Case Report: posterior approach with sub-laminar wiring as management of comminuted fracture of the odontoid process of the axis [version 1; peer review: awaiting peer review]

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Abstract
Background: Odontoid fractures (OF) account for 5-18% and 10-19% of all injuries at C2 and in the cervical region, respectively. According to the Anderson and D’Alonzo classification, there are three main types of OF: Type I, II and III. Most cases involving OF of the axis by high impact trauma result in death.
Case presentation: A 21-year-old male patient, with comminuted OF caused by a high impact traffic accident. On admission, the patient reported moderate to severe pain in the posterior craniocervical junction, with significant limitation to lateral rotation of the head and severe cervical muscle spasm. There was evidence of comminuted OF of C2 without apparent displacement in the cervical region. The patient underwent surgery via a posterior approach with double sub-laminar wiring between C1 and C2. The procedure was considered to be completely resolutive with no postoperative complications or sequelae, with total recovery of the patient’s functionality.
Discussion: The posterior approach is a viable option when the anterior approach is not possible due to the nature of the comminuted fracture and risks of complications, even when it involves a degree of compromise in the rotation of the C1-C2 joint. OF is a medical emergency, requiring individualized treatment tailored to the characteristics of the patient. There are currently no standardized treatment guidelines for OF.

Keywords
case report, cervical axis vertebra, odontoid process

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List of abbreviations
C1: first cervical vertebra
C2: second cervical vertebra
OF: odontoid fracture

Background
The odontoid process of the second cervical vertebra is a bony projection arising from the vertebral body of C2. It functions as a fulcrum for the lateral rotation of the ring of C1 or atlas over the body of the axis.1

Traumatic axis injury is a common cervical spine injury, accounting for more than 20% of cervical fractures. The odontoid process of C2 is the main site of axis injury. Odontoid fracture (OF) accounts for 5-18% of C2 injuries, and 10-19% of all fractures in the cervical region.2 Multiple axis fractures account for only 1% of cervical spine fractures.3

The etiology of OF varies according to the patient’s age; in young people, the main cause is high-impact trauma, such as traffic accidents, sports injuries, or falls from great heights. In older people, it is the result of low-impact trauma that usually occurs when slipping and falling on the same plane of support4,5 and pathologies that compromise bone density.6

Hyperflexion of the spine is the most frequent mechanism of injury; it induces anterior displacement of the odontoid process of the axis. Hyperextension causes posterior displacement.7 Lateral flexion movements, compression or rotational forces are also mechanisms that cause OF.8,9

There are no standardized treatment guidelines for OF. Therapeutic options should be individualized to the patient’s characteristics, experience and the surgeon's available resources. Conservative treatment includes external immobilization and use of devices including rigid collar or halo vest immobilization.5,10 Surgical treatment includes anterior fixation/posterior fixation. However, the most efficient treatment strategy is still under debate.11

The traumaticism in the odontoid process of C2 was treated conservatively until 1910, when posterior fixation with wires began to be used as a surgical treatment, a procedure that has evolved since it was first described by Mixter and Osgood.9,12

The aim of this case report was to describe the surgical experience and favorable evolution in the treatment of a young patient with multiple OF of the axis, in which early age of presentation and causative mechanism in most cases are the cause of death. After surgery, the patient had no sequelae, with return to work and full recovery of quality of life.

Clinical presentation
A 21-year-old male patient, from an urban area, with no prior pathological, pyscho-social, or past intervention history of interest, suffered high impact trauma in a motorcycle rollover road accident. He was transferred while unconscious to the emergency department of a private hospital for stabilization. He was later referred to the Hospital Militar del Norte in San Pedro Sula, Honduras, for further specialized treatment.

He was admitted to the emergency room wearing a rigid Philadelphia-type cervical collar and the initial evaluation revealed a Glasgow Coma Scale score of 15, no respiratory distress, and isochoric pupils. Intentional neurological examination showed a motor strength of 5/5 on the Daniels scale in all four extremities, and non-referred neurosensory alterations. Ecchymosis on the head and multiple abrasions on the body were present. On admission, the patient reported moderate to severe pain in the posterior craniocervical junction, with significant limitation to lateral rotation of the head and severe cervical muscle spasm. There were no signs of spinal cord compression. Blood biometry and blood chemistry studies were within normal parameters. Cerebral tomography revealed no abnormalities in encephalic structures, and cervical tomography evidenced comminuted OF of C2 without apparent displacement in the cervical region (Figure 1).

On day four hospitalization, a posterior surgical approach was performed due to comminution of the odontoid process of C2, a determining factor that contraindicated an anterior approach with an odontoid screw. Due to the patient's economic limitations, and lack of medical insurance to cover the costs of a posterior transpedicular screw system and lateral mass screws, we opted for sub-laminar wiring.

The patient was taken to the operating room, placed prone with the head in neutral position, and approached by the midline, exposing occipital bone, C1, C2 and C3. Double sub-laminar wiring was performed between C1 and C2 with 0.7-mm orthopedic cerclage wire. Autologous graft was harvested from the patient's left iliac crest. First, decortication of the C2 laminae and the posterior arch of C1 was performed. Bilateral simple wiring was closed and later, bilateral autologous bone graft wiring was performed (Figures 2, 3).
The patient left the operating room wearing a Philadelphia collar, extubated, with no motor deficit. He was transferred to the intermediate intensive care unit for monitoring. He was prescribed antibiotic coverage for two days and discharged on postoperative day two.

The use of a collar was indicated for three months after the procedure. However, the patient only used it for one week, but there were no complications during recovery. In functional terms, recovery was considered successful despite an approximately 50% decrease in cervical range of motion, which is within the expected range in C1-C2 fusion. Two control appointments were made with cervical tomography at three- and six-months post-operation (Figure 4). The patient made a total recovery without sequelae, with return to work and preserved quality of life.

**Figure 1.** Cervical computed tomography with simple reconstruction. Comminuted fracture of the odontoid process of the second cervical vertebra.

**Figure 2.** Intraoperative photograph showing simple sublaminar wiring with bilateral iliac crest bone graft.
Discussion

Fracture of the second cervical vertebra (C2) is the most common cervical spine injury in the geriatric population, accounting for 69% of cases with 36% in young adults.4,5 Our patient belongs to the minority group of those affected, who usually die as soon as the accident occurs in high-impact trauma or later during stabilization.

Autopsy studies of patients killed in road traffic accidents have revealed that a significant proportion of mortality is attributed to fractures of the cervical region; axis fractures account for approximately 25–71% of fatalities.13 Neurological deficits occur in 8.5% of cases, and 2.4% of mortality is due to neurological deficits. A low percentage of patients with neurological injury are transported to the hospital in time.8 This patient suffered a comminuted fracture at cervical level in

Figure 3. Postoperative cervical X-ray (A) Anteroposterior projection; (B) Lateral projection.

Figure 4. Cervical tomographic control 3 months after the procedure: simple reconstruction in sagittal section showing osteosynthesis material and resolution of more than 90% of the fracture.
a high-impact road accident while riding a motorcycle, with transient loss of consciousness and no neurological deficit, and survived for subsequent stabilization and transfer without motor impairment.

The neurological risk associated with OF of C2 is potentially fatal, due to the proximity to the spinal cord, and the mobility of the atlantoaxial joint, which greatly increases the risk of instability. For these reasons, the associated morbidity and mortality is high.

C2 fractures can be subdivided into odontoid, Hangman’s, and atypical fractures. OF account for approximately one-third of all cervical spine fractures, constituting 18% of cases in the general population and more than 50% in adults over 80 years of age.

Anderson and D’Alonzo (1974) classified the OFs of C2 into three main types: type I, which are oblique fractures in the apical region of the odontoid process; type II occurring at the junction of the odontoid process with the vertebral body; and type III, which are fractures that pass through the vertebral body. Type II OFs are the most frequent. Likewise, Hadley et. al propose an infrequent subtype of fracture: type IIA, which is characterized by comminuted fragments at the base of the vertebral body. The patient suffered a type IIA OF, which is why it is considered a peculiar case in the literature, with an atypical presentation of OF.

According to recommendations of Ryken TC (2013), for the initial management of non-displaced OF type I, type II and type III OF, external cervical immobilization is recommended. In contrast, type II and III fractures with displacement ≥5 mm and commutation of the odontoid require surgical intervention for stabilization and fusion of the lesion.

Surgical intervention is indicated for unstable OFs associated with neurological risk and when non-union ranges are high. Recently, surgical treatment of these fractures has increased, due to faster mobilization, higher fusion rates, potential reduction in mortality, and preservation of C1-C2 joint motion.

There are multiple options for fusion of the C1-C2 joint: screws to the lateral masses of C1, transpedicular screws to C2, and translaminar screws and posterior wires. The primary goal in performing any of the procedures is to align and stabilize the upper cervical spine.

The C1-C2 complex allows 50% of cervical spinal rotation and 10° of flexion-extension and 50° axial rotation. Therefore, fusion of these segments will undoubtedly cause permanent loss of this movement. The anatomy and location of this complex along with the transfer of kinetic energy contribute to a wide variety of fractures. The technique of choice was the posterior approach, which involves the loss of lateral rotation of the atlantoaxial joint. The patient was informed of the potential sequela and agreed to undergo the surgical procedure, judging that the benefits outweigh the surgical risks. The condition of the ligaments is the most important factor in the selection of treatment. The main elements that guide surgical treatment are the involvement of the ligamentous complex at the occipito-cervical junction, in the atlantoaxial complex, and in the complex between the second and third cervical vertebrae. Despite the integrity of the articular ligamentous complex, we decided to intervene surgically because of the instability and potential neurological risk caused by the OF.

The posterior approach consists of achieving stabilization and fusion with wire and bone graft from the iliac crest, which requires that the posterior arch of C1 and C2 are intact. The procedure provides strong bony fixation, with a high healing rate. However, the sacrifice of atlantoaxial rotational function is unavoidable. It is a viable option when the anterior approach is contraindicated in comminuted fracture, unfavorable antero-posterior fracture plane angulation, or rupture of the transverse ligament of C1-C2.

C1-C2 fusion can be performed to stabilize OFs; however, this involves compromising rotational function. Among the techniques of C1-C2 fusion with sub-laminar wire, the Gallie technique is one of the most commonly used, involving the use of a bone graft fixed by means of a sub-laminar wire below the spinous process of C2 and around the arch of C1. When performing the posterior approach, a variant of the technique was used in which the graft was placed over the arch of C1 above the laminae of C2. Unlike Gallie's technique, double bone grafting and bilateral double wiring were used.

Transarticular fixation of C1-C2 with screws was a method introduced by Magerl and Seemann, which provides superior fixation to posterior wiring techniques and a greater range of rotational stiffness. In contrast, transarticular fixation cannot be performed in cases of fixed subluxation of C1 and C2 or where the vertebral artery follows an aberrant trajectory. The technique described by Harms addresses these limitations by inserting bilateral screws into the lateral masses of C1 and pedicles of C2. A limitation of the treatment process was the lack of medical insurance to cover the bilateral screw
system, since it is not a procedure available within the public services of the country, and the patient’s economic condition prevented its application. Therefore, a surgical option that did not incur additional economic costs was used.

**Conclusion**

OF is a medical emergency, due to its proximity to vital structures; it represents a high mortality rate when caused by high-impact mechanisms. The posterior approach is a viable option when the anterior approach is not possible due to the comminuted nature of the fracture and the risks of complications, even though it involves some degree of compromise in the rotation of the C1-C2 joint.

**Consent for publication**

Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

**Data availability**

Patient’s files and datasets used to support the findings of this study are restricted by the ethics committee of the “Universidad Católica de Honduras” to protect the privacy of clinical data. Data are available to investigators who comply the criteria for access to confidential data under request to the ethics committee. Requests for access to these data should be directed to César Alas: cesar_alas10@hotmail.com.

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**References**

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