Eur Spine J
DOI 10.1007/s00586-017-5257-6

CASE REPORT

Anterior transarticular C1–C2 fixation with contralateral screw insertion: a report of two cases and technical note

Ivan Lvov[1,3] · Andrey Grin[1,2] · Aleksandr Kaykov[1] · Vladimir Smirnov[1] · Vladimir Krylov[1,2]

Received: 22 May 2017 / Revised: 19 July 2017 / Accepted: 3 August 2017

Abstract

Purpose Anterior transarticular fixation of the C1–C2 vertebrae is a well-known technique that involves screw insertion through the body of the C2 vertebra into the lateral masses of the atlas through an anterior transcervical approach. Meanwhile, contralateral screw insertion has been previously described only in anatomical studies.

Methods We describe two case reports of the clinical application of this new technique.

Results In Case 1, the patient was diagnosed with an unstable C1 fracture. The clinical features of the case did not allow for any type of posterior atlantoaxial fusion, Halo immobilization, or routine anterior fixation using the Reindl and Koller techniques. The possible manner of screw insertion into the anterior third of the right lateral mass was via a contralateral trajectory, which was performed in this case. Case 2 involved a patient with neglected posteriorly dislocated dens fracture who could not lie in the prone position due to concomitant cardiac pathology. Reduction of atlantoaxial dislocation was insufficient, even after scar tissue resection at the fracture, while transdental fusion was not possible. Considering the success of the previous case, atlantoaxial fixation was performed through the small approach, using the Reindl technique and contralateral screw insertion.

Conclusions These two cases demonstrate the potential of anterior transarticular fixation of C1–C2 vertebrae in cases where posterior atlantoaxial fusion is not achievable. This type of fixation can be performed through a single approach if one screw is inserted using the Reindl technique and another is inserted via a contralateral trajectory.

Keywords Anterior transarticular C1–C2 fixation · Atlantoaxial instability · Contralateral screw insertion · Jefferson fracture · Neglected dens fracture

✉ Ivan Lvov
dr.speleolog@gmail.com

1 Department of Neurosurgery, Sklifosovsky Research Institute of Emergency Care, Moscow, Russia

2 Evdokimov Moscow Medical University, Moscow, Russia

3 Sklifosovsky Research Institute of Emergency Care, B. Suharevskaya Pl. 3, Moscow, Russia 107945

Introduction

Anterior transarticular fixation of the C1–C2 vertebrae is a well-known technique first described in 1998 by Lu et al., providing the anatomical foundations for this technique [1]. This method details screw insertion through the body of the C2 vertebra into the lateral masses of the atlas through an anterior transcervical approach. The first clinical application was reported by Reindl et al. [2], whereby surgeons used short screws and performed the insertion through the point below the anterior lip of the C2 lateral mass. In 2005, Sen et al. conducted a biomechanical study, which demonstrated the high stability of anterior transarticular fixation and a slight reduction in fusion rigidity in flexion–extension tests [3]. The technique reported by Koller et al. in 2006 [4] outlined the success of screw insertion placement in the vicinity of the C2 pinafore. This allows for the insertion of longer screws than the technique described by Reindl et al. [2]. Lapsiwala et al. demonstrated no significant difference in rigidity of anterior and posterior transarticular fixations [5].

In 2015, Ji et al. reported the results of a cadaveric study and demonstrated a third option for screw insertion trajectory during anterior transarticular fixation [6]. The entry point was located on the anterolateral surface of the C2

Published online: 08 August 2017

body, 5 mm cranially and more lateral from the midline. The direction of screw insertion was oriented towards the opposite lateral mass through the whole body of the C2 vertebra. This entry point location allowed for the insertion of another shorter screw into the homolateral mass of the atlas via the same approach. To date, there has been no report on the clinical application of this technique in the literature.

We hereby present two case reports outlining the clinical application of anterior contralateral fixation in patients who underwent surgery in 2014 and 2015, respectively.

Case reports

Case 1

Data and examination

A 50-year-old man was admitted to our department in May 2014 after a car accident. Cervical spine computed tomography (CT) scans revealed multiple fractures in the anterior and posterior arcs of the atlas and abruption of the posterior third of its lateral mass (Fig. 1, left). Clinical symptoms included severe cervical pain that increased dramatically when the patient moved his head; otherwise, he was neurologically intact. The concomitant traumatic brain injury, linear fracture of the left frontal and temporal bones, and soft tissue wound on the head prevented us from using the Halo device for an extended period of time. Initially, we planned to perform C1–C2 fixation using the Harms technique and fusion of the shattered lateral mass of the atlas with a screw. However, the patient's anatomical characteristics prevented this. The location of the vertebral artery on the right side of the C2 vertebra made it impossible to perform transarticular fusion on that side. The small size of the C2 right pedicle, pars interarticularis, and arc also made it impossible to use the posterior screw fixation technique of C1–C2 on the right side (Fig. 1, right). Due to these limitations, the combined anteroposterior atlantoaxial fixation technique with contralateral screw insertion (Fig. 2) and Magerl trajectory [7] was performed.

Surgery

First, we used the Halo device for head fixation whilst the patient was in the supine position. One of the Halo pins was placed according to the location of the skull fracture and skin wound. For this reason, we fixed the Halo using only three pins, which allowed us to reposition appropriately and achieve immobilization during surgery. Reduction of the vertical atlantoaxial dislocation was performed using traction. Skin incision for contralateral screw insertion was planned using transoral radiography. A K-wire was attached according to the screw insertion trajectory. The intersection between the K-wire line and the medial edge of the sternocleidomastoid muscle indicated the midpoint of skin incision. The left anterior bar of the Halo device was temporally removed to facilitate approach performance during contralateral fixation. The left transcervical approach to the base of the C2 vertebra was performed through a 2 cm skin incision. A port for the cannulated instrument was placed near the lower edge of C2, 5 mm lateral from the midline. K-wire was inserted through the lower edge of C2 into the opposite lateral mass of the atlas under two-plane X-ray control (Fig. 3a). This K-wire was used for bone tunnel drilling. A cannulated self-tapping cortical lag screw (4 mm in diameter and 38 mm in length)

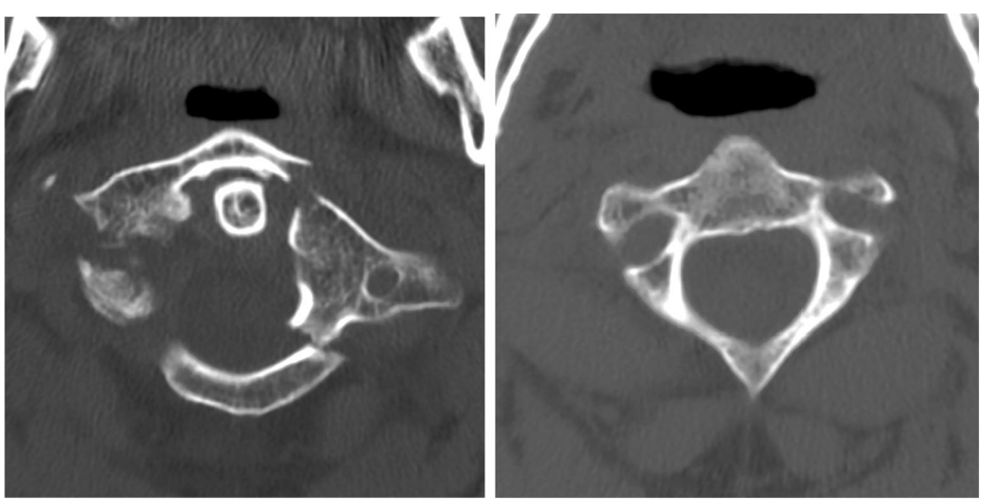

Fig. 1 Case 1: pre-operative CT scan of the cervical spine. *Left* multisplintered fracture of the C1 vertebra. *Right* thinning pedicle, arc, and pars articularis of the C2 vertebra as well as bilateral thinning of the anterior lip of the C2 lateral mass. *CT* computed tomography

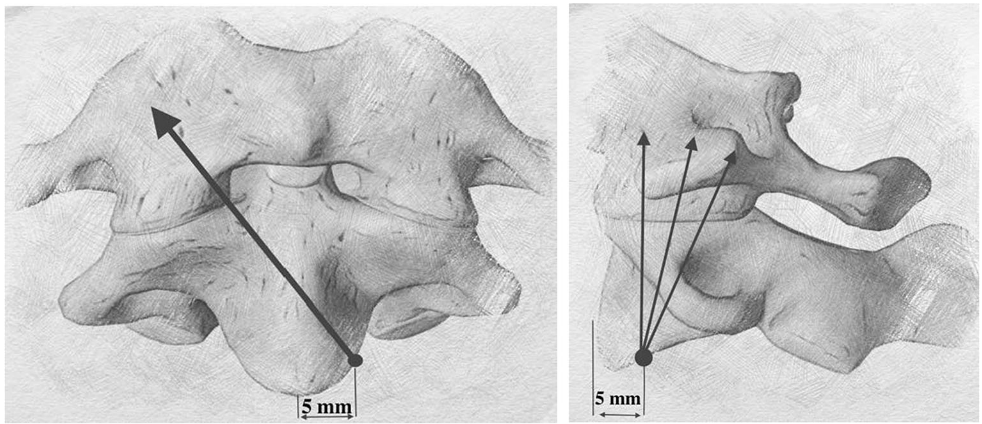

Fig. 2 Schematic representation of the contralateral trajectories of screw insertion during anterior transarticular fixation of C1–C2. Anteroposterior (*left figure*) and lateral (*right figure*) views are shown here

was inserted through this tunnel. The position of the screw head in the C2 vertebra facilitated fixation of the left lateral joint using the Reindl method; however, significant, bilateral thinning of the anterior lip of the C2 lateral mass (CT data; Fig. 1, right) prevented us from using this technique.

While using the Halo device, the patient was subsequently turned over into the prone position, and a left-sided unilateral transarticular fixation using a cannulated self-tapping cortical lag screw (4 mm in diameter and 40 mm in length) was performed using the standard technique [7] (Fig. 3b). Control X-ray images and CT data are provided in Fig. 3c, d. Following surgery, the Halo device was removed.

Post-operative period

No intra- or post-operative complications were observed. The patient was discharged 12 days after surgery. CT scan at 12 months follow-up revealed fracture fusion, with no signs of fixation inconsistency observed.

Case 2

Data and examination

A 54-year-old man presented to our institute in July 2015 with a diagnosis of neglected rostral type III fracture of the odontoid process with posterior dislocation reaching 4 mm. The immobilization that was performed using a collar was ineffective, which resulted in fracture nonunion. The patient's complaints included mainly neck pain and severe dizziness that increased after cervical flexion and extension. During abrupt movement, the patient described an electric-like feeling in all limbs. Functional X-ray of the cervical spine revealed further 2 mm fragment dorsal dislocation during extension.

Surgery

First, the Halo device attachment was performed for further safe rotation of patient and adequate intraoperative immobilization. We initially planned to perform posterior atlantoaxial fixation; however, the patient exhibited low blood pressure and a decrease in oxygen saturation in the prone position. Considering the high risk of complications, we tried to perform transdental fixation. A standard left-sided submandibular approach was performed, which was complemented by fibrous tissue removal around the fracture. However, our attempts to reduce the dislocation were unsuccessful, therefore, it was impossible to perform the transdental fusion. As a result, the anterior transarticular fixation technique was performed. Insertion of the left screw was performed using the Reindl method. Another screw was inserted into the right lateral mass using a contralateral trajectory through the same approach (Fig. 4). Cannulated self-tapping cortical lag screws (4 mm in diameter; 22 mm and 38 mm in length) were used.

Post-operative period

No intra- or post-operative complications were observed. The patient was discharged 7 days after surgery. Follow-up studies 1 year after surgery revealed no bone fusion in the area with partially dislocated fragments, despite accurate resection of scar tissue during surgery. However, the implants were not dislocated, and there were no clinical symptoms of unstable fixation.

Discussion

Various methods of atlantoaxial fusion have been described. Methods outlined by Magerl and Harms are typically regarded as the optimal approaches among dorsal

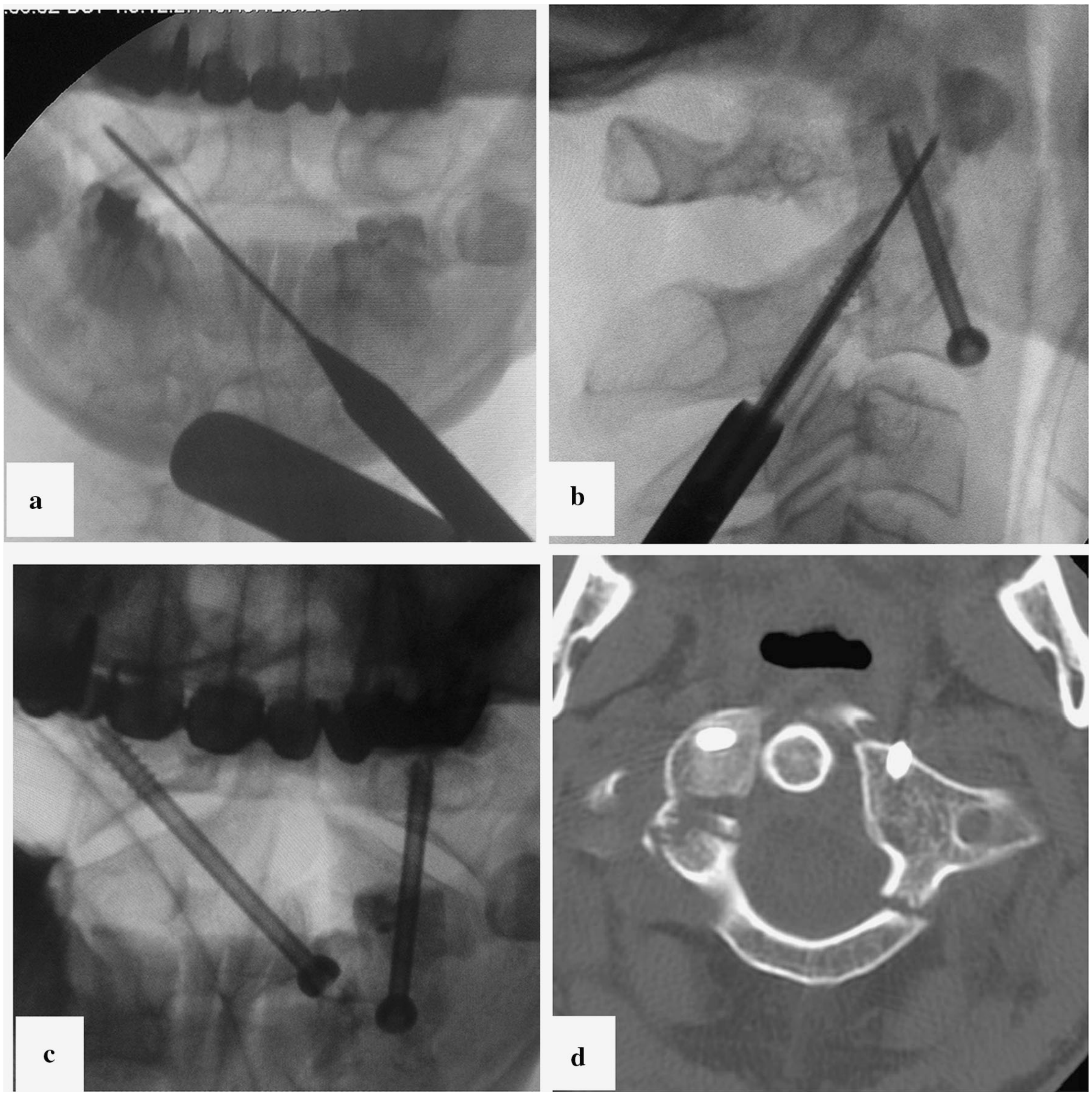

Fig. 3 Case 1: X-ray images of the fixation stages and control CT scan. **a** K-wire insertion into the right lateral mass using a contralateral trajectory. **b** Left-sided unilateral posterior transarticular fixation. **c** Control X-ray in the transoral plane. **d** CT scan control after screw insertion (*axial plane*). Screws are located in the lateral masses of the atlas on both sides and are bicortical on the *left side*. *CT* computed tomography

techniques [7, 8]. The incidence of fusion formation among all cases of screw fixation is 93% [9]. Contraindications for these techniques include the aberrant location of vertebral arteries, fractures of C1–C2 posterior structures, and fractures of C1 lateral masses. In cases with contraindications, anterior transarticular fixation is an alternative to the Magerl and Harms methods. Several available screw insertion trajectories have been reported to date [2, 4, 6]. Biomechanical studies have demonstrated the adequate rigidity of this fixation, comparable to posterior fusion techniques [3, 5]. No complications associated with the surgical technique have been reported in the literature. Contralateral fixation allows for placement of the screw inside the C2 vertebra 2–3 mm deeper than the cortical layer, while the techniques described by Reindl [2] and Koller [4] involve insertion of the screw subcortically over a large area. A deeper position of the screw in the C2 vertebra may be more stable, however, this has not yet been demonstrated through biomechanical studies. A screw can be placed in any area of the C1 lateral mass during contralateral fixation, while the other methods suggest that the screw must be inserted into the rear part of the C1 lateral mass. As a result, this method restricts the application of other techniques if the fracture is located in this area. The Ji method [6] (i.e., contralateral fixation combined with the Reindl technique) allows for fixation using a small

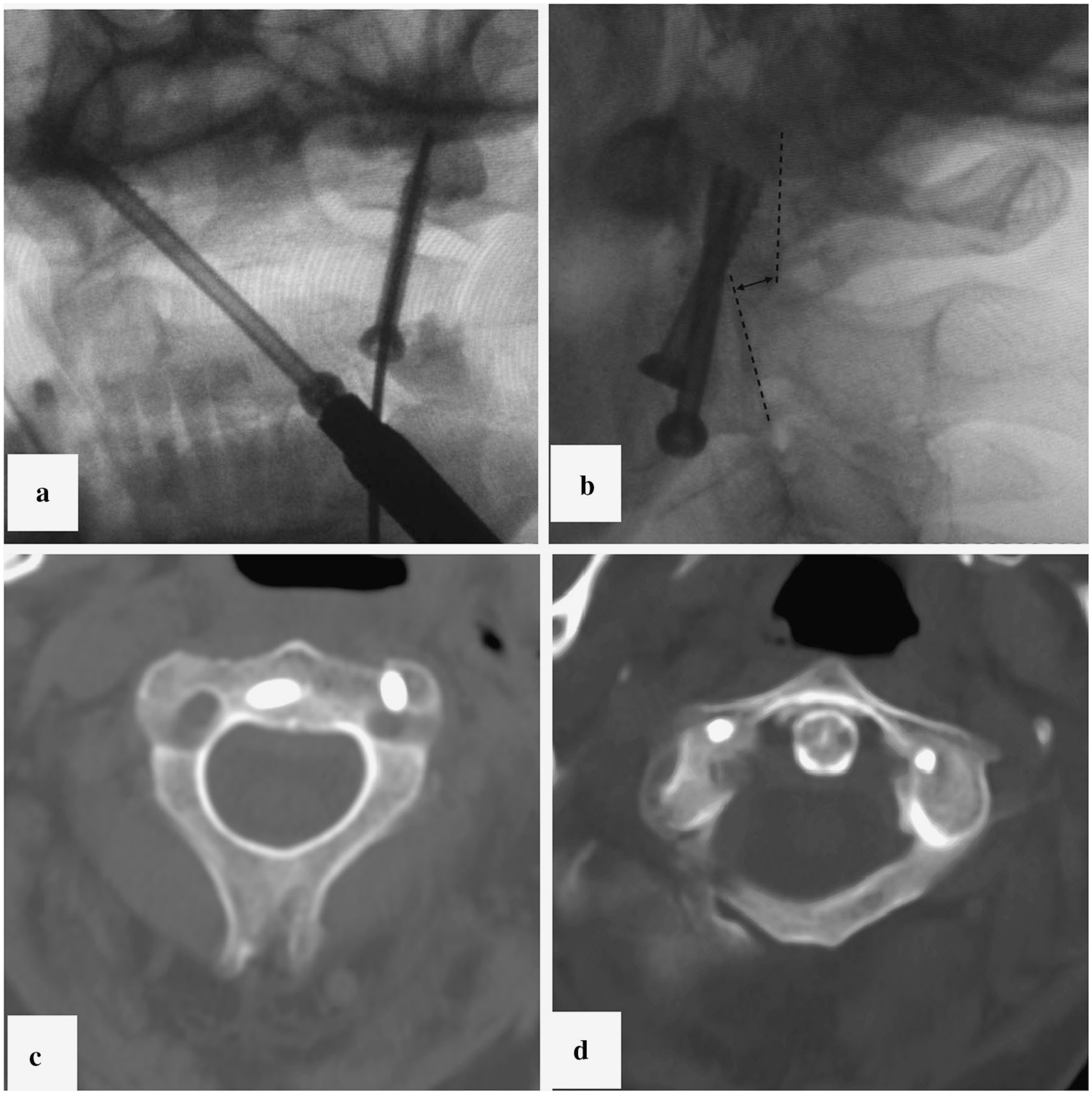

Fig. 4 Case 2: post-operative X-ray images and CT scans. **a** Control X-ray in the transoral plane. **b** Control X-ray in the lateral plane. We continued to observe dorsal dislocation of the atlantoaxial complex by up to 4 mm. **c** Screw position in C2 vertebra. **d** Screw position in C1 vertebra. *CT* computed tomography

unilateral transcervical approach, while the Koller method requires bilateral surgery.

In Case 1, the patient was diagnosed with an unstable C1 fracture. The right-sided location of the vertebral artery and the small-sized C2 pedicles prevented us from performing any type of posterior atlantoaxial fusion. Continuous Halo fixation was also contraindicated. To preserve the mobility of the cervical spine in this patient, we avoided occipito-cervical fusion or additional C3 fixation. Routine anterior fixation using the Reindl and Koller techniques for the right lateral atlantoaxial joint were also unsuitable due to the characteristics of the lateral mass fracture. As no alternative methods of transarticular fixation were available, the only possible and logical way of screw insertion into the anterior third of the right lateral mass was a contralateral trajectory from left to right, which we performed. The Koller technique was unsuitable for the left lateral joint due to crossing of the screw insertion trajectories. Significant thinning of the anterior lip of the C2 lateral mass at the left side resulted in the Reindl technique being unsuitable. Therefore, another atlantoaxial joint was fixed using routine Magerl technique.

In Case 2, the patient could not lie in the prone position due to concomitant cardiac pathology. Reduction of the atlantoaxial dislocation was insufficient, even after scar tissue resection at the odontoid process fracture via a left-sided submandibular approach. In addition, transdental fusion was not possible. Therefore, anterior transarticular fixation was the method of choice in this case. Fixation was performed using a previously established left-sided submandibular approach. Immobilization of the left lateral C1–C2 joint was performed using the Reindl technique. Both the Reindl and contralateral methods were suitable for the right lateral joint. Contralateral fixation was used since it was possible to insert a longer screw (38 mm vs. 20–22 mm) and to place the screw deeper into the C2 body. Good orthopedic results that were obtained in a previous case were also considered.

In both cases, contralateral fixation was not associated with any complications, and provided excellent stabilization of the C1–C2 segment.

Conclusion

Anterior transarticular fixation of the C1 and C2 vertebrae is an alternative method of upper cervical stabilization that is applicable in cases where posterior atlantoaxial fusion is not achievable due to anatomical characteristics of the patient, or if a prone position is undesirable due to concomitant diseases or combined injuries. Contralateral transarticular fixation can be applied if the screw has to be inserted into the anterior third of the lateral mass of the atlas. This type of fixation can be performed through a single approach if one screw is inserted using the Reindl technique and another is inserted via a contralateral trajectory. However, additional biomechanical studies of contralateral transarticular fixation stability and rigidity should be performed.

Acknowledgements We would like to thank Editage (https://www.editage.com) for English language editing.

Compliance with ethical standards

Conflict of interest None of the authors has any potential conflict of interest.

References

1. Lu J, Ebraheim NA, Yang H, Heck BE, Yeasting RA (1998) Anatomic considerations of anterior transarticular screw fixation for atlantoaxial instability. Spine 23:1229–1235
2. Reindl R, Sen M, Aebi M (2003) Anterior instrumentation for traumatic C1–C2 instability. Spine 28:E329–E3233
3. Sen MK, Steffen T, Beckman L, Tsantrizos A, Reindl R, Aebi M (2005) Atlantoaxial fusion using anterior transarticular screw fixation of C1–C2: technical innovation and biomechanical study. Eur Spine J 14:512–518
4. Koller H, Kammermeier V, Ulbricht D, Assuncao A, Karolus S, van den Berg B et al (2006) Anterior retropharyngeal fixation C1–2 for stabilization of atlantoaxial instabilities: study of feasibility, technical description and preliminary results. Eur Spine J 15:1326–1338
5. Lapsiwala SB, Anderson PA, Oza A, Resnick DK (2006) Biomechanical comparison of four C1 to C2 rigid fixative techniques: anterior trans- articular, posterior transarticular, C1 to C2 pedicle, and C1 to C2 intralaminar screws. Neurosurgery 58:516–521
6. Ji W, Zheng M, Tong J, Huang Z, Chen J, Qu D et al (2015) Feasibility and trajectory study of anterior transarticular crossing screw placement for atlantoaxial joint instability: a cadaveric study and description of a novel technique. Eur Spine J 24:2954–2960
7. Greene KA, Dickman CA, Marciano FF, Drabier JB, Hadley MN, Sonntag VK (1997) Acute axis fractures. Analysis of management and outcome in 340 consecutive cases. Spine 22:1843–1852
8. Jacobson ME, Khan SN, An HS (2012) C1–C2 posterior fixation: indications, technique, and results. Orthop Clin N Am 43:11–18
9. Elliott RE, Tanweer O, Boah A, Morsi A, Ma T, Frempong-Boadu A et al (2014) Outcome comparison of atlantoaxial fusion with transarticular screws and screw-rod constructs: meta-analysis and review of literature. J Spinal Disord Tech 27:11–28