Original Article

Transoral screw and wire fixation for unstable anterior ½ atlas fracture

ABSTRACT

Study Design: Atlas fractures are evaluated according to the fracture type and ligamentous injury. External immobilization may result in fracture nonunion.

Objective: The ideal treatment method for non-stabilized atlas fractures is limited fixation without restricting the range of motion of the atlantoaxial and atlantooccipital joints.

Summary of Background Data: Such a result can be established by using either anterior fixation or posterior lateral mass fixation. However, none of these techniques can fully address anterior 1/2 atlas fractures such as in this case.

Materials and Methods: A transoral technique in which bilateral screws were placed intralaminarly and connected with wire was used to reduce and stabilize an anterior 1/2 fracture of C1.

Result: Radiological studies after the surgery showed good cervical alignment, no screw or wire failure and good reduction with fusion of anterior arcus of C1.

Conclusions: Internal immobilization by this screw and wire osteosynthesis technique protects the mobility of the atlanto-occipital and atlantoaxial joints. The main advantage is that neither the twisted wires inserted under the anterior lamina, nor the laterally placed screw heads interfere with midline wound closure; unlike the plate/cage and rod systems used together with anterior screws. A computer navigation system with intraoperative 3D imaging facilities will be of benefit for safe placement of the screw, however we preferred a free-hand technique, as the starting point was at the fracture line along the trajectory of the routinely accessible anterior lamina.

Keywords: Atlas fracture, C1 fracture, screw, transoral, wire

INTRODUCTION

Fractures of the atlas account for 25% of all craniocervical injuries and approximately 1.3% of all spinal fractures.[1,2] They were originally described in the 1800s and classified by Jefferson,[3] Segal *et al.*,[4] and Levine and Edwards.[5] Due to its unique anatomy, anterior and posterior arches are thin and thus fracture with two or more breaks in the ring. Burst fractures, posterior arch fractures, and comminuted lateral mass fractures each represent 20%–30% of all atlas injuries.[6] In the anterior isolated fractures of the atlas, when the transverse atlantal ligament is insufficient to reduce the fractured parts as in our case [Figure 1]; prolonged nonunion with persistent neck pain is common.[7-10] Neurologic injury is rare because ring fractures increase the space and thus inhibit any compression; quadriplegia and hemiparesis may occur (12%–33%) but often transiently for a few minutes.[11,12]

Surgical versus nonsurgical treatment are often determined by fracture location and integrity of the transverse ligament.[13,14] Fractures are best assessed by multidetector computed tomography (CT),[15] and although a lateral mass spread >6.9 mm shows disruption of the transverse ligament,

Access this article online	
	Quick Response Code
Website: www.jcvjs.com	
DOI: 10.4103/jcvjs.JCVJS_94_17	

Semih Keskil, Murat Göksel, Ulas Yüksel

Department of Neurosurgery, Kırıkkale University Medical School, Kırıkkale, Turkey

Address for correspondence: Prof. Semih Keskil, Department of Neurosurgery, Kirikkale University Medical School, Kırıkkale, Turkey.
E-mail: semihkeskil@gmail.com

How to cite this article: Keskil S, Göksel M, Yüksel U. Transoral screw and wire fixation for unstable anterior ½ atlas fracture. J Craniovert Jun Spine 2017;8:364-8.

magnetic resonance imaging (MRI) is a more sensitive indicator of ligament disruption or partial avulsion.[16-18] Long-term nonsurgical immobilization can cause irreversible arthrosis of the atlantoaxial joint,[19] and surgical fusion of C_1 to either C_2 or occiput restricts range of motion[20] causing degeneration of the subaxial cervical spine.[21] Recently, posterior motion-preserving ring osteosynthesis techniques that fix the fracture fragments in a reduced position so as to implement internal immobilization have been described.[17,22,23] However, none of these posterior approach techniques can be used in anterior 1/2 Jefferson fractures as in our case. There are also reports describing anterior motion-preserving ring osteosynthesis by transoral approach, using either screw-plate or screw-rod constructs.[21,24,25]

Since CT and MRI data on the integrity of the transverse ligament were not usually reported in these reports, transverse ligament rupture may cause permanent anterior instability. However, ring osteosynthesis has been shown to provide adequate stabilization even when associated with transverse ligament rupture.[26] Moreover, none of the documented cases have reported on late instability.[21,27] The main problem with the present transoral ring osteosynthesis techniques is the thickness of the posterior pharyngeal soft tissue being not enough to cover the plate or rod, thus increasing the risk of wound problems.[28,29] The purpose of this paper is to describe a novel technique in which screws and wire are used as a transoral motion-preserving surgical technique for reduction and stabilization of unstable ½ anterior atlas fractures.

MATERIALS AND METHODS

After informed consent, a 51 years old male patient involved in a motor vehicle accident was admitted to our department with complaints of severe neck pain and stiffness. His neurological examination was normal except for increased deep tendon reflexes and global hypoesthesia in the upper extremities. The thin section computerized tomography revealed a bilateral fracture in atlas anterior arcus and mild comminution of the fracture together with lateral mass displacement [Figure 2] making us think about an unstable fracture while MRI could not visualize the transverse atlantal ligament in detail. We discussed with the patient about his noncompliance with our instructions concerning the use of rigid cervical collar and the resulting progression of his pain. We also talked about the risks, benefits and expectations of surgical intervention; and the patient chose to undergo surgery. Preoperative evaluation also included orthodontic examination, nutritional condition of the patient, and the functional state of lower cranial nerves. The patient was informed that data concerning the case would be submitted for publication and agreed to this.

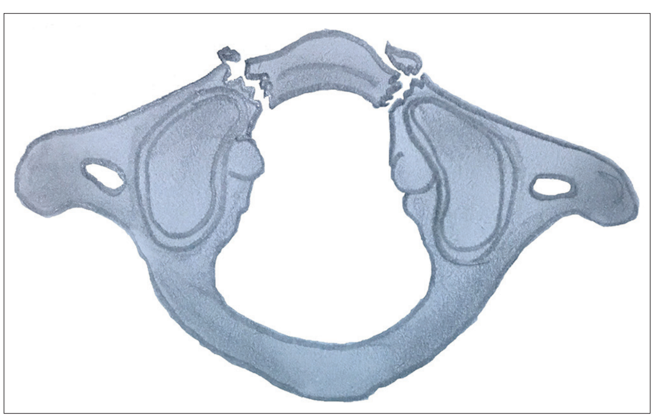

Figure 1: A line diagram showing anterior 1/2 Jefferson fracture

Surgical technique

The patient was positioned supine with the head slightly extended and secured in the Mayfield (Integra Co, Plainsboro, New Jersey, USA) three-point skull fixation system while the operating table was in a slight Trendelenburg position. We did not use our navigation system or intraoperative three-dimensional (3D) imaging facilities for this case. The surgeon stood on the right side of the patient. A nasogastric feeding tube was placed and parenteral antibiotics were given prophylactically. We placed 2.0 silk sutures bilaterally into the uvula and later on for the duration of the procedure pulled these sutures up through the nostril to elevate the soft palate bisected at the right of the uvula from the mid-region up to the hard palate so as to visualize the upper portion of the posterior pharynx. A Crockard self-retaining oral retractor system was used to open the patient's jaw. Care was taken to avoid trapping the tongue against the teeth. Anesthesia aided a wide mandibular opening by creating a temporary neuromuscular blockade. Throughout the remainder of the

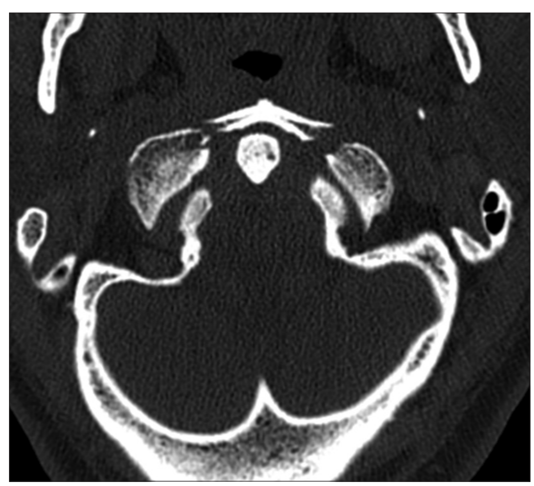

Figure 2: Preoperative axial computed tomography scan shows atlas anterior arch comminuted fracture together with lateral mass displacement

procedure making contact with the oral cavity was avoided aside from the incision.

After injection of the posterior pharynx with 1% lidocaine with epinephrine, fluoroscopy was used to identify the area of the posterior pharyngeal wall overlying the odontoid process and C-1 arch. Under microscopic visualization with a 400-mm lens, a 2-cm incision of the mucosa of the posterior pharynx was made overlying the midline C-1 arch to form a lateral-based door-like flap. Care was taken to minimize the extent of the incision, taking into account that the incision would be further expanded by subsequent retraction. The longitudinal muscles were split in the midline to isolate the C-1 arch using monopolar electrocautery and subperiosteal technique. Isolation and skeletonization of the fracture lines marked the lateral extent of the dissection. Once the fracture line was adequately visualized, a dissector was place and its location over the C_1 anterior arch was confirmed through two-dimensional fluoroscopy.

The entry point for the intralaminar screws was the fracture line. Since the drill could slip and break the C1 lamina during the process of forming the pilot hole, a high-speed burr was used to drill the pilot hole. For the free-hand screw trajectory, the lower margin and the medial edge of the lateral mass of C1 were also palpated and the drill hole was controlled to be without breach by further probing. The screw was advanced fully with excellent purchase through the fracture line and was tightened until the proximal end was countersunk into the bone for 1–2 mm. The length and diameter of the titanium screws used were 20 and 3.5 mm, respectively. The screw heads were then wrapped with separate titanium wires which were approximated and twisted in the midline so as to fix the mobile part of the C1 arch between the fracture lines. The position of the screws was verified by C-arm fluoroscopy. The twisted wires were inserted under the anterior lamina so that they did not interfere with wound closure.

Thorough irrigation of the operative site with povidone-iodine solution was performed. The surgical bed was then filled with Gelfoam. The closure was performed in two layers, muscular and mucosal, with Vicryl 3.0 continuous stitches. In the site of myotomy of the uvula and the soft palate, closure was performed in three layers. The operative time was 125 min, the fluoroscopic time was 60 s, and the patient did not require blood transfusion. The nasogastric tube that was placed before the surgery was retained.

Postoperative course

The patient was mobilized the first postoperative day. The patient did not take any solids or fluids orally for 3 days following surgery. External immobilization through hard collar was used for 6 weeks. Antibiotics were continued for 5 days. A CT scan obtained in the early postoperative period showed significant reduction of the fracture with appropriate placement of the screws and wires [Figure 3] while CT scan taken in the late postoperative period showed no implant failure, good cervical alignment, and good reduction with fusion of C1 [Figure 4]. Neurologic function was assessed 6 months after the surgery to find that hyperreflexia and hypoesthesia being resolved with a mild rhinolalia aperta symptom. Dynamic flexion and extension radiographs were taken at 180 days postoperatively to detect any flaws in fracture consolidation.

DISCUSSION

Transoral approaches (transpharyngeal, transpalatal, transmaxillary, and transmandibular) are not new surgical procedures. In 1917, Kanavel[30] first reported removing a bullet fragment from the anterior arch of the atlas by this approach which has since been used for the treatment of many extradural and intradural lesions[31-37] with a high mortality rate.[34,38-41] In spite of the recent technical advances in monitorization, retraction, magnification, illumination, navigation, wound closure[31,32,38] and regardless of the standard, microscopic or endoscopic approaches;[31,32,42] postoperative complication rates as high as 75%,[21,24,28,29,43,44] including wound infection and dehiscence rates of 9-22%,[24,26] breathing-swallowing and speech dysfunction rates of 4%,[44] velopharyngeal insufficiency rates of 40%[24,26] are still being reported together with cerebrospinal fluid leaks and pseudomeningocele.[32,36,44,45]

Indications for the presented surgical technique include displaced anterior 3/4 and 1/2 atlas fractures. Reduction through an anterior approach is logical since the center of the lateral masses is close to the anterior aspect of the atlas and the lever arm for reduction shorter. Internal immobilization by this screw and wire osteosynthesis

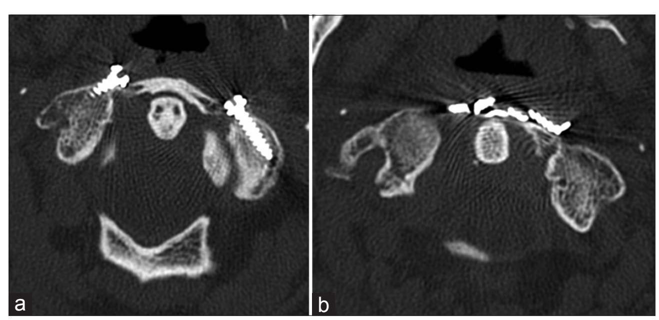

Figure 3: Postoperative axial computed tomography (CT) scan shows the screws inserted at the fracture line (a) and the twisted connecting wire underlying the lamina (b)

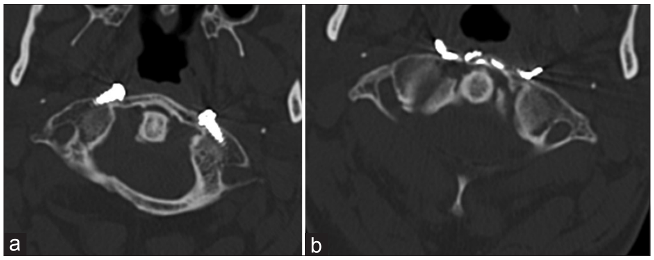

Figure 4: Axial plane computed tomography at 1 year follow-up showing satisfactory osseous fusion, good position of the screw (a) and wire (b) construction and good reduction of the fracture

technique also protects the mobility of the atlanto-occipital and atlantoaxial joints. The main advantage is that neither the twisted wires inserted under the anterior lamina nor the laterally placed screw heads interfere with midline wound closure; unlike, plate/cage and rod systems used together with anterior screws. A computer navigation system with intraoperative 3D imaging facilities will be of benefit for safe placement of the screw; however, we preferred a free-hand technique as the starting point was at the fracture line along the trajectory of the routinely accessible anterior lamina.

To conclude, transoral C1-ring osteosynthesis using wire and screws has the potential to become a valid alternative method, in our opinion, to achieve an optimal stabilization and bony fusion of the fragments in anterior Jefferson burst fractures with a low morbidity rate while preserving important cervical joint motion. Further investigation is warranted to establish the safety and efficacy of this technique, but in our knowledge, this is the first description of the transoral use of screw and wire to achieve reduction of distracted fragments in anterior 1/2 fracture of the atlas.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. An HS. Cervical spine trauma. Spine (Phila Pa 1976) 1998;23:2713-29.
2. Dickman CA, Sonntag VK. Injuries involving the transverse atlantal ligament: Classification and treatment guidelines based upon experience with 39 injuries. Neurosurgery 1997;40:886-7.
3. Jefferson G. Fractures of the atlas vertebra. Report of four cases, and a review of those previously recorded. Br J Surg 1919;7:407-22.
4. Segal LS, Grimm JO, Stauffer ES. Non-union of fractures of the atlas. J Bone Joint Surg Am 1987;69:1423-34.
5. Levine AM, Edwards CC. Traumatic lesions of the occipitoatlantoaxial complex. Clin Orthop Relat Res 1989;239:53-68.
6. Bransford R, Chapman JR, Bellabarba C. Primary internal fixation of unilateral C1 lateral mass sagittal split fractures: A series of 3 cases. J Spinal Disord Tech 2011;24:157-63.
7. Easter JS, Barkin R, Rosen CL, Ban K. Cervical spine injuries in children, part II: Management and special considerations. J Emerg Med 2011;41:252-6.
8. Guiot B, Fessler RG. Complex atlantoaxial fractures. J Neurosurg 1999;91:139-43.
9. Rozzelle CJ, Aarabi B, Dhall SS, Gelb DE, Hurlbert RJ, Ryken TC, *et al.* Management of pediatric cervical spine and spinal cord injuries. Neurosurgery 2013;72 Suppl 2:205-26.
10. Wang J, Zhou Y, Zhang ZF, Li CQ, Zheng WJ, Zhang Y, *et al.* Direct repair of displaced anterior arch fracture of the atlas under microendoscopy: Experience with seven patients. Eur Spine J 2012;21:347-51.
11. Han SY, Witten DM, Mussleman JP. Jefferson fracture of the atlas. Report of six cases. J Neurosurg 1976;44:368-71.
12. Levine AM, Edwards CC. Fractures of the atlas. J Bone Joint Surg Am 1991;73:680-91.
13. Dickman CA, Greene KA, Sonntag VK. Injuries involving the transverse atlantal ligament: Classification and treatment guidelines based upon experience with 39 injuries. Neurosurgery 1996;38:44-50.
14. Landells CD, Van Peteghem PK. Fractures of the atlas: Classification, treatment and morbidity. Spine (Phila Pa 1976) 1988;13:450-2.
15. Lin JT, Lee JL, Lee ST. Evaluation of occult cervical spine fractures on radiographs and CT. Emerg Radiol 2003;10:128-34.
16. Haus BM, Harris MB. Case report: Nonoperative treatment of an unstable Jefferson fracture using a cervical collar. Clin Orthop Relat Res 2008;466:1257-61.
17. Jo KW, Park IS, Hong JT. Motion-preserving reduction and fixation of C1 Jefferson fracture using a C1 lateral mass screw construct. J Clin Neurosci 2011;18:695-8.
18. Spence KF Jr., Decker S, Sell KW. Bursting atlantal fracture associated with rupture of the transverse ligament. J Bone Joint Surg Am 1970;52:543-9.
19. Hein C, Richter HP, Rath SA. Atlantoaxial screw fixation for the treatment of isolated and combined unstable Jefferson fractures – Experiences with 8 patients. Acta Neurochir (Wien) 2002;144:1187-92.
20. Payer M, Luzi M, Tessitore E. Posterior atlanto-axial fixation with polyaxial C1 lateral mass screws and C2 pars screws. Acta Neurochir (Wien) 2009;151:223-9.
21. Ruf M, Melcher R, Harms J. Transoral reduction and osteosynthesis C1 as a function-preserving option in the treatment of unstable Jefferson fractures. Spine (Phila Pa 1976) 2004;29:823-7.
22. Abeloos L, De Witte O, Walsdorff M, Delpierre I, Bruneau M. Posterior osteosynthesis of the atlas for nonconsolidated Jefferson fractures: A new surgical technique. Spine (Phila Pa 1976) 2011;36:E1360-3.
23. Keskil S, Göksel M, Yüksel U. Unilateral lag-screw technique for an isolated anterior 1/4 atlas fracture. J Craniovertebr Junction Spine 2016;7:50-4.
24. Hu Y, Albert TJ, Kepler CK, Ma WH, Yuan ZS, Dong WX, *et al.* Unstable Jefferson fractures: Results of transoral osteosynthesis. Indian J Orthop 2014;48:145-51.
25. Ma W, Xu N, Hu Y, Li G, Zhao L, Sun S, *et al.* Unstable atlas fracture treatment by anterior plate C1-ring osteosynthesis using a transoral approach. Eur Spine J 2013;22:2232-9.
26. Koller H, Resch H, Tauber M, Zenner J, Augat P, Penzkofer R, *et al.* A biomechanical rationale for C1-ring osteosynthesis as treatment for displaced Jefferson burst fractures with incompetency of the transverse atlantal ligament. Eur Spine J 2010;19:1288-98.
27. Böhm H, Kayser R, El Saghir H, Heyde CE. Direct osteosynthesis of instable gehweiler type III atlas fractures. Presentation of a dorsoventral osteosynthesis of instable atlas fractures while maintaining function. Unfallchirurg 2006;109:754-60.
28. Ai F, Yin Q, Wang Z, Xia H, Chang Y, Wu Z, *et al.* Applied anatomy of transoral atlantoaxial reduction plate internal fixation. Spine (Phila Pa 1976) 2006;31:128-32.

29. Hu Y, Yang S, Xie H, He X, Xu R, Ma W, *et al.* The anatomic study on replacement of artificial atlanto-odontoid joint through transoral approach. J Huazhong Univ Sci Technolog Med Sci 2008;28:327-32.
30. Kanavel AB. Bullet located between the atlas and the base of the skull: Technic of removal through the mouth. Surg Clin Chic 1917;1:361-6.
31. Apuzzo ML, Weiss MH, Heiden JS. Transoral exposure of the atlantoaxial region. Neurosurgery 1978;3:201-7.
32. Crockard HA. The transoral approach to the base of the brain and upper cervical cord. Ann R Coll Surg Engl 1985;67:321-5.
33. Dickman CA, Locantro J, Fessler RG. The influence of transoral odontoid resection on stability of the craniovertebral junction. J Neurosurg 1992;77:525-30.
34. Janecka IP. Transoral-translabiomandibular approach to the craniovertebral junction. In: Dickman CA, Spetzler RF, Sonntag VH, editors. Surgery of the Craniovertebral Junction. New York: Thieme; 1998. p. 383-93.
35. Menezes AH, VanGilder JC. Transoral-transpharyngeal approach to the anterior craniocervical junction. Ten-year experience with 72 patients. J Neurosurg 1988;69:895-903.
36. Tuite GF, Veres R, Crockard HA, Sell D. Pediatric transoral surgery: Indications, complications, and long-term outcome. J Neurosurg 1996;84:573-83.
37. Yen YS, Chang PY, Huang WC, Wu JC, Liang ML, Tu TH, *et al.* Endoscopic transnasal odontoidectomy without resection of nasal turbinates: Clinical outcomes of 13 patients. J Neurosurg Spine 2014;21:929-37.
38. al-Mefty O, Borba LA, Aoki N, Angtuaco E, Pait TG. The transcondylar approach to extradural nonneoplastic lesions of the craniovertebral junction. J Neurosurg 1996;84:1-6.
39. de Almeida JR, Snyderman CH, Gardner PA, Carrau RL, Vescan AD. Nasal morbidity following endoscopic skull base surgery: A prospective cohort study. Head Neck 2011;33:547-51.
40. Türe U, Pamir MN. Extreme lateral-transatlas approach for resection of the dens of the axis. J Neurosurg 2002;96:73-82.
41. Yamaura A, Makino H, Isobe K, Takashima T, Nakamura T, Takemiya S, *et al.* Repair of cerebrospinal fluid fistula following transoral transclival approach to a basilar aneurysm. Technical note. J Neurosurg 1979;50:834-8.
42. Choi D, Crockard HA. Evolution of transoral surgery: Three decades of change in patients, pathologies, and indications. Neurosurgery 2013;73:296-303.
43. Al-Holou WN, Park P, Wang AC, Than KD, Marentette LJ. Modified trans-oral approach with an inferiorly based flap. J Clin Neurosci 2010;17:464-8.
44. Jain VK, Behari S, Banerji D, Bhargava V, Chhabra DK. Transoral decompression for craniovertebral osseous anomalies: Perioperative management dilemmas. Neurol India 1999;47:188-95.
45. Ponce-Gómez JA, Ortega-Porcayo LA, Soriano-Barón HE, Sotomayor-González A, Arriada-Mendicoa N, Gómez-Amador JL, *et al.* Evolution from microscopic transoral to endoscopic endonasal odontoidectomy. Neurosurg Focus 2014;37:E15.