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Case Report

Transpedicular direct osteosynthesis of hangman's fracture from a mini-open exposure as a less invasive procedure: A technical note

Viktor Zsolt Kovari*, Attila Josvai, Andras Csokay

Hungarian Defense Forces Medical Centre, Department of Neurosurgery, 44. Robert Karoly krt., 1134 Budapest, Hungary

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ABSTRACT

This surgical technical case report presents initial clinical experience and preliminary results with a less invasive surgical solution for selected hangman's fracture. A well-known stabilization technique (i.e. direct transpedicular osteosynthesis) was applied through a minimally invasive small incision transmuscular posterior approach guided by a standard C-arm fluoroscopy. This mini-open approach to C2 vertebra allows similar dissection, visualization of the bony landmarks, visual control of the transpedicular screw path drilling, tapping and screw insertion to the standard posterior cervical spine approach. At the same time it has the benefits of less invasive procedures.

Introduction

In this technical case report C2 direct transpedicular osteosynthesis from mini-open access without navigation is presented.

Traumatic spondylolisthesis of the axis, or so called hangman's fracture, is a common type of cervical fracture [1,4,12].

The fracture classification is based on Effendi's and Levine-Edwards' system.

Surgical treatment options are C2–C3 anterior cervical discectomy and fusion (ACDF), posterior C2–C3 (or C1–C3 depending on the degree of instability) fixation and C2 direct transpedicular osteosynthesis, or the combination of anterior and posterior fixations [2,3,7,8,10,11]. Only C2 direct transpedicular osteosynthesis provides motion preservation, although the application of this technique is questionable in highly unstable fractures [5,6,12].

There are several articles describing similar percutaneous intraoperative O-arm or Iso-C3D fluoroscopy assisted, computed navigation based, direct transpedicular screw fixation methods of Type II, Type IIa and even Type I C2 traumatic spondylolisthesis [9,13].

There is only one article which presents a percutaneous C2 hangman's fracture direct osteosynthesis guided by standard intraoperative C-arm fluoroscopy without spinal navigation [12].

Case

35-year-old woman, who was injured in a motor vehicle accident, was neurologically intact on site. Later on both hands gripping strength decreased. Computed Tomography (CT) scan revealed a bilateral pediculo-isthmic component fracture of the axis with 7 mm anterior dislocation, 24° tilting and lower posterior corner fracture of the body of the C2 vertebra (Fig. 1). Magnetic Resonance Imaging (MRI) showed no spinal cord compression, no myelopathy, no cord edema, no sign of disc rupture between C2 and C3 vertebrae (Fig. 2). The C2 vertebral fracture was classified, according to Levine-Edward's classification, as Type IIa. Due to the

* Corresponding author.
E-mail address: viktor.zs.kovari@gmail.com (V.Z. Kovari).

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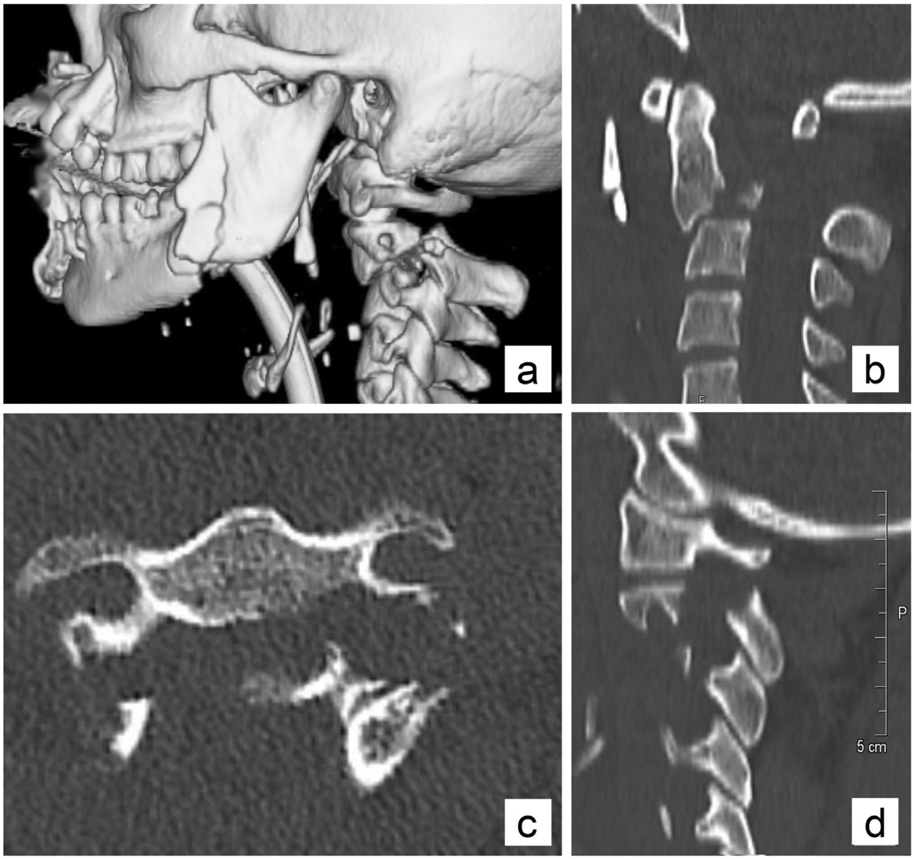

Fig. 1. Initial three dimensional (3D) reconstruction of craniofacial and cervical spine CT scan shows the multiple fracture of the maxilla and the mandibula beside the dislocated traumatic spondylolisthesis of the axis (a). Mid-sagittal (b), axial (c), left sagittal (d) CT images present the hangman's fracture.

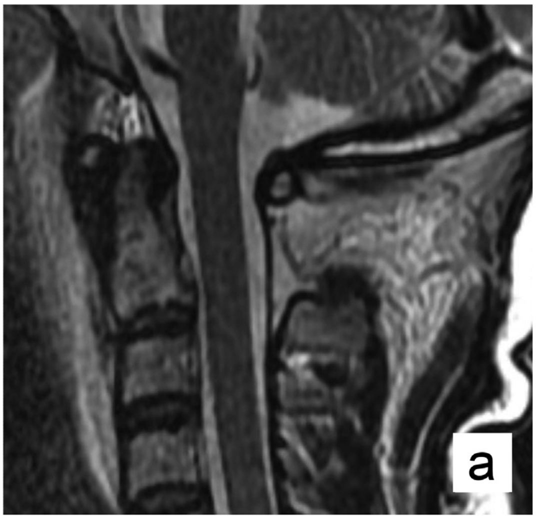

Fig. 2. Preoperative MRI T2 sequence mid-sagittal slice reveals no damage to intervertebral disc between C1 and C2 vertebrae.

tracheostomy which had to be performed because of concomitant multiple open fractures of the mandible, maxilla a ventral approach for the C2 unstable hangman's fracture was out of question. We decided first to perform a posterior fixation choosing direct transpedicular osteosynthesis which provides a chance for motion preservation between C2 and C3, knowing that a ventral stabilization might be necessary later on (sacrificing the segmental motion).

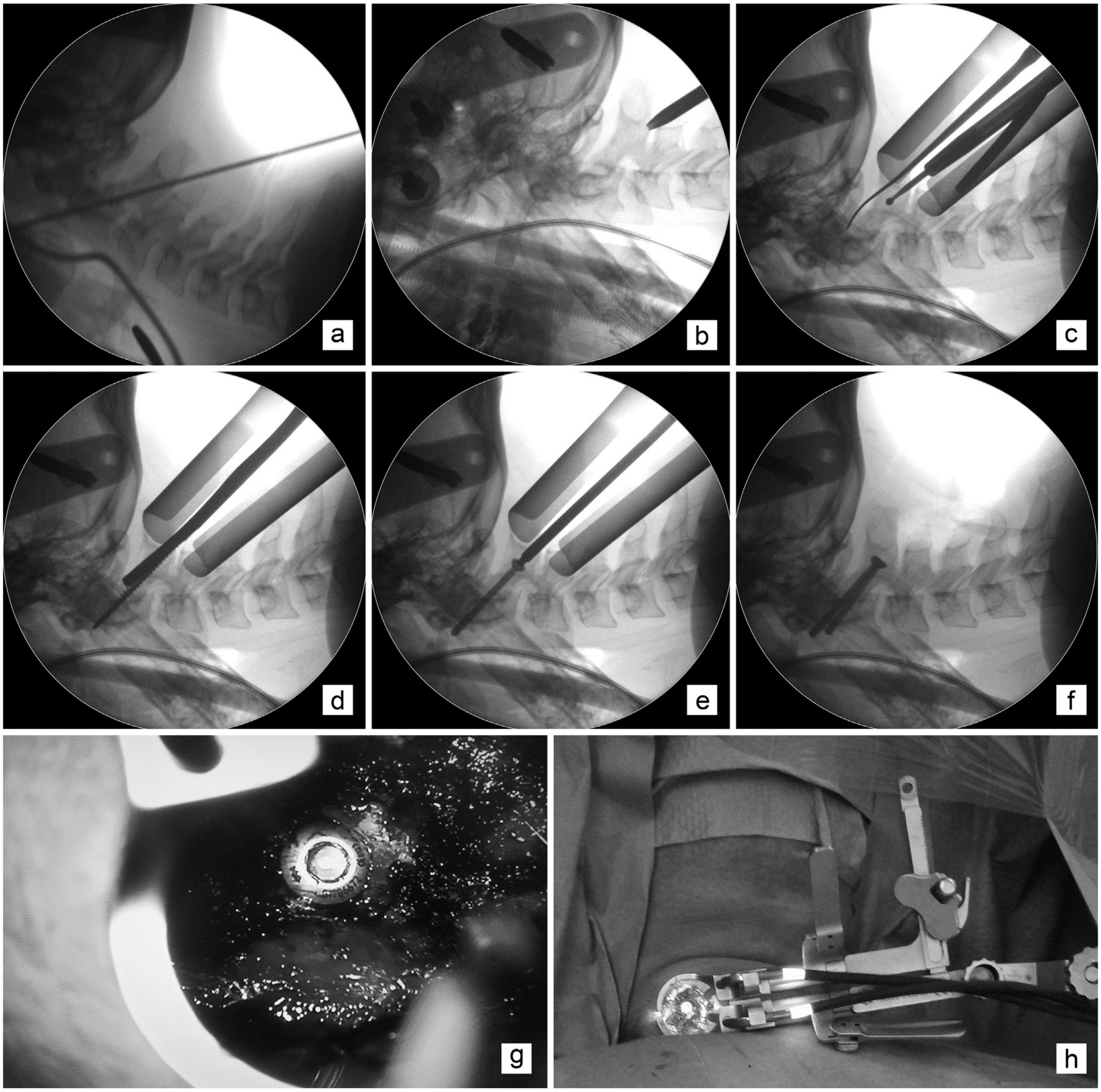

Fig. 3. Intraoperative fluoroscopy images present the procedure. Guidewire aiming for the determination of the screw trajectory in sagittal plane and of skin incision site is demonstrated (a). Introduction of the smallest dilator of the used minimally invasive, mini-open retractor system is shown (b). Between the retractor blades a fine elevator along the C2 pedicle (which is used for palpation and visualization of the superiomedial border of the pedicle) and the drill with a rosen burr bit above the inferior articular process of C2 vertebra are seen (c). Thread-cutting is showed (d). Screw placement is demonstrated (aiming bicortical purchase) (d). Both transpedicular screws are visible in their final position (f). Close photo image presents the view through the mini-opening revealing the inserted screw (g). Photo image shows the posterior view of the neck of the prone positioned patient within the minimally invasive retractor device on the left. The inserted screw is visible in the center between the retractor blades (h).

Surgical technique

The patient was placed in prone position on a radiolucent operating table under general anesthesia. The dorsal part of the halo west was removed. The head was stabilized in a halo ring attached to the ventral part of the halo vest after a closed reduction of the fracture under fluoroscopy guidance.

The ideal trajectory and incision site for screw insertion into the C2 pedicles were determined by a K-wire placed laterally along the cervical spine under fluoroscopy imaging. (Fig. 3a). The first 4 cm long left paramedian skin incision was made above the C6 vertebra, 2.5 cm from midline (Fig. 4). The trapezius, splenius capitis and semispinalis capitis muscles were divided along the direction of the fibers using a penfield dissector. Probing the C2–3 zygapophyseal joint the position of the tip of the dissector was confirmed by fluoroscopy in two dimensions (antero-posterior and latero-lateral). A minimally invasive retractor system (Medtronic -

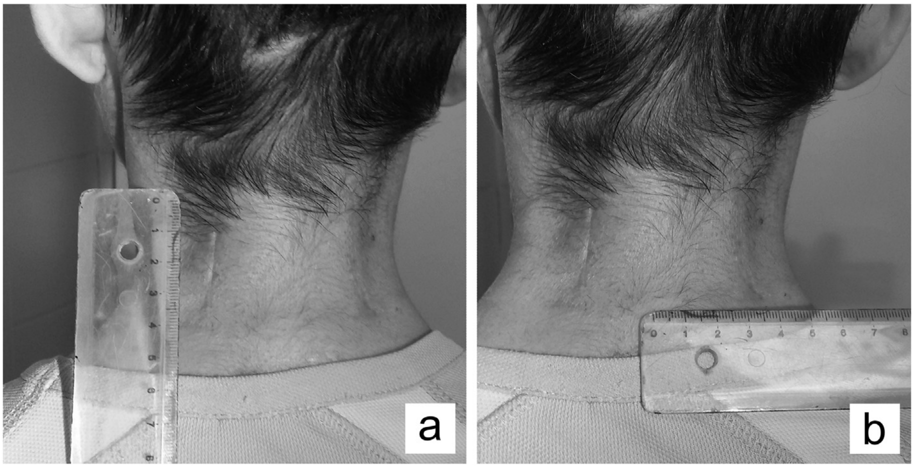

Fig. 4. Healed surgical skin incision sites are presented in Case I. Ruler shows the 4 cm length of the left scar (a). Ruler shows the distance (3 cm) of the right scar from the midline (b).

Mast Quadrant) was placed through the muscles, ending on the C2–3 facet (Fig. 3b). The insertion of this retractor system was based on guide-wire aiming and dilation of the soft tissue by tubes. The remaining muscle was detached from the articular mass and inferior articular process of the C2 vertebra by a long straight monopolar pencil to achieve visual control of the screw entry point. The superiomedial border of the C2 pars interarticularis was exposed with a fine dissector, detaching the atlantoaxial ligament. The tip of the dissector was held at the inner side of the pars to help aim the drill (Fig. 3c). The entry point was determined visually which was approximately at the center of the articular mass of C2. The drilling angle in the sagittal plane was determined by aiming the contralateral cortex of C2 body under the C1 anterior arch. From lateral to medial the drill was aimed parallel to the C2 pars superio-medial edge which was exposed by the aforementioned dissector being held at the medial side of the pars (Fig. 3c). The pilot hole was made by low speed drill with a 2.7 mm rosen burr drill bit under fluoroscopy guidance. The drill bit was then changed to a 2.5 mm twist drill. The pedicle was drilled, advancing carefully, until the tip of the drill went through the ventral cortex of the C2 body to create a screw path. The integrity of screw path was confirmed with a probe. After thread cutting (Fig. 3d), a partial threaded screw (4 × 38 and 4 × 40 mm BBraun in case I and 4 × 26 mm on the left side and 4 × 28 mm on the right side in case II) was inserted across the fracture site and tightened (Fig. 3e). Once all the threads passed the fracture line and went into the body of C2 vertebra the screw closed the gap between the fractured bony elements and compressed them together (Fig. 3g, h). The screw was intentionally placed bicortically to provide a stronger screw purchase, as compared to monocortical screw placement. The fascia was closed by single sutures and the subcutaneous layers and skin were closed by running sutures in different layers. The procedure was repeated on the right side (Fig. 3f).

Results

Procedure duration was 98 min. Estimated blood loss was 100 ml. No screw or realignment-related injury to nerve or vertebral artery were observed and there was no sign of surgical site infection.

At the end of the surgical procedure, a functional test was performed under lateral view fluoroscopy. A slight degree of tilting was observed between C2 and C3 vertebrae, although this minimal intervertebral movement was deemed to be normal (Film. flexion-extension test). She was also neurologically intact after recuperating and had a functionally good outcome.

Postoperative CT control confirmed that the screws did not breach the walls of the pediculo-isthmic components and the intended bicortical purchase was achieved (Fig. 5c, e). It must be noted that one of the screws violated one of the C1-C2 zygapophyseal joints unintentionally (Fig. 5b). A partial, acceptable, however not perfect, reduction of the C2 body over the C3 vertebra was shown on the control CT scan (Fig. 5a). The C2–C3 intervertebral disc appeared to be normal even on post-operative (4 months later) MRI scan (Fig. 5f) and even the last functional X-ray control (14 months later) showed no evidence of re-dislocation, instability or implant failure (Fig. 6).

Discussion

In this article the stabilization of selected hangman's fracture types from a mini-open transmuscular approach using a well-known surgical stabilization technique from Laconte and Judet (i.e. transpedicular osteosynthesis, direct pars repair), is presented as a combination of an old fixation technique and a modern approach [5,6].

Minimally invasive solutions (MIS) for stabilization of lumbar and thoracic spine injuries are beginning to be utilized worldwide. Significantly less tissue damage, less blood loss, a lower infection rate and often less procedural time compared to a standard posterior open procedure with the same level of accuracy are the principal advantages of these techniques. MIS techniques are often

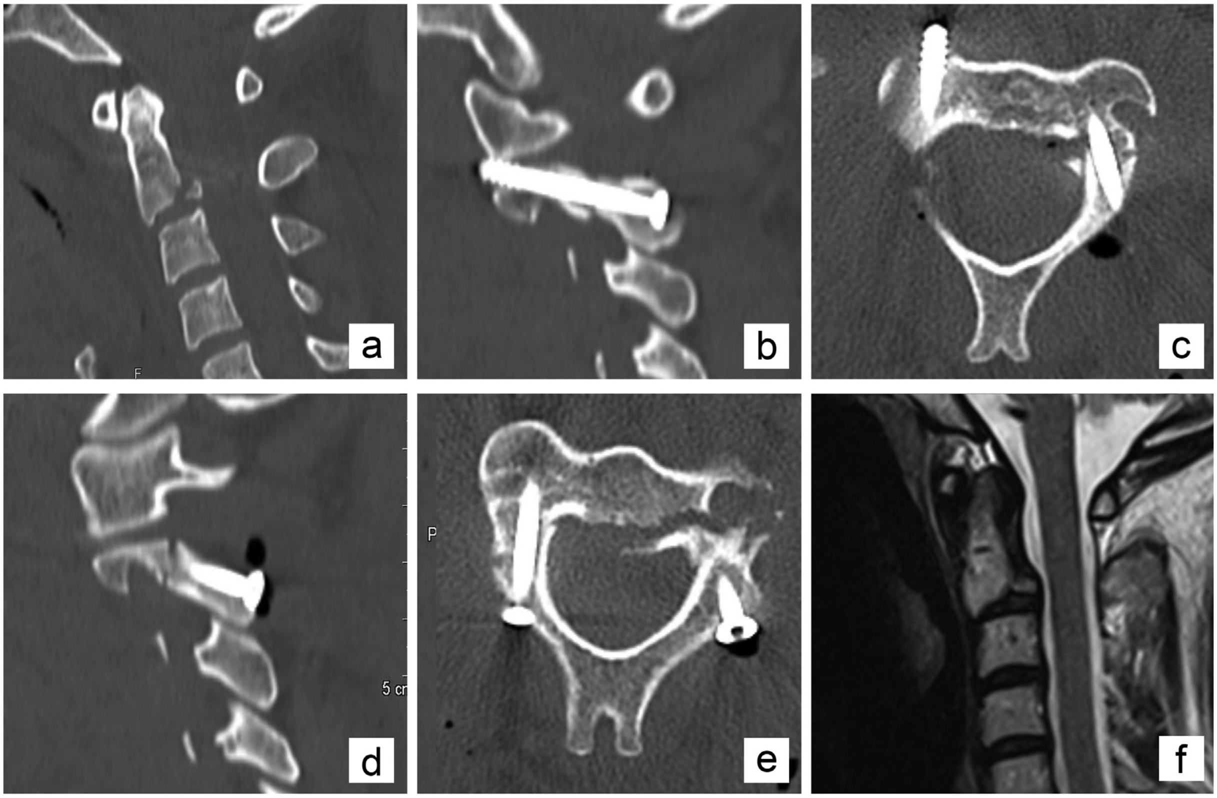

Fig. 5. Postoperative mid-sagittal CT image shows the repositioned C2 body in Case I (a). Right transpedicular screw and the right compressed fracture site are shown on sagittal (b) and axial (c) CT images. Left screw is presented also on sagittal (d) and axial (e) CT slices with the diminished left fracture fissure. Postoperative sagittal T2 weighted MRI slice presents non injured intervertebral disc between C1 and C2 vertebrae (f).

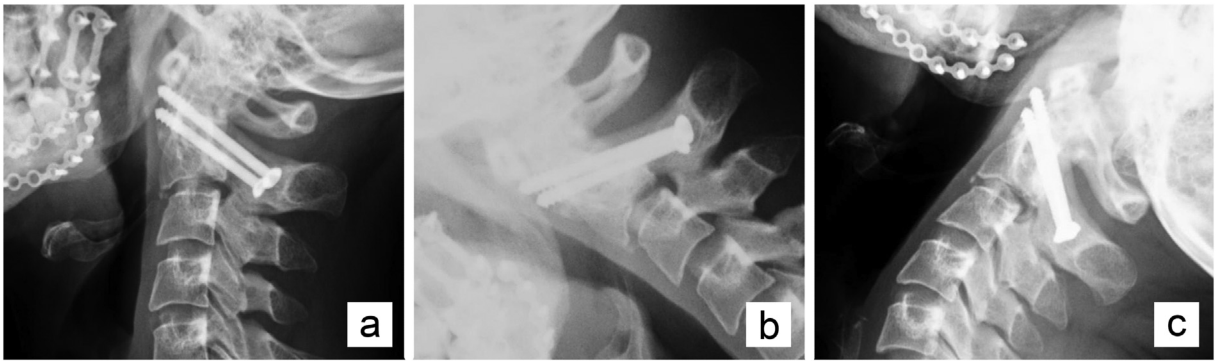

Fig. 6. Postoperative cervical spine neutral lateral (a), flexion (b), extension (c) X-rays are presenting no implant failure and no instability between C2 and C3 vertebrae, repositioned C2 body after one year of the procedure.

associated with 3D image-based navigational systems, although the expensive navigation tools are worldwide available.

Screw insertion through a mini-open approach, depending on the tissue damage, stands between the percutaneous screw placement (which is the most minimally invasive solution), and the standard stabilization from an open posterior approach (which is the most invasive among the possible approaches).

We are aware of Wu's C-arm fluoroscopy-guided percutaneous direct transpedicular C2 osteosynthesis technical report, although we think even some of the experienced surgeons would be reluctant to perform percutaneous screw insertion into the C2 vertebra pediculo-isthmic component without a spinal navigation system due to the risk of vertebral artery and spinal cord injury [12].

C1–C2 joint violation by the screws should be avoided. It must be emphasized that the zygapophyseal joint violation in our case was not the result of the applied technique but the improper screw aiming at the ventral C2 body cortical.

The limitation to the clinical application of this presented technique is the limited number of cases in which this method was used, the retrospective design, a short follow up, the lack of randomization, and the fact that these have been the experiences of a singlesurgeon.

Conclusions

Although there are some prerequisite conditions for direct transpedicular osteosynthesis of a hangman's fracture, it might be utilized through a mini-open transmuscular approach. Our presented surgical technique combines the value of visual control of the screw insertion, given in the standard open approach and the benefits of a mini-open, trans-muscular approach as a less invasive procedure.

The presented technique can be an alternative method in the hands of those surgeons who have experience with standard posterior craniocervical junction spinal surgeries but do not have access to navigation systems for percutaneous MIS stabilization.

Preliminary results with this surgical technique are promising although further and more extensive studies are necessary.

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Conflict of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Retrospective study

For this type of study formal consent is not required. “This article does not contain any studies with human participants performed by any of the authors.”

This study was approved by our Institutional Review Board.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tcr.2017.10.025.

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