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GRAND ROUNDS

Salvage of failed odontoid fixation through anterior C1/C2 transarticular screws

K. M. I. Salem · I. Collins · B. M. Boszczyk

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Abstract

Odontoid fracture fixation allows for early mobilisation out of orthosis. Both anterior and posterior fixation techniques have been described but anterior surgery has less post-operative morbidity through the use of natural cleavage planes. We described the use of anterior transarticular stabilisation as a salvage procedure following a failed odontoid screw fixation.

Keywords Odontoid fracture · Revision surgery · Odontoid screw fixation · Anterior C1/2 transarticular fusion

K. M. I. Salem (✉) · B. M. Boszczyk
Nottingham University Hospital NHS Trust, Centre for Spinal Studies and Surgery, Queen's Medical Centre Campus, Nottingham NG7 2UH, UK
e-mail: kmsalem@gmail.com

B. M. Boszczyk
e-mail: bronek.boszczyk@nuh.nhs.uk

I. Collins
Morriston Hospital, Swansea, West Glamorgan SA6 6NL, UK

Case presentation

A healthy 66-year-old male presented to the emergency department shortly after falling off a bicycle and was complaining of neck pain and transient right upper and lower limb numbness lasting 20 min. He was wearing a helmet and hit his head against concrete. Following a basic examination, he was found to have a laceration to the forehead and mild neck tenderness on palpation. His neurological examination was reported as normal and because of pre-existing stiffness in the neck following a preceding fall 2 years ago, the limited neck range of motion was deemed insignificant. He was discharged home from the emergency department with no imaging.

He reattended the emergency department a couple of days later with persistent neck pain, limited range of motion, and altered sensation in the right upper and lower limbs with subjective right upper and lower limb weakness. A repeat examination recorded diffuse posterior cervical spine tenderness with reduced range of motion. A neurological examination revealed a right-sided upper and lower limb weakness (grade 4/5 in all myotomes) with altered sensation in the same distribution and a normal rectal examination. He was placed in a hard collar and an X-ray and a CT of his neck (Fig. 1) identified a C2 fracture with C1/2 displacement and a referral to the regional spine unit made.

After transfer, an MRI scan of the cervical spine was performed (Fig. 2) and after counselling the patient, surgical stabilisation was felt to be the better option in managing this unstable injury.

Under a general anaesthetic and after reducing the fracture, an anterior odontoid osteosynthesis with a single central 38 mm × 4.5 mm cannulated odontoid screw was performed (Fig. 3).

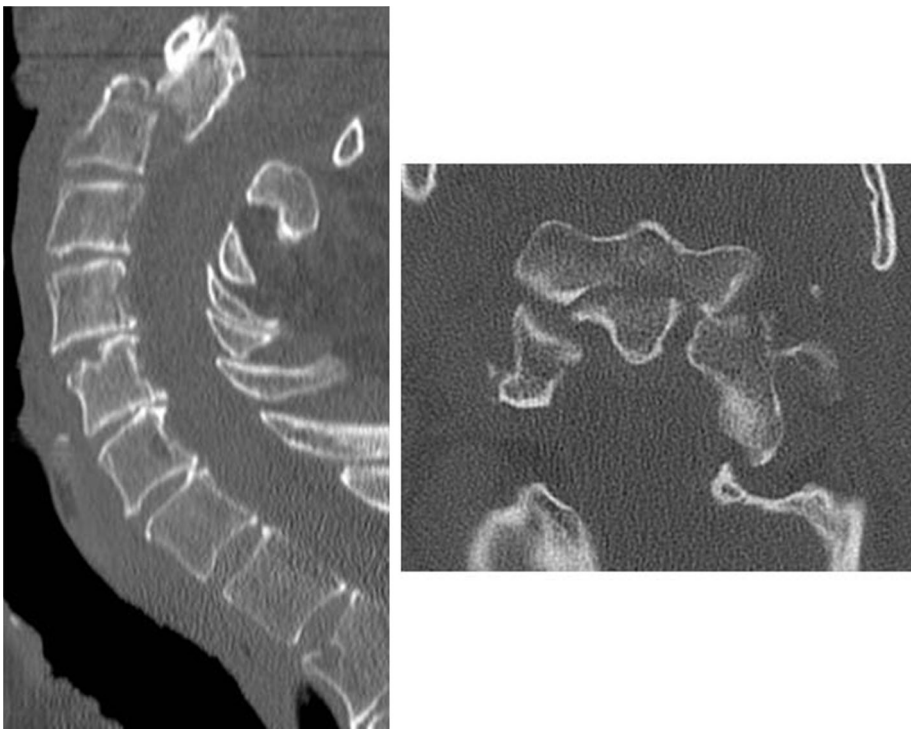

Fig. 1 Coronal and axial images of the cervical spine confirming a displaced type 2 odontoid fracture

Fig. 2 Pre-operative MRI scan of the cervical spine confirming a displaced odontoid fracture with no significant cord compression but evidence of cord oedema at C2 level

Diagnostic imaging section

Cervical spine X-rays taken 4 days post-operatively demonstrated recurrent displacement of the odontoid which was subsequently also confirmed with a CT scan (Figs. 4, 5). The patient's power had improved post-surgery and remained normal in the upper and lower limbs but the fracture position was felt to be unacceptable and he was consented for revision fixation.

Historical review of the condition, epidemiology, diagnosis, pathology, differential diagnosis

Odontoid fractures are not uncommon accounting for 9–18 % of all cervical spine fractures and are the most common cervical spine fractures in the elderly [1] usually caused by a hyperextension or hyperflexion injury. In their paper published in 1974, Anderson and D'Alonzo reviewed 49 odontoid fractures and classified them into three groups;

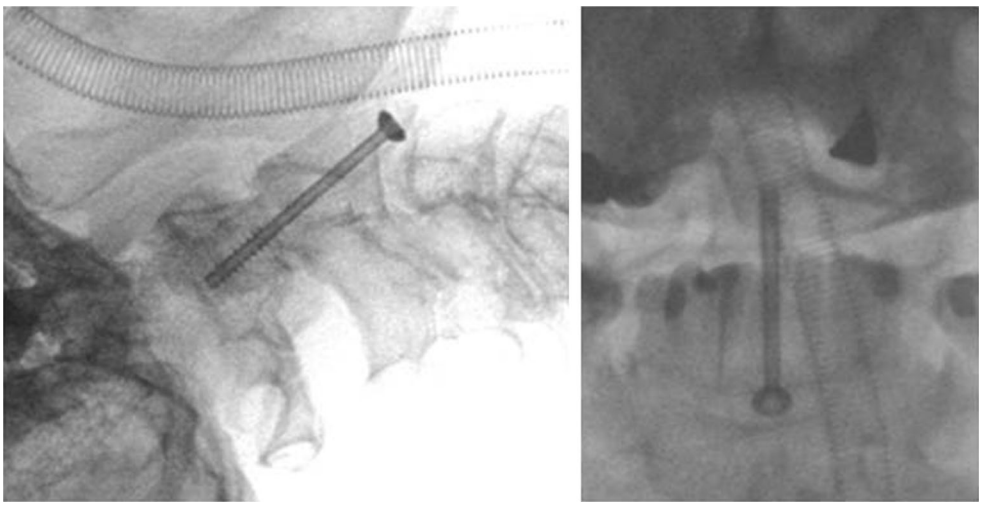

Fig. 3 Intraoperative image intensifier AP and lateral views of the upper cervical spine confirming the incomplete but improved reduction of the fracture with a satisfactory position of the cannulated screw and interfragmentary compression

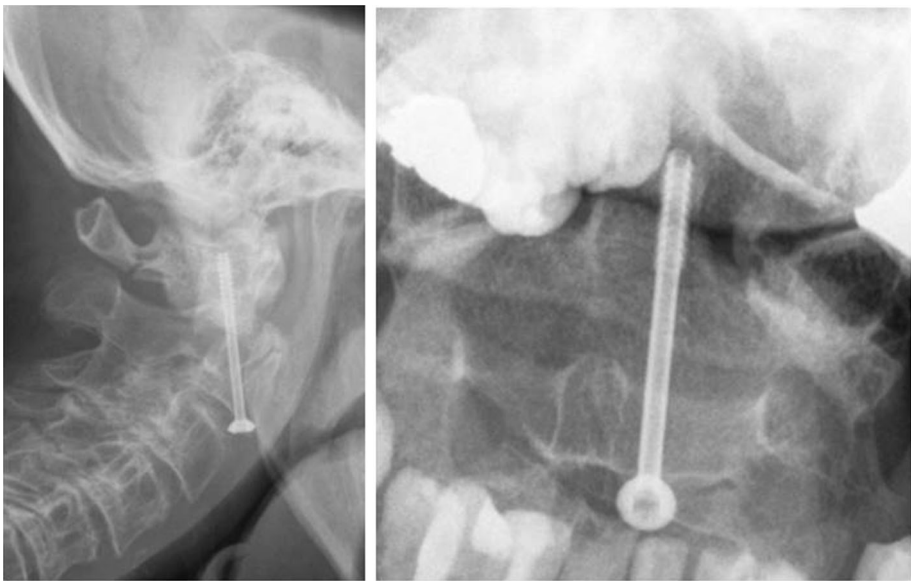

Fig. 4 A cervical spine X-ray taken 4 days post-surgery confirming displacement of the fracture

type 1 was described as an avulsion fracture at the tip of the odontoid above the transverse ligament (TL), type 2 (the most common) is an "odontoid body" fracture occurring between the TL and the base of the odontoid whilst a type 3 was described as basilar and extended into the vertebral body of the axis [2]. More recently, Grauer et al. set out to address the challenge of differentiating type 2 from 3 and address the morphological variations within type two injuries; the authors defined type 2 fractures as those located at or below the inferior aspect of the anterior C1 ring and do not extend into the superior articular facets of C2 which meant that involvement of the C2 superior facet was the marker for a type 3 fracture irrespective of the distal extension of the fracture. The authors also described subtypes in type 2 fractures; 2A being transverse fractures without comminution and with less than 1 mm displacement, 2B fractures pass from anterior superior to posterior inferior or displaced transverse fractures (greater than 1 mm) and type C passes from anterior inferior to posterior superior or fractures with significant comminution [3]. Based on this classification, our patient had suffered odontoid fracture type 2B. Of note is that the literature lacks information investigating the limit of angulation in a type 2B odontoid fracture amenable to anterior odontoid screw fixation.

Although both conservative and operative treatment for type 2 fractures are well described [4], a critical review of the literature suggested that surgical intervention supersedes the conservative treatment in clinical outcome (better Neck Disability Index), had a better osseous union (78 vs

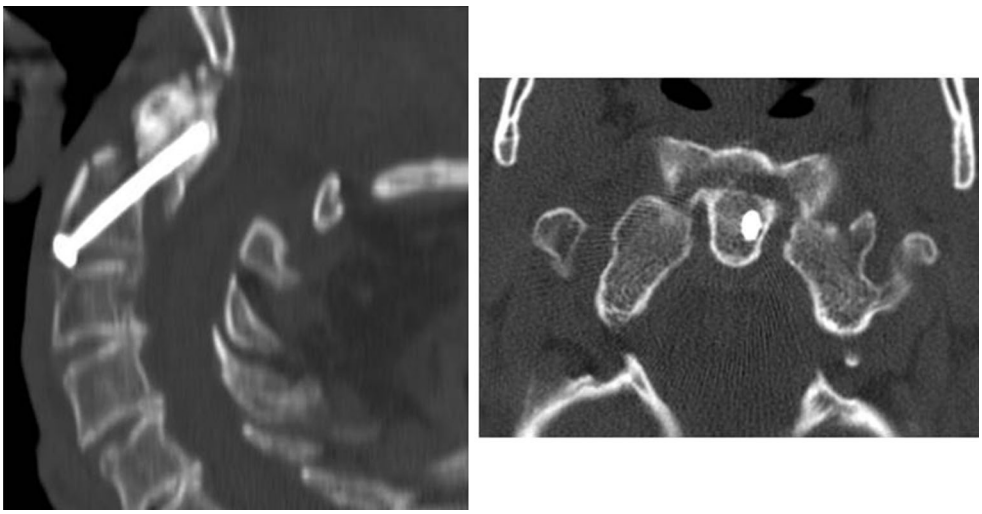

Fig. 5 CT scan of the cervical spine confirming the redisplacement of the fracture and outlining the position of the cannulated screw. No further significant comminution noted

36 %), and a superior fracture stability measured using dynamic (Flexion/Extension) X-rays (95 vs 77 %) [1].

A number of surgical interventions have been described including Gallie's [5] C1/2 posterior wiring, Magerl's [6] posterior transarticular screws, Goel's [7] posterior C1 lateral mass, and C2 pedicle instrumentation which was later described by Harms and Melcher [8] using polyaxial screws. Despite the apparent advantage of a high fusion rate approaching 100 % with fusion surgery, the techniques are attached to significant risks including vascular injury to the internal carotid or vertebral arteries, the hypoglossal nerve injury, and significant limitation of cervical spine rotation (approximately reduced by 50 %) [4] which encouraged alternative anterior fixation using anterior odontoid screw fixation as described by Bohler [9] in 1982.

An anterior odontoid screw fixation is believed to provide adequate stability to allow for early cervical mobilisation preserving the C1/2 rotation [10]. Stability can be achieved using one 4.5 mm cannulated screw or two 3.5 cannulated screws; a biomechanical cadaveric study revealed a 4.5 mm screw fixation to have a better shear stiffness and a significantly higher torsional stiffness [11]. Fusion rates were not significantly different (approximately 83 %) when the two techniques were compared [12]. In the elderly population, the anterior odontoid screw fixation is a recognised management option [13] albeit compromised by the associated osteoporosis and the significant comminution at the fracture site [14].

Rationale for treatment and evidence-based literature

In 2005, Sen et al. described an anterior C1/2 fixation through an anterior (Smith–Robinson) approach. Compared

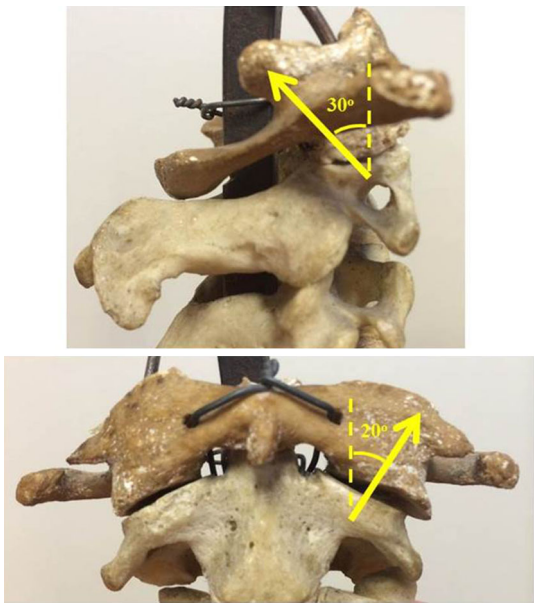

Fig. 6 Trajectory of the anterior C1/C2 screws

with posterior fusions, patient positioning is easier, the approach is less traumatic, and has a lower infection rate whilst compared with Magerl's technique; the starting point is closer to the vertebral artery foramen so the screw path is safer whilst the segmental stability is not significantly different [15]. The authors described a starting point just below the sulcus on the anterior body of C2, mid-lateral mass. A K-wire is advanced in a posterior-superior direction angled 20° coronally and 30° sagittally until it reaches the subchondral bone of the superior joint surface of the C1 mass (Fig. 6). The screw length is then measured and a 4.5-mm self-cutting partially threaded cannulated cortical screw was inserted.

The results of a 3-year follow-up of 22 (44 screws) patients treated with an anterior C1/2 transarticular fusion reported no significant intraoperative complication with 18 % of the screws too long, 7 % too anterior, and 7 % too medial. The author has described low intraoperative blood loss and a significant improvement in pain immediately post-surgery [16].

We believe the failure of the initial fixation with an anterior odontoid screw was the result of under appreciation of the local comminution which did not allow for the maintenance of the interfragmentary compression achieved intraoperatively. A posterior fusion procedure is an option but the displaced anterior metalwork had to be addressed and we felt that a revision of the anterior odontoid supplemented by bilateral anterior transarticular fusion will be sufficient to prevent further displacement whilst avoiding the morbidity of the exposure and the fixation in a posterior technique.

Procedure (surgery, intervention)

The revision procedure was done under general anaesthetia with the patient supine; bilateral C1/C2 anterior transarticular lateral mass cannulated screws (4.5 × 20 mm) (Fig. 7) were introduced under image guidance. Postoperatively, the course was uncomplicated, a single drain was removed the first day post-surgery and was discharged full weight bearing in a moulded Occipito-Cervico-Thoracic (OCT) orthosis.

Intraoperatively we used a size 8 endotracheal tube to act as a working channel for introducing the K-wires and screws. The tube has a conveniently bevelled end which can be rested on the anterior aspect of the C2 vertebral body lateral mass allowing for atraumatic instrumentation. Additionally, the tube has a useful radiopaque marker that guides positioning intraoperatively.

Outcome and follow-up

At follow-up, serial cervical spine X-rays were taken and a CT scan of the cervical spine was performed at 3 months post-operatively which conformed bony union across the fracture with no metal work loosening. The OCT was removed at that stage. At 1 year post-operatively, the patient had no neck pain, satisfied with the intervention, cycling 60 miles per week with a Neck Disability Index of 2 %, and a pain visual analogue score of 0/10.

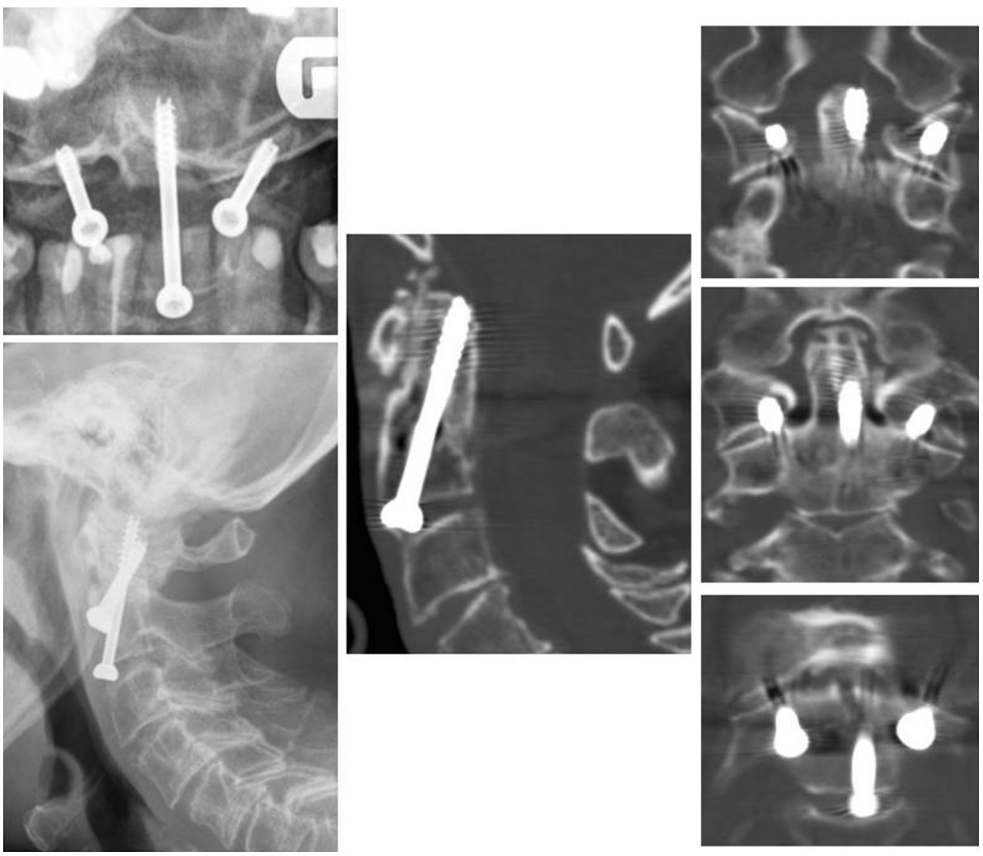

Fig. 7 X-ray and CT scans of the cervical spine confirming satisfactory placement of the screws

Conflict of interest None.

References

1. Huybregts JG, Jacobs WC, Vleggeert-Lankamp CL (2013) The optimal treatment of type II and III odontoid fractures in the elderly: a systematic review. Eur Spine J Off Publ Eur Spine Soc Eur Spinal Deform Soc Eur Sect Cerv Spine Res Soc 22(1):1–13 (Epub 2012/09/04)
2. Anderson LD, D'Alonzo RT (1974) Fractures of the odontoid process of the axis. J Bone Joint Surg Am Vol 56(8):1663–1674 (Epub 1974/12/01)
3. Grauer JN, Shafi B, Hilibrand AS, Harrop JS, Kwon BK, Beiner JM et al (2005) Proposal of a modified, treatment-oriented classification of odontoid fractures. Spine J Off J N Am Spine Soc 5(2):123–129 (Epub 2005/03/08)
4. Pal D, Sell P, Grevitt M (2011) Type II odontoid fractures in the elderly: an evidence-based narrative review of management. Eur Spine J Off Publ Eur Spine Soc Eur Spinal Deform Soc Eur Sect Cerv Spine Res Soc 20(2):195–204 (Epub 2010/09/14)
5. Gallie WE (1937) Skeletal traction in the treatment of fractures and dislocations of the cervical spine. Ann Surg 106(4):770–776 (Epub 1937/10/01)
6. Magerl F, Seeman PS (1986) Stable posterior fusion of the atlas and axis by transarticular screw fixation. In: Kehr P, Weidner A (eds) Cervical spine. Springer, Wien, pp 267–278
7. Goel A, Laheri V (1994) Plate and screw fixation for atlanto-axial subluxation. Acta Neurochir (Wien) 129(1–2):47–53 (Epub 1994/01/01)
8. Harms J, Melcher RP (2001) Posterior C1-C2 fusion with polyaxial screw and rod fixation. Spine 26(22):2467–2471 (Epub 2001/11/15)
9. Bohler J (1982) Anterior stabilization for acute fractures and nonunions of the dens. J Bone Jt Surg Am Vol 64(1):18–27 (Epub 1982/01/01)
10. Sasso R, Doherty BJ, Crawford MJ, Heggeness MH (1993) Biomechanics of odontoid fracture fixation. Comparison of the one- and two-screw technique. Spine 18(14):1950–1953 (Epub 1993/10/15)
11. McBride AD, Mukherjee DP, Kruse RN, Albright JA (1995) Anterior screw fixation of type II odontoid fractures. A biomechanical study. Spine 20(17):1855–1859 (discussion 9–60) (Epub 1995/09/01)
12. Jenkins JD, Coric D, Branch CL Jr (1998) A clinical comparison of one- and two-screw odontoid fixation. J Neurosurg 89(3):366–370 (Epub 1998/09/02)
13. Chapman J, Smith JS, Kopjar B, Vaccaro AR, Arnold P, Shaffrey CI et al (2013) The AOSpine North America Geriatric Odontoid Fracture Mortality Study: a retrospective review of mortality outcomes for operative versus nonoperative treatment of 322 patients with long-term follow-up. Spine. 38(13):1098–1104 (Epub 2013/01/29)
14. Andersson S, Rodrigues M, Olerud C (2000) Odontoid fractures: high complication rate associated with anterior screw fixation in the elderly. Eur Spine J Off Publ Eur Spine Soc Eur Spinal Deform Soc Eur Sect Cerv Spine Res Soc 9(1):56–59 (Epub 2000/04/15)
15. 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 Off Publ Eur Spine Soc Eur Spinal Deform Soc Eur Sect Cerv Spine Res Soc 14(5):512–518 (Epub 2005/01/26)
16. Josten C, Jarvers J, Riesner H, Franck A, Glasmacher S, Schmidt C (2012) 3 year results of the anterior transarticular c1-2 fusion in atlanto-axial instabilities of elder patients. J Bone Joint Surg Br 94-B(SUPP XXXVII):386