Case Series

Posterior wiring with sublaminar polyester bands, titanium-peek fixation system for C2 fracture management: a 4-patient case series with a maximum of 18 months' follow-up

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Background: C2 fractures can be classified differently when dens, pedicles or body are injured. With regards to the best management of Type-II Anderson-D'Alonzo fractures, Hangman's fractures of pedicles and C2 body fractures are more debatable. However, vertebral pedicle and/or articular screw and dorsal wiring are the most common surgical posterior approaches opted for. Compared to the screw technique, dorsal wiring provides certain benefits such as a lower risk of vertebral artery injury, no need for navigation, less lateral dissection of the paraspinal muscles, shorter surgery time and lower medical costs.

Case Description: Two patients with failed conservative treatment for Anderson-D'Alonzo Type-III fractures (Cases 1A and 1B), a patient suffering from a Type-II Hangman's fracture (Case 2) and a patient with failed conservative treatment for a C2 transversal body fracture (Case 3) underwent surgery at the Neurosurgery Division of the University Hospital of Modena (Italy) between July 2020 and September 2021. All patients were treated with posterior wiring with 5 mm Polyester bands, titanium-peek fixation system (Jazz-Lock system MediNext®-Implanet) inserted through the C1 posterior arch and either the C2 or C3 laminae. A fracture diastasis reduction was observed ranging between 4.5 and 1 mm. No intraoperative and post-operative complications were encountered. The duration of the period of hospitalisation ranged between 5 and 12 days. All patients who had worked prior to the traumatic event were able to return to work 18 months following surgery.

Conclusions: In reducing C2 fractures, a sublaminar fixation with polyester bands and a titanium-peek fixation system can be proposed for fragile and elderly patients.

Keywords: C2 fractures; posterior wiring; spine fracture consolidation; case series

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Introduction

The cervical spine is a region with maximal mobility, owing to which it has greater chances of being injured.

Fractures of the axis make up approximately 20% of all cervical spine fractures.

C2 fractures can be subdivided into odontoid fractures, Hangman's fractures, and body fractures.

Fractures of the odontoid process are the most common

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type of C2 fracture (representing between 5% and 15% of all cervical spine injuries) and have a biphasic age distribution with peaks both at 20–30 and at 70–80 years of age (1-3). They are commonly grouped into three types according to the Anderson and D'Alonzo classification. Type-I fractures are avulsion fractures of the tip of the dens (0–4% of odontoid fractures); Type-II fractures are located at the junction of the odontoid base with the central body of the axis (60–80%), and Type-III fractures pass through the cranial cancellous body of the axis (20–39%) (4).

C2 fractures have a biphasic appearance: younger patients are more susceptible to high-energy trauma-related injuries, while elderly sustain bone density-related injuries. The common causes of injury in younger subjects are motor vehicle accidents and sports-related injuries (5).

External immobilisation is the treatment of choice for Types-I and III unless a failure of bone fracture consolidation is observed during follow-up. Most debated is the best management for Type-II fractures (6). Non-union after conservative treatment occasionally occurs in Type-III fractures (13% in conservative treatment), and a surgical strategy must be chosen (7). Older age, a greater coronal angle of the C2 dens, and the lateral mass gap were risk factors for non-union in patients with Type-III odontoid fractures treated conservatively (8).

Hangman's fractures are the second most common fracture of the C2 vertebrae, representing about 10% of upper cervical fractures. The Hangman's fracture is a bilateral fracture of the pars interarticularis of the C2 vertebra that causes traumatic spondylolisthesis of C2 (9). Subgroup proportions of Hangman's fractures are in 29–72% Type-I, 28–69% Type-II and 0–10% Type-III classified according to Effendi (10). Hangman's fractures Type-I are a domain of nonsurgical treatment, while for Types-II and III fractures there is a consensus on surgical treatment depending on the degree of displacement (11).

Another type of C2 fracture is the body fracture. C2 body fractures account for approximately 10% of the upper cervical fractures (12). The more common system of classification of axis body fractures is based on the orientation of fracture line and classifies these fractures as coronal (Type-I), sagittal (Type-II), and transverse (Type-III) fractures (13). Surgical management is advocated for a minority of cases and has only been recommended in fractures associated with obvious instability of adjacent joints, irreducible displaced superior articular facet fracture, spinal cord compression and severe malalignment of atlanto-axial joint (14).

There are several surgical techniques to treat axial instability: transarticular atlantoaxial arthrodesis, that consist in the positioning of bilateral cortical screw through the articular process of C1 and C2, polyaxial screw and rod fixation, that consist in the positioning of cortical screw through the lateral mass of cervical vertebrae and then blocked with rods, and dorsal wiring, consisting of using a braided silk suture or a polyester band looped around the posterior arch of C1, C2 and/or C3.

Transarticular atlantoaxial arthrodesis has several complications: screw malposition (2–15%) vertebral artery injury (2.4%) and dural tears (11.1%) (15-17).

Polyaxial screw and rod fixation has several complications: screw malposition (0–7%), paresthesia in the region innervated by the greater occipital nerve (4%), a case of symptomatic compression of the vertebral artery by the rod (18,19).

Complications of dorsal wiring, reported in literature and compared with other surgical techniques are non-union, iatrogenic fracture of the posterior arch during wire tensioning, graft breakage and wire loosening (20,21). Dorsal wiring has some benefits, compared to C2 pedicle or articular screws: lower risk of vertebral artery injury, no navigation requirements, less lateral dissection of the paraspinal muscles and then less post-operative pain, shorter surgery times, lower medical costs, and reduced amount of blood loss (22-24). We present this case series in accordance with the AME Case Series reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-22-77/rc).

Highlight box

Key findings

- In reducing C2 fractures, the surgical technique of dorsal wiring with polyester bands and titanium-peek fixation system can be proposed for fragile and elderly patients.

What is known and what is new?

- Posterior wiring is a known technique used in reducing C2 fractures; in the past have been used several materials, like titanium wires, braided silk suture or a polyester band.
- In this case series of four patients, C2 fractures (Hangman's type II, body, Andreson-D'Alonzo type III) have been reduced with sublaminar fixation with polyester bands and titanium-peek fixation system.

What is the implication, and what should change now?

- The minor invasiveness, the shorter duration, and the reduced blood loss of the operation makes this technique more suitable for fragile and elderly patients.

Case presentation

The authors present 4 patients with C2 fractures who underwent posterior wiring using 5 mm Polyester bands, titanium-peek fixation system (Jazz-Lock system MediNext®-

Implanet, Cambrige, MA, USA) inserted either through the C1 posterior arch and the C2 or C3 laminae.

The patients underwent surgery at the Neurosurgery Division of the University Hospital of Modena, Italy between July 2020 and September 2021, and were subjected to an 18-month follow-up.

All patients reported cervical fracture following traffic accidents and were neurologically intact upon admission to the Emergency Room and throughout the post-operative follow-up stage. Two patients had isolated Type-III odontoid fractures (Cases 1A and 1B), one patient suffered from a Type-II Hangman's fracture (Case 2) and another had a C2 transversal body fracture (Case 3).

No patient had conditions that could influence the post-operative prognosis.

In each case, the measure of the diastasis has been taken with the instrument ruler of the software Carestream PACS.

Conservative treatment failure for an Anderson-D'Alonzo Type-III fracture

Case 1A

An emergency computed tomography (CT) scan performed on the 47-year-old male patient revealed a fracture at the base of the odontoid process (1 mm diastasis). An MRI scan disclosed neither ligament and/nor disc lesions nor any Spinal Cord Injury (SCI). After 3 months wearing a Minerva cervical-thoracic collar, a CT scan illustrated an increased fracture diastasis (2 mm). The patient underwent a transoral injection of bioactive cement and was advised to wear a cervical bivalve collar for 6 months. An increased dens retropulsion (3 mm diastasis) was encountered at a CT scan (*Figure 1*). The patient underwent C1–C2 posterior cervical arthrodesis using polyester bands and the placement of the C2 spinous bone. The patient was discharged 7 days later, was deemed neurologically intact and wore a rigid cervical collar for 1 month followed by a soft cervical collar for 2 weeks. Follow-up CT scans showed reduced dens retropulsion (2 mm diastasis) as well as pseudoarthrosis (1 mm diastasis) at 1- and 12-month intervals respectively (*Figure 2*).

Case 1B

An emergency CT scan performed on the 76-year-old male patient highlighted a fracture at the base of the odontoid process (1 mm diastasis). After wearing a Philadelphia® cervical collar, follow-up CT scan performed after 11 months revealed an unstable pseudarthrosis with an increased diastasis fracture (3 mm) (*Figure 3*). The patient underwent C1–C2 arthrodesis with sublaminar fixation using polyester bands and the positioning of C2 spinous bone in plant location. The patient was discharged 5 days after surgery and wore a rigid cervical collar for 1 month followed by a soft cervical collar for 2 weeks. The 3-month follow-up cervical CT scan illustrated a reduction in the degree of the fracture diastasis (1 mm) alongside and pseudoarthrosis (*Figure 4*).

Case 2 (Hangman's Type-II fracture)

The 24-year-old female patient suffered blunt cranio-facial, spinal, and thoracic traumas. An emergency CT scan performed revealed a bipeduncular diastatic C2 fracture (5 mm on the left, 4 mm on the right) irradiating to the laminae with a C2 on C3 anterolisthesis as well as an increase of the C1–C2 interspinous distance (*Figure 5*). An MRI scan disclosed neither ligament, disc lesions nor any SCI. The patient underwent C1–C3 arthrodesis with polyester bands locking C1, C2, C3 posterior arches. 4 days following surgery, another CT scan was performed and highlighted a C1–C2 interspinous distance and fracture diastasis reduction. The total duration of the hospitalisation was 12 days. The patient subsequently wore a rigid cervical collar for 1 month followed by a soft cervical collar for 2 weeks. A CT follow-up scan performed 6 months later highlighted partial consolidation of the fracture (diastasis 0.5 mm on the left and 0.5 mm on the right) (*Figure 6*).

Case 3 (conservative treatment failure for transverse course C2 body fracture)

An emergency CT scan performed on the 69-year-old male patient revealed a full-thickness transverse course C2 body fracture extending to the base of the odontoid process, the transverse processes, and the upper articular masses bilaterally (1.5 mm diastasis). Neither ligament, disc lesions nor any SCI were revealed via the performance of an MRI scan. 1 month after wearing a rigid Philadelphia® cervical collar, a CT scan revealed an increased fracture diastasis (2 mm) (*Figure 7*). The patient underwent C1–C3 cervical arthrodesis with sublaminar fixation using polyester bands with the strengthening of bone fragments taken from the C2 spinous process. The patient was discharged 13 days following surgery and wore a rigid cervical collar for 1 month followed by a soft cervical collar for 2 weeks. A post-operative CT scan revealed a reduced 1.5 mm diastasis at intervals of 2 days and 3 months respectively (*Figure 8*).

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as

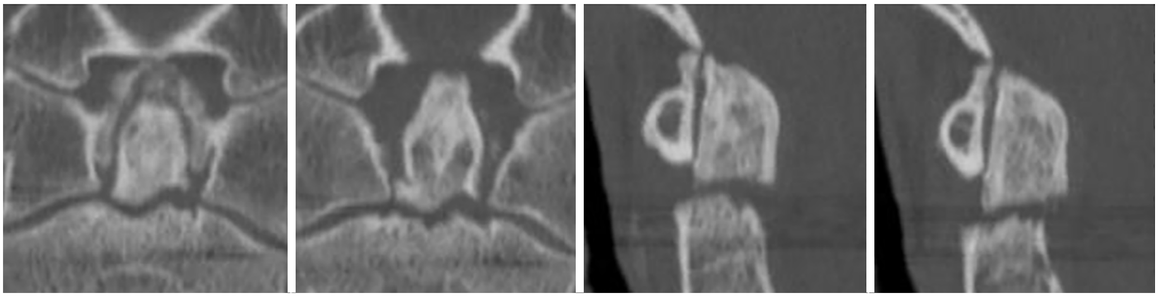

Figure 1 Six-month follow-up CT scan. No evidence of fracture consolidation with increase in the retropulsion of the odontoid process has been disclosed at CT scan (diastasis 3 mm) and no evidence of bioactive cement. CT, computed tomography.

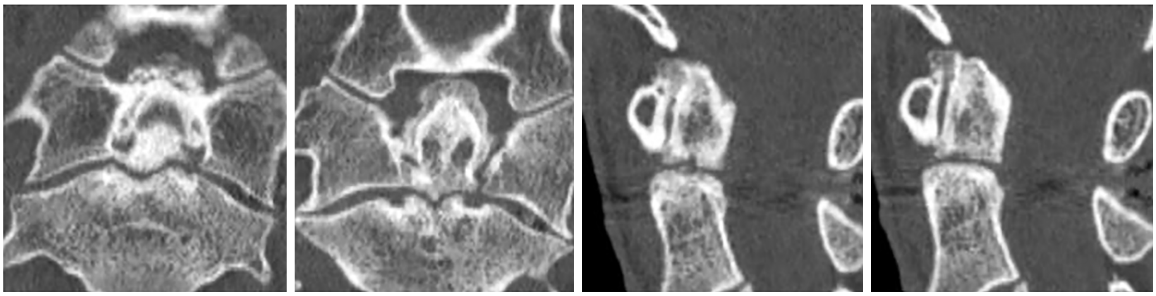

Figure 2 Twelve-month follow-up CT scan after surgery. Alignment of the dens, 2 mm of diastasis with pseudoarthrosis. CT, computed tomography.

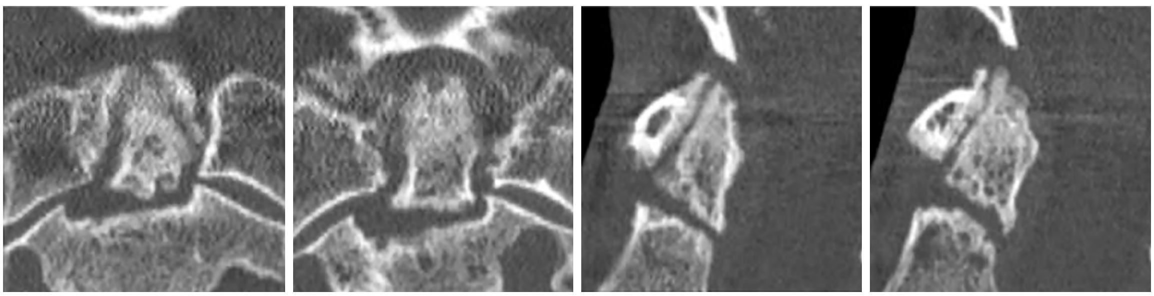

Figure 3 Control CT scan after 11 months of conservative treatment. evolution in unstable pseudarthrosis and an increase of the diastasis (3 mm). CT, computed tomography.

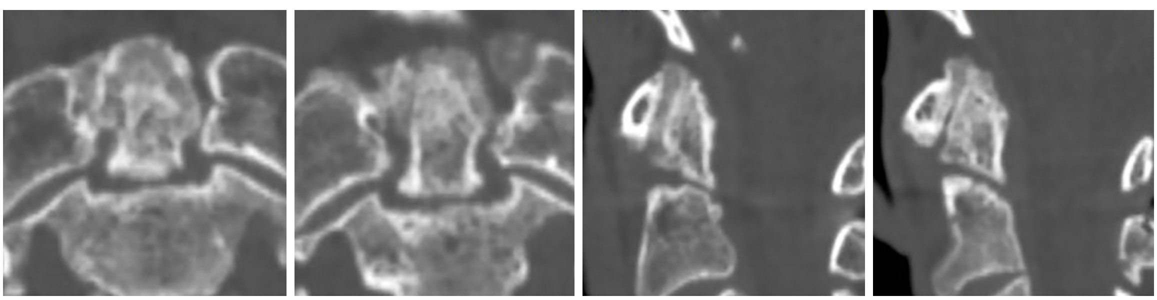

Figure 4 Control CT scan 3 months after surgery. Reduction in the degree of fracture's diastasis (1 mm) and pseudoarthrosis. CT, computed tomography.

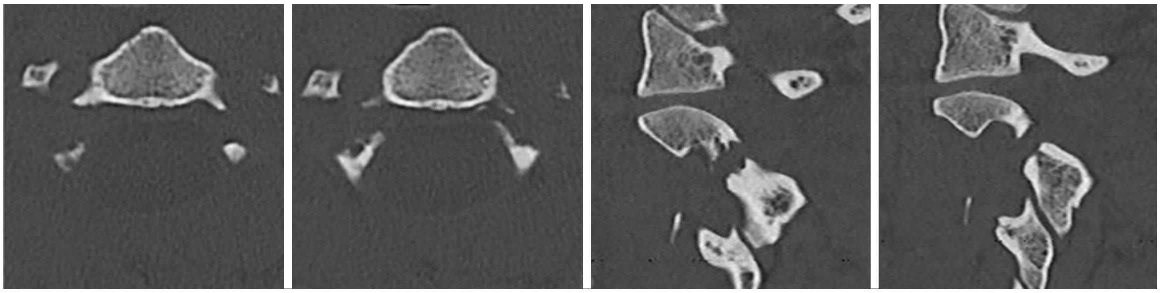

Figure 5 First CT scan. C2 bipeduncular diastatic fracture (5 mm on the left and 4 mm on the right) irradiated to the laminae with anterolisthesis of C2 on C3 and increase of the interspinous distance of C1–C2 (Hangman's C2 Type-II fracture). CT, computed tomography.

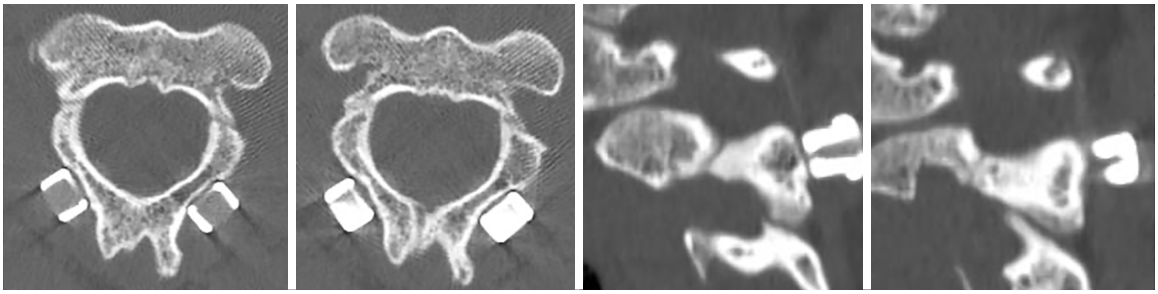

Figure 6 Six-month follow-up CT scan. Partial consolidation of the cervical fracture (diastasis 0.5 mm on the left and 0.5 mm on the right). CT, computed tomography.

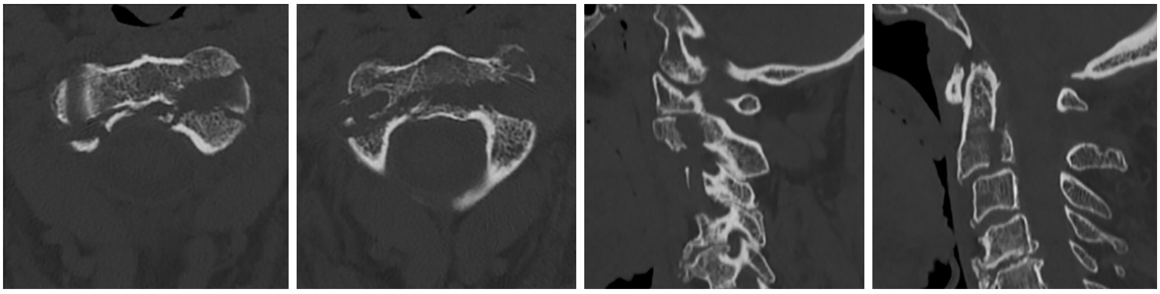

Figure 7 Results of a follow-up CT scan performed 1 month after surgery. The cervical spine CT scan performed 1 month after the event showed an increase in fracture diastasis (2 mm). CT, computed tomography.

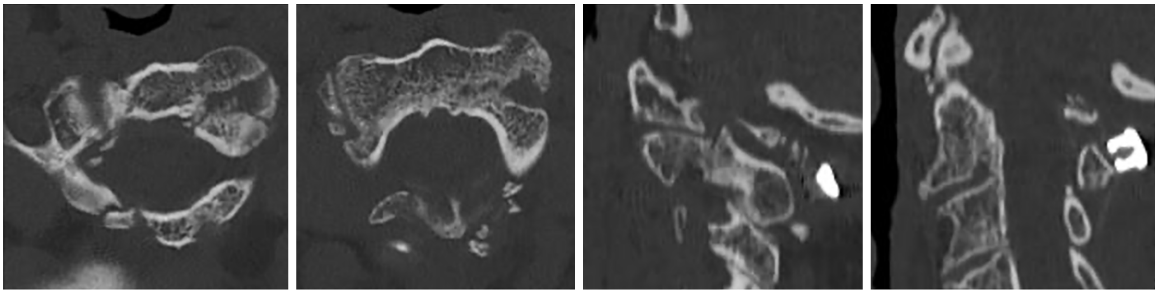

Figure 8 Results of a follow-up CT scan performed 3 months after surgery. Partial repairing phenomena (diastasis 1 mm). CT, computed tomography.

Figure 9 Titanium-peek fixation system (Jazz-Lock system MediNext®-Implanet).

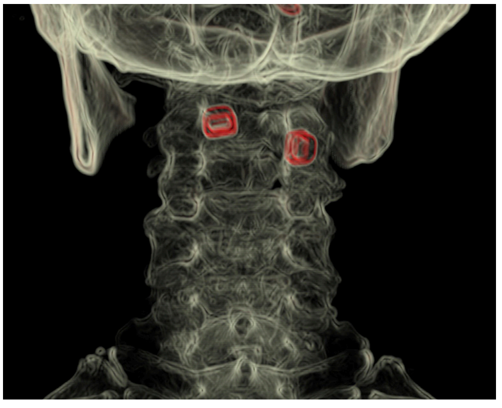

Figure 10 3D-view of the titanium-peek fixation system seen via the CT scan. CT, computed tomography.

revised in 2013). Written informed consent was obtained from the patients for publication of this case series and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Surgical strategy

All patients underwent asleep intubation in a prone surgical position, taking care to avoid any excessive pressure on the eyes. The head was secured by means of a Mayfield headboard. An antibiotic, cefazolin, was infused 30 minutes prior to carrying out the incision.

A midline incision and dissection of soft tissue were carried out from the external occipital protuberance to the C3 (or C4) spinous process to achieve exposure of the posterior arch of C1 and posterior appendicular structures of the C2 and C3 vertebrae; using electrocautery and elevators, the posterior elements of cervical spine were exposed subperiosteally. On each side, a sublaminar polyester band was passed under the C2 or C3 laminae as well as under the posterior C1 arch from inferior to superior bilaterally. Next, the C2 spinous process was placed under the polyester bands. Then, the bands were tightened with a band tensioner and fixed with titanium-peek fixation system (Jazz-Lock system MediNext®-Implanet) (*Figures 9,10*). Once satisfactory tightening and reduction was achieved, the redundant part of cable was removed.

Frontal and lateral radiographs of the cervical spine were taken intraoperatively.

All patients wore a cervical collar postoperatively for at least 1 month and this was removed following confirmation of bone fusion via CT scan performance.

Discussion

All patients were neurologically intact both upon admission and when discharged from hospital. The average duration of the surgery was 128.75 minutes (ranging between 110 and 160 minutes). An average maximum reduction of the fracture diastasis of 2.375 mm was achieved (ranging between 4.5 and 1 mm). No intraoperative, post-operative complications nor wound infections were encountered. Blood loss during surgery was encountered in only 1 surgical operation and amounted to approx. 150 cc; while, in the other 3 operations, the blood loss was less than 150 cc, therefore it had not been taken into account. Post-operative pain was kept well under control by administering painkillers during the first days following surgery: patients were administered the Numerical Rating Scale (NRS) scale to monitor post-operative pain; during the post-operative days the average value was 3.25/10 (a minimum of 2 and a maximum of 4). The average duration of the hospitalisation period was 9.25 days (ranging between 5 and 12 days). 18 months following surgery no patient underwent any further follow-up surgery. All patients who had worked prior to the traumatic event were able to return to work.

There are both advantages and disadvantages to the wiring technique.

The advantages include simple to apply, valuable addict to other firmer fusion methods and lower medical expense than encountered with screw implantation (24). This surgical technique is less durable than the instrumented posterior arthrodesis system (22,23). Furthermore, the risks of vascular damage are significantly lower; the risk of neurologic damage is also lower, and this is related only to the sublaminar passage of the band. Other benefits include no need for navigation and minor lateral dissection of the paraspinal muscles (22,23).

Disadvantages of posterior wiring technique are related to the fact that these techniques can only be applied safely when posterior elements are intact and the bone arches are adequate (25). Another drawback of the posterior wiring technique is a period of hard external support and that the polyester band must be passed below the C1 arch which poses a risk of spinal cord injury (26).

Dorsal wiring can be performed with several materials, such as braided silk suture, metal wires and polyester band. The non-metal wiring system reported in this study allows no imaging artifacts shown on post-operative CT scans performed as well as the reduction of the risk of iatrogenic laminar fractures. Murakami *et al.*, via an *in vitro* laminar cut-through test, proved that the cut-through force for polyethylene tape was higher than that of either a steel wire or cable (27).

A risk of spinal cord injury can be associated with the passage of the bands below the C1 arch (26).

Nevertheless, the polyester bands of the system reported in this study are both flat and flexible, due to absence of metal components, providing an easy, safe manipulation in the epidural space with lower risk of causing any dural damage and SCI, compared to previous dorsal wiring techniques (26).

The main limitation of this article is the reduced number of patients; the authors were able to suggest both the safety and effectiveness of a sublaminar fixation with polyester bands and a titanium-peek fixation system in reducing C2 fractures, but a larger series is needed to help define the safety and clinical utility of the technique. Furthermore, the four patients were subjected to a brief follow-up period and there is a lack of biomechanical studies; long-term follow-up and biomechanical studies are needed to define the real effectiveness of this surgical technique.

Conclusions

The dorsal wiring technique entailing the positioning of polyester bands and titanium-peek fixation system (Jazz-Lock system MediNext®-Implanet) is a surgical procedure that can be used to reduce C2 fractures and ensure cervical atlantoaxial stabilisation.

This technique has a shorter duration of surgical time and incurs a lower cost than other surgical techniques such as screw implantation. Furthermore, it can provide atlantoaxial stabilisation, reduce the diastasis of the fracture as well as bone fusion. The minor invasiveness, the shorter duration, and the reduced blood loss of the operation makes this technique more suitable for fragile and elderly patients.

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Footnote

Reporting Checklist: The authors have completed the AME Case Series reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-22-77/rc

Peer Review File: Available at https://jss.amegroups.com/article/view/10.21037/jss-22-77/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jss.amegroups.com/article/view/10.21037/jss-22-77/coif). CI reports counselling with Integra Life Science is about topic in Traumatic Brain Injury and Crania reconstruction, nothing in relationship with this manuscript. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for publication of this case series and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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