractures of the axis represent a unique set of cervical injuries, owing to the peculiar anatomy and biomechanics of this vertebra and the stresses applied to the atlantoaxial complex during trauma. Fractures of the axis may be divided into three subtypes : fractures of the odontoid process, traumatic spondylolisthesis of the axis (hangman's fracture), and vertical C2 body fractures.

The commonest injury of the axis is a fracture of the odontoid process, representing 7% to 17% of all cervical fractures (20). Motion at the C1-C2 level

is primarily rotational, accounting for 50% of the axial rotation of the head on the neck (37). The atlantoaxial complex is one of the most common sites of dislocation in fatal cervical spinal cord injuries (8,17,31).

In the workup of an *acute* cervical spine injury, most clinicians recommend anteroposterior, lateral, oblique and open-mouth odontoid radiographs (23,29). In case of an *old* cervical lesion flexion/extension views may be added. Computerised tomography is performed if a high index of suspicion for a fracture exists, a bony injury is identified on plain radiographs, a fracture is suspected or identified on a radiograph, or if the patient has an altered mental status or distraction injury. Sagittal and coronal reformats are important to trace transverse fractures, to fully characterise injuries seen on other sequences, and to assist in surgical planning. An MRI-scan may also be considered if there is a neurological deficit, to evaluate ligamentous injury, or to exclude potential underlying pathology.

A variety of treatment options exist for the treatment of odontoid fractures, ranging from cervical collar immobilisation to advanced internal fixation techniques. Most importantly, medical comorbidities must be considered when developing a treatment plan.

Type I odontoid fractures are rare and are generally treated with collar immobilisation. Most type III odontoid fractures can be treated with collar immobilisation, however, halo-vest immobilisation may also be considered (25). The exception to this treatment are type III fractures associated with anterior displacement, which may require internal fixation to achieve stability and to prevent further displacement as in Case 2 (32). In general, type II odontoid fractures are less stable, and associated with lower union rates than type I and III fractures. External immobilisation with a cervical collar or halo-vest has led to inconsistent results (10,25,38). A number of factors appear to be associated with an increased incidence of nonunion for type II odontoid fractures, including: posterior displacement, displacement of 4-6 mm, 10° of angulation, fracture comminution, fracture malalignment during follow-up, delayed treatment, and patients older

than 40-65 years (3,7,16,17). Hadley *et al* (16), in a recent review of the literature, found a wide variation in success rates for halo immobilisation of type II fractures. The overall fusion rate was 70%, although figures ranged from 0% to 89%. As higher complication rates have also been associated with halo use, especially in older patients (14), surgical intervention should be considered in those patients, if it can be accomplished with an acceptable risk of morbidity and death. Operative treatment may also be considered in any odontoid fracture, when external immobilisation is believed to be insufficient, intolerable, or ineffective, or if other problems are present, such as polytrauma or neurological deficit.

A number of posterior techniques have been described for stabilisation of odontoid fractures. The common goal was to achieve a solid C1-C2 fusion. The primary disadvantages of these techniques are the morbidity associated with posterior cervical approaches and the loss of rotational motion after fusion at this level (2). Gallie (13) described the first posterior C1-C2 wiring technique. Brooks and Jenkins (5) later devised an alternative wiring technique using bilateral sublaminar C1-C2 wires with 2 structural autograft blocks (1 on each side). An alternative method of C1-C2 stabilisation is that of transarticular screws (22). After posterior exposure of the upper cervical spine, screws are placed through the isthmus of C2 and the C1-C2 articulation into the C1 lateral mass. Biomechanically, transarticular screw constructs have a 10-fold increased rotational stiffness and similar lateral bending stiffness as compared with posterior wiring techniques (9,15).

The need for C1-C2 fusion is common to all posterior techniques for odontoid stabilisation. Unfortunately, this requirement eliminates approximately 50% of cervical rotation (2). This disadvantage led to the development of an alternative stabilisation technique for type II odontoid fractures, namely, direct anterior screw fixation (2,4). However, full preservation of C1-C2 motion using this technique has been questioned (21). On the other hand, the anterior approach is less traumatic and does not require bone graft harvesting, thus decreasing postoperative morbidity. This method

can also be considered in case of concomitant C1 ring fractures, assuming that the transverse ligament is intact.

Both patients in this report were treated with C1 supralaminar hooks and C2 pars screws-rods. Cervical laminar hooks were tested *in vitro* by Grob *et al* (15) as early as 1992. Their efficiency was also confirmed by clinical studies. They allow early mobilisation, which is an important consideration, especially in the elderly population, where halo-vests and prolonged bedrest have been associated with significant morbidity. The authors felt that this technique would prevent the hazards of placing C1 lateral mass screws, namely lesions of the vertebral artery and the first cervical root.

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