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CASE REPORT

Temporary fusionless posterior occipitocervical fixation for a proximal junctional type II odontoid fracture after previous C2-pelvis fusion: case report, description of a new surgical technique, and review of the literature

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Abstract
Purpose Axial fractures in patients with a previous C2-pelvis posterior instrumented fusion are rare and may be challenging to manage. Motion preservation in the axial spine for these patients is important, as the C1–2 and Occipit-C1 joints are their only remaining mobile spinal segments. In this unique report, we present for the first time the use of a fusionless occipitocervical operation for the treatment of a type II odontoid fracture and unilateral C2 pars fracture adjacent to a previous C2-pelvis posterior instrumented fusion.
Methods Case report.
Results Three years after proximal extension of a T3-pelvis posterior instrumented fusion to C2, the patient sustained a displaced odontoid fracture and unilateral C2 pars fracture after a mechanical fall. She underwent fracture stabilization with extension of instrumentation to the occiput. No attempt at fusion was performed. Post-operatively, she was distraught by severely limited neck range of motion, which was reflected in worsening of health-related quality of life (HRQoL) scores. The fracture healed uneventfully after which the instrumentation from the occiput and C1 were removed, which resulted in improvement of neck range of motion. Two years post-operatively, HRQoL scores showed minimal neck disability (NDI 12), no neck or arm pain (VAS 0), and outstanding general health (EQ-5D 85 out of 100, SF-36 PCS 35.3, SF-36 MCS 41.1).
Conclusion In this one patient, instrumentation without fusion allowed for successful and timely union of a displaced odontoid fracture in a patient with a previous C2-pelvis fusion. Axial range of motion was preserved after instrumentation removal.

Keywords Odontoid fracture · Atlantoaxial motion · Occipitocervical fixation · Motion preservation · Cervical trauma

Introduction

Long posterior instrumented fusions extending from the pelvis to the thoracolumbar junction or upper thoracic spine are hallmarks of adult spinal deformity surgery. Extension of instrumentation and fusion to the cervical spine in these patients is uncommon, but may be required for post-operative junctional failures (i.e., vertebral fractures, instrumentation pull-out, and/or posterior ligamentous disruption) [1–9] or for multi-level posterior cervical operations to address a superimposed cervical degenerative disorder. After extension to C2, junctional stresses concentrate at C1 and C2, which may increase this patient population's risk of sustaining an axial spine fracture (i.e., dens, hangman). In the event that a patient with a previous C2-pelvis fusion sustains an axis or atlas fracture, motion of the axial spine should ideally be preserved, as the atlanto-axial and atlanto-occipital joints are their only remaining mobile spinal segments.

In this report, we present a unique case of a patient with a previous C2-pelvis posterior instrumented fusion who

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sustained an anteriorly displaced type II dens fracture and unilateral C2 pars fracture that was treated with extension of instrumentation to C1 and the occiput without fusion. After the fracture healed, the occipital plate and C1 instrumentation were removed, which facilitated preservation of axial motion.

Case report

History, physical examination, pertinent imaging

A 64-year-old female with a history of hypertension, chronic back pain, previous L3–5 posterior instrumented fusion (PSIF) for degenerative spondylolisthesis, and a left L2–3 lateral interbody fusion for adjacent segment disease (Fig. 1a) underwent a T3-pelvis PSIF with L3 pedicle subtraction osteotomy and revision L2–5 laminectomies for lumbar flatback and sagittal and coronal imbalance (Fig. 1b). Seven months after the operation, she underwent a C2–T3 PSIF (C2 intralaminar screws), C3–7 laminectomies, and bilateral C5–T1 foraminotomies for cervical spondylotic myelopathy and radiculopathy (Fig. 1c). Before this operation, she had severe neck disability (NDI 66), severe neck and arm pain (VAS neck 8, VAS right arm 9, VAS left arm 9), and poor general health (EQ-5D VAS 40, SF-36 PCS 31.5, SF-36 MCS 40.1). She had an uneventful post-operative course and her health-related quality of life scores (HRQoL) at 1 year post-op demonstrated persistent neck disability (NDI 60), improved neck and arm pain (VAS neck 1, VAS left arm 4, VAS right arm

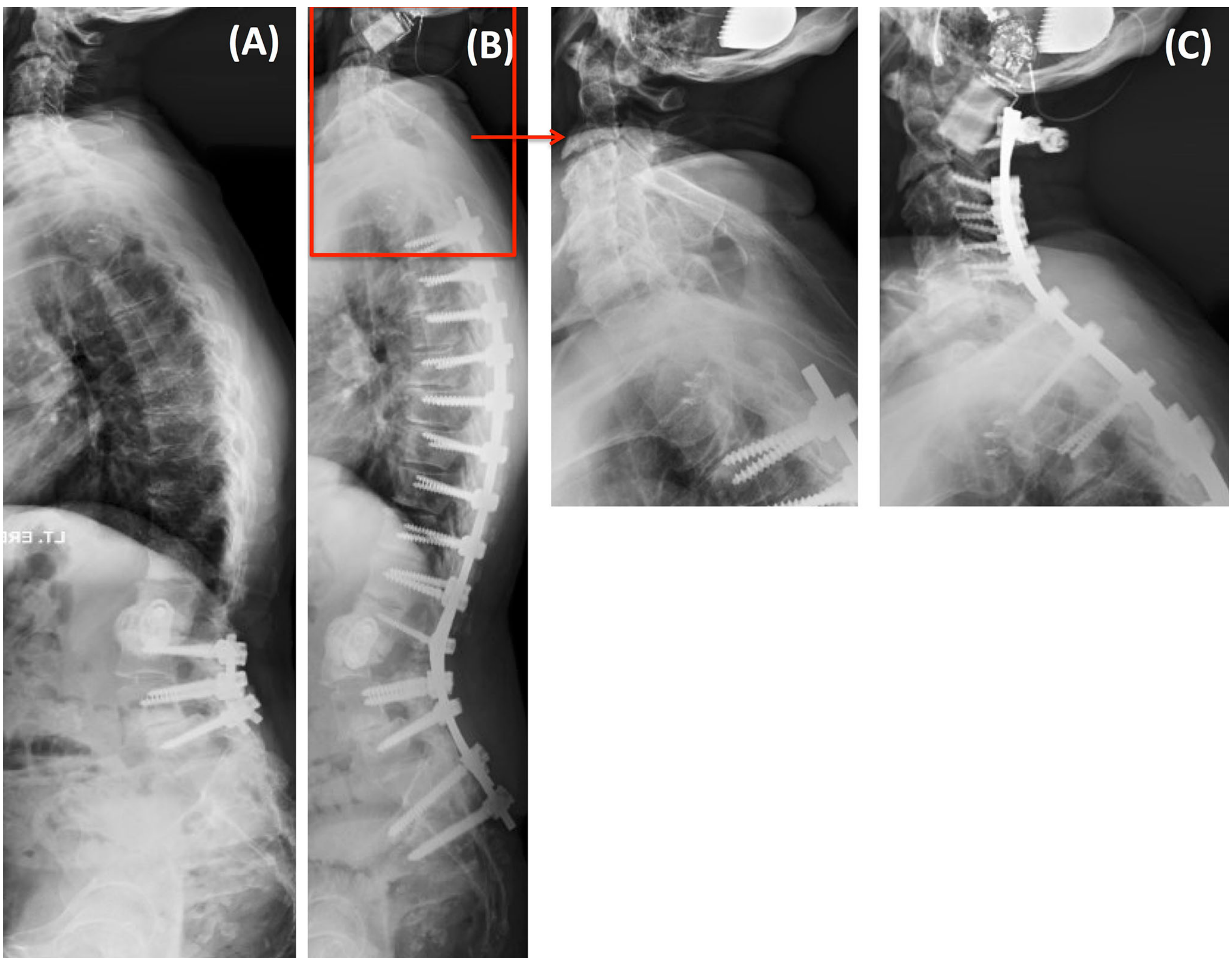

Fig. 1 A 64-year-old female with a history of a previous L3–5 posterior instrumented fusion (PSIF) for degenerative spondylolisthesis and a left L2–3 lateral interbody fusion for adjacent segment disease (**a**) underwent a T3-pelvis PSIF with L3 pedicle subtraction osteotomy and revision L2–5 laminectomies for lumbar flatback and sagittal and coronal imbalance (**b**). Seven months after the operation, she underwent a C2–T3 PSIF (C2 intralaminar screws), C3–7 laminectomies, and bilateral C5–T1 foraminotomies for cervical spondylotic myelopathy and radiculopathy (**c**)

2), and improved general health (EQ-5D VAS 72, SF-36 PCS 42.6, SF-36 MCS 25.9).

She then sustained a mechanical fall getting out of a chair 3 years post-operatively. During the fall, she recounts striking her head against a wall. She had immediate onset of new neck pain and subjective extremity weakness. She presented to an outside hospital's emergency department where she was noted to have full strength in the upper and lower extremities. No hyperreflexia and no clonus were noted. Bilateral Hoffman's were negative. A CT scan of the cervical spine demonstrated an acute type II dens fracture with 5 mm anterior displacement and a left C2 pars fracture (Fig. 2a, c, d). The atlas was without fracture (Fig. 2b). She was placed into a hard collar and transferred to our institution. On presentation, her neurologic examination was stable. Nonoperative and operative options were discussed with the patient. Operative intervention was recommended given the displacement of the odontoid fracture and concomitant pars fracture. A posterior approach was chosen given her advanced age and previous posterior instrumentation.

Surgical technique

The patient was taken to the operating room and placed in the supine position. General anesthesia was induced. She was given 1 g of Vancomycin for surgical prophylaxis. After a standard operating room timeout a Halo ring was applied with a 4-pin construct set at 8 lbs. The patient was then placed into the prone position with her head held in the neutral position using the Mayfield. The odontoid fracture was then partially reduced under fluoroscopy. Under fluoroscopic guidance the levels from Occiput-C2 were identified and marked on the skin in the midline incorporating part of the patients prior midline incision. A midline incision was then made through the skin

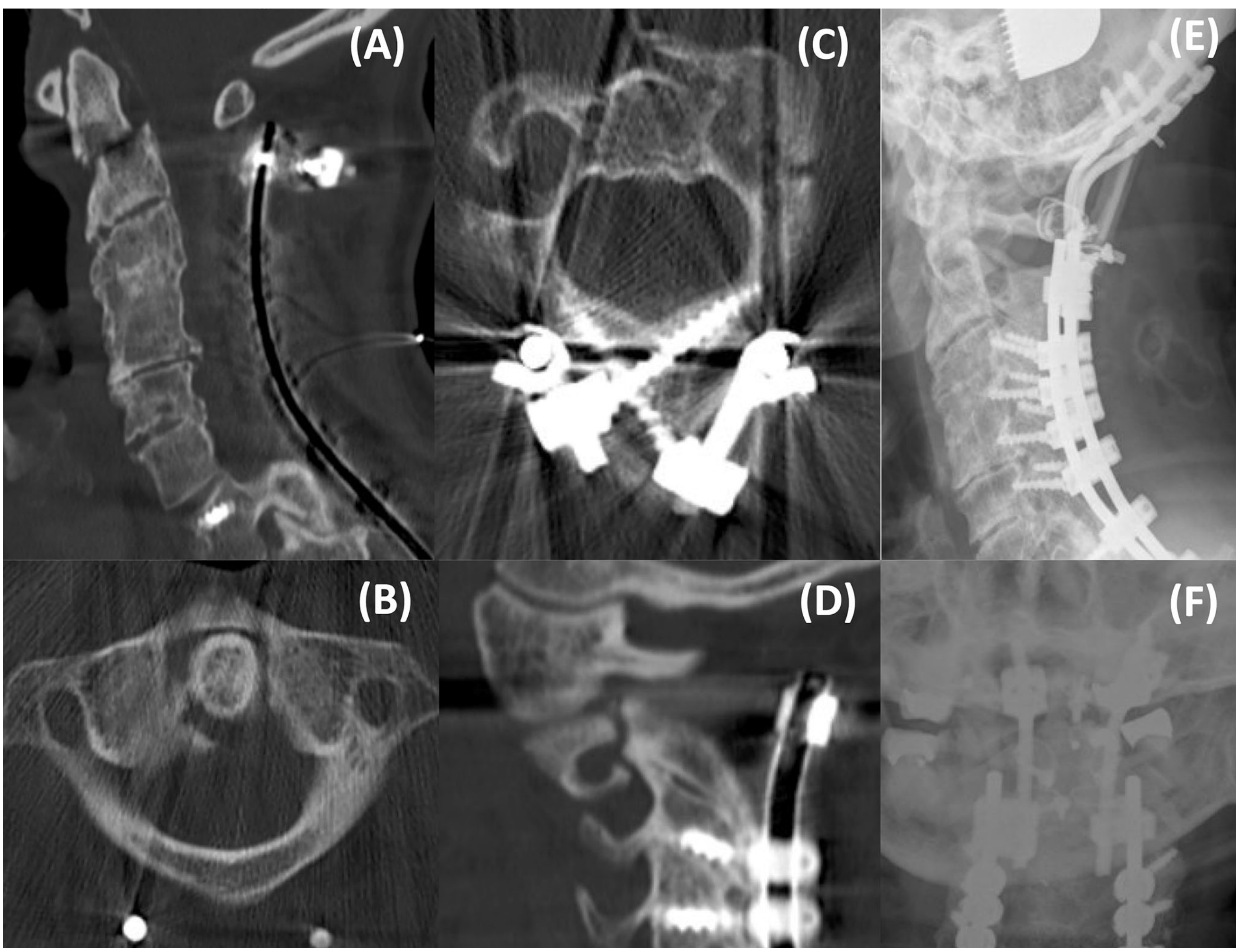

Fig. 2 Three years after the previous C2-pelvis posterior spinal instrumented fusion, she hit her head against a wall after a fall. A CT scan of the cervical spine demonstrated an acute type II dens fracture with 5 mm anterior displacement (**a**) and a left C2 pars fracture (**c**, **d**). The atlas was without fracture (**b**, **d**). She underwent extension of instrumentation to C1 and the occiput without fusion (**e**, **f**)

subcutaneous tissue down to level of the ligamentum nuchae, which was then incised in the midline to expose the spinous process of C2, the C1 ring, and the Occiput to the level of the inion. Great care was taken not to detach muscle attachments from the spinous process of C2 distally. Lateral dissection was carried out to expose the lamina of C2, the C2 pars, the C1 ring about 1.5 cm lateral to the midline, and the spinal hardware at C2 and C3. The C2 screws were removed and the C2–3 fusion was explored with curettes and found to be healed.

Two titanium atlas cables were then placed under the C1 ring. A central 6 mm burr hole was made 1 cm cephalad to the foramen magnum and a third atlas cable was placed through the burr hole to exit the foramen magnum. Two rod-plate constructs were cut to span from the occiput to C2 and connected to the end of the existing cervical rod using side-to-side connectors. The plates were then affixed to the occiput using sequential drilling with a positive stop drill to allow bicortical purchase of the plate on the occiput. Five 4.5 mm diameter and one 5 mm diameter screws were used. The offset connectors were then final tightened to lock the occiput to the existing cervical instrumentation. Further open reduction of the C2 fracture was then performed by translating the C1 ring posteriorly by tightening the Atlas cables underneath the C1 ring to the posterior rods. No decortication was performed. The wound was irrigated with antibiotic irrigation solution. A lateral radiograph was taken to confirm that all hardware was in good position and that fracture reduction was appropriate. The incision was closed in multiple layers. Sterile dressings were applied and the halo ring was removed. There were no intraoperative complications. Motor-evoked and somatosensory-evoked potentials were normal throughout the case. The patient was placed in a well-fitting Miami J collar and admitted to the Intensive Care Unit (ICU) in stable condition for neurological monitoring and pain management.

Post-operative course

Post-operatively, she was transitioned from the ICU to the ward and then discharged on postoperative day (POD) 10. Her neurologic exam remained stable throughout hospitalization. Postoperative visits showed intact hardware and a reassuring examination and a normal gait. She was noted to have persistent cervical muscular pain that was treated with physical therapy and baclofen. Range of motion of the cervical spine on physical examination was severely limited: flexion of 10°, extension of 0°, lateral rotation (right) of 5°–10°, and lateral rotation (left) of 0° (Supplementary Video 1). Because of this limitation in range of neck motion, her HRQoL scores were extremely poor and included severe neck disability (NDI 62), considerable neck pain (VAS neck pain 8), no arm pain (VAS left arm pain 0, VAS right arm pain 0), and poor general health (EQ-5D VAS 35, SF-36 PCS 23.7, SF-36 MCS 51.2). She was extremely distraught by her motion limitation.

At her 1-year postoperative visit, the patient complained of new onset pain in the posterior occipital area that was different from the muscular discomfort she had previously described. A cervical CT scan and cervical radiographs demonstrated healed odontoid and pars fractures, a broken occipital–cervical plate, and no posterior fusion (Fig. 3a, b). There was no significant C1–2 or Occipital-C1 arthritis. In turn, the patient underwent removal of the occipital plate and posterior cables from C1 to relieve pain and attempt to regain C1–2 and Occipit-C1 motion (Fig. 3c). Her postoperative recovery was uneventful and her neurological exam was stable. She was discharged on POD 8 without incident. At the patient's 4-month postoperative visit, she reported resolution of her posterior occipital pain and improvement in her neck range of motion (Supplementary Video 2). Physical examination of the cervical spine was notable for flexion of 35°, extension of 5°, lateral rotation (right) of 45°, and lateral rotation (left) of 25° (Supplementary Video 2). As such, her HRQoL scores had improved and included less neck disability (NDI 48), less neck pain (VAS neck pain 5), left arm pain (VAS 4), no right arm (VAS 2), and better general health (EQ-5D VAS 55 out of 100, SF-36 MCS and SF-36 PCS not obtained). At her 2-year follow-up, she remained extremely happy with her neck range of motion, which was similar to the previous visit. Her HRQoL scores at 2-year post-op were also outstanding with minimal neck disability (NDI 12), no neck or arm pain (VAS 0), and improved general health (EQ-5D 85 out of 100, SF-36 PCS 35.3, SF-36 MCS 41.1). She expressed that she was exceedingly satisfied with the ultimate outcome and rated it as outstanding.

Discussion

In this report, we present for the first time the treatment of an odontoid fracture and unilateral C2 pars fracture adjacent to a previous C2-pelvis PSIF with temporary fusionless occipitocervical instrumentation. The instrumentation allowed for successful and timely union of the fractures as well as preservation of sufficient axial range of motion after the occipital-C2 instrumentation was removed. Due to the improved motion, her HRQoL scores for neck disability and overall general health improved after the hardware removal.

While this is the first presentation of this technique, the use of temporary posterior segmental fixation without fusion for the treatment of odontoid fractures is not a new concept. Feasibility of using temporary C1–C2 fixation for

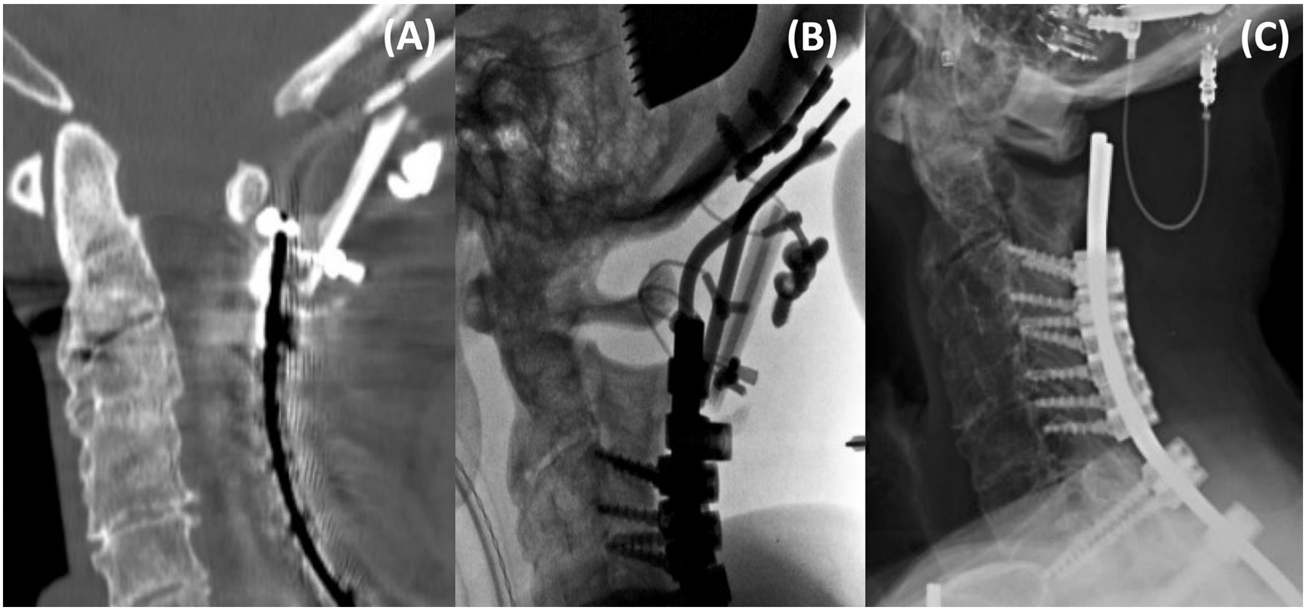

Fig. 3 One year postoperatively, the patient complained of new onset pain in the posterior occipital area. A cervical CT scan (**a**) and cervical radiographs (**b**) demonstrated healed odontoid and pars fractures (**a**), a broken occipital-cervical plate (**b**), and no posterior fusion (**a**, **b**). There was no significant C1–2 or Occipital-C1 arthritis. In turn, the patient underwent removal of the occipital plate and cables from C1 to relieve pain and attempt to regain C1–2 and Occipit-C1 motion (**c**)

type II odontoid fractures not suitable for anterior screw fixation was initially described by Han et al. [10]. In their 13 patients, all fractures were confirmed to be united with CT scan and hardware was removed at a mean 9.0 ± 2.8 months (range 6–15 months) post-operatively [10]. After hardware removal, dynamic CT scan demonstrated mean axial neck rotation of 59.7° ± 12.1° (left), 56.8° ± 14.1° (right), and 116.5° ± 25.8° (total) [10]. This resulted in a total axial neck rotation of 78.2 ± 14.8% (range 43.9–93.7%) of matched historic controls, which the authors noted, "was better than the 30% decrease reported in 35 patients with C2 fractures treated with anterior screw fixation or external immobilization" [11]. In a separate study of 22 patients with type II/III odontoid fractures treated with posterior C1–2 temporary fixation without fusion (C1 lateral mass screws combined with C2 pedicle/laminar screws), Guo et al. removed instrumentation within 6 months of the operation in 21 of the patients (95.5%) who achieved union (average time to union: 4.1 ± 1.7 months) [12]. Three months after hardware removal, atlanto-axial rotation was 25.7° ± 5.5° and 4.8° ± 1.6° in flexion–extension [10, 12]. Additionally, patients who underwent temporary fixation and instrumentation removal had significantly less neck pain (0.2 ± 0.3 vs. 1.0 ± 0.6; $p < 0.01$), less neck stiffness (none-18 vs. 7; $p < 0.01$), lower NDI scores (1.7 ± 1.8 vs. 17.4 ± 11.1; $p < 0.01$), greater satisfaction (9.3 ± 1.4 vs. 6.7 ± 1.5; $p = 0.01$), higher SF-36 physical component scores (88.7 ± 11.4 vs. 64.1 ± 17.9; $p < 0.01$), and higher SF-36 mental component scores (88.5 ± 13.9 vs. 72.8 ± 20; $p < 0.01$) at an average 45.2 months post-operatively than 21 patients with odontoid fractures treated with posterior instrumented C1–2 fusions at an average 47.3 months post-operatively [12].

Our case and these two previous reports demonstrate that odontoid fractures can be safely and efficaciously treated with posterior instrumentation without fusion and delayed implant removal to facilitate preservation of axial motion, albeit not complete. While this strategy necessitates a second operation for implant removal, which has related risks inherent to any operation, preservation of C1–2 and Occiput-C1 motion in patients with previous C2-pelvis PSIF is paramount, as they are their only remaining mobile spinal segments.

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Compliance with ethical standards

Conflict of interest No funds were received in support of this work. Financial activities outside of the submitted work included: consultancy, grants for fellowship, and royalties.

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