Journal of Experimental and Clinical Medicine
https://dergipark.org.tr/omujecm

Research Article

J Exp Clin Med
2021; 38(2): 94-98
doi: 10.52142/omujecm.38.2.7

The application of C2 transpedicular screw, C1 laminar hook fixation and bone graft in the atlantoaxial instability

Sukru Oral[1,*]

[1]Department of Neurosurgery, Kayseri City Hospital, Kayseri, Turkey

Received: 30.09.2020 • **Accepted/Published Online:** 29.10.2020 • **Final Version:** 14.03.2021

Abstract

Traumatic atlantoaxial instability usually results from a motor vehicle accident, falls and motorcycle accidents. Atlantoaxial instability can lead to spinal cord compression and neck pain, but, spasticity and radicular symptoms as well. The purpose of surgery is to remove the compression and stabilize the joint permanently. To date, several surgical techniques have been described to remedy C1-C2 instability. In this study, the clinical and radiological outcomes of patients who operated with the C1 (Atlas bone) laminar hooks fixation and bilateral C2 (Axis bone) trans-pedicular screw technique were shown. Also, the advantages and disadvantages of this technique are discussed. From March 2010 to December 2017, 12 patients who have atlantoaxial instability were surgically treated by modified fixation technique which consists C1 laminar hooks fixation and bilateral C2 transpedicular screw. Twelve patients were operated with this procedure from March 2010 to December 2017. All the patients were checked with flexion-extension x-rays at the end of the twelfth week. The posterior bony fusion formation was observed on imaging in all patients. C2 bilateral pedicle screw combined with C1 laminar hook system is a good method for atlantoaxial instability in the conditions which is not convenient for insertion of C1 lateral mass and C2 trans-articular screw. However, this method may not be available in some cases such as traumatic, infection, neoplastic or degenerative pathologies in which the posterior arch of the atlas is damaged.

Keywords: curcumin, epidural, fibrosis, metilprednisolone

1. Introduction

The atlantoaxial region is a susceptible anatomic complex that involves an intricate relationship between the C1 and the dens of axis to permit the head to move in all directions. The atlantoaxial instability usually consists of traumas in the atlas and axis, rheumatological diseases, congenital anomalies or the rupture of the transverse ligament (Dickman and Sonntag, 1998). In these patients, the C1-C2 joint is corrected surgically, by performing fusion and stabilization (Bahadur et al., 2010). So far, many surgical methods have been defined for this region such as posterior wiring, and interlaminar clamping. In 1979, Magerl et al. presented the outcomes of a posterior C1-C2 trans-articular screw fixation (Gallie, 1939; Brooks and Jenkins, 1978; Magerl and Seemann, 1987). This technique and combination with posterior wiring is accepted as the gold standard in the surgical treatment of atlantoaxial instability by many authors (Grob et al., 1991; Coyne et al., 1995; Dickman and Sonntag, 1998). This is a very powerful technique biomechanically, but it is technically difficult. In addition, this technique may present some dangerous complications such as vertebral artery injury. From March 2010 to December 2017, 12 consecutive patients who have atlantoaxial instability were surgically treated by modified fixation technique which consists C1 laminar hooks fixation and bilateral C2 trans-pedicular screw. The advantages and disadvantages of this technique are shared in this study.

2. Materials and methods

2.1. Patients

The data from 12 patients who underwent surgery between 2010 and 2017 in our clinic were retrospectively scanned from hospital records. The demographic features and clinical characteristics of the patients are shown in Table I. All these

* Correspondence: sukruor@yahoo.com

patients were analyzed using computed tomography (CT), and magnetic resonance imaging (MRI) and cervical column X-ray. The radiological images include neutral, flexion-extension lateral radiographs (Figure 1). All patients presented to our institution after traumatic injury such as falls, motor vehicle accidents and motorcycle accidents. Their age ranged from 18 to 65 years. The main symptom is neck pain that spread towards the occipital area in the patients. Their neurological examination was intact in all cases. Physical findings included cervical spasm, cervical tenderness and resistance to range of motion. No other injuries to the thorax, abdomen or extremities were noted. Postoperative radiographic imaging was performed at 3, 6 and 12 months in the first year (Figure 2). The patients used the Philadelphia collar for an average of 8-12 weeks following the surgery. Ethics approval for the study was given by the local ethics committee (2020/10-15.01.2020).

2.2. Surgical Technique

All the operations were performed with general anesthesia. After anesthesia, the patients were given a prone position by applying a head holder on the operating table. The rolled side pillows were used to keep the rib cage under pressure. The surgical incision extending from the occipital protuberance to C3 spinous process was made in the posterior dorsal midline. After the skin and subcutaneous passage, the incision was directed to the midline avascular area and entered between the ligamentum nuchae and paravertebral muscles. The muscle layer was dissected and passed to the sides softly and bluntly. Then, the posterior tubercle of the C1 spine is exposed and slowly, without exerting too much pressure with subperiosteal dissection opened laterally. The pedicle screw insertion was executed under lateral radiographic control. The screw entry hole was created with high-speed surgical drill. Then, the screws are performed in a neutral to 20degree medial direction and 20degree superiorly. Then the laminar hooks which are designed for the posterior arch of atlas were placed on the ring of C1. Next the hooks were assembled to the screws with a suitable rod. Then, the rod is placed, and the screw covers are tightened and system integrity is ensured. The C1 posterior ring and axis bone surface prepared for fusion with a high-speed drill. Autogenous cancellous bone graft material which was procured from the posterior superior iliac spine was inserted between the atlas and axis. The surgical area was washed with saline. Then, the surgical area was closed with appropriate sutures and technique.

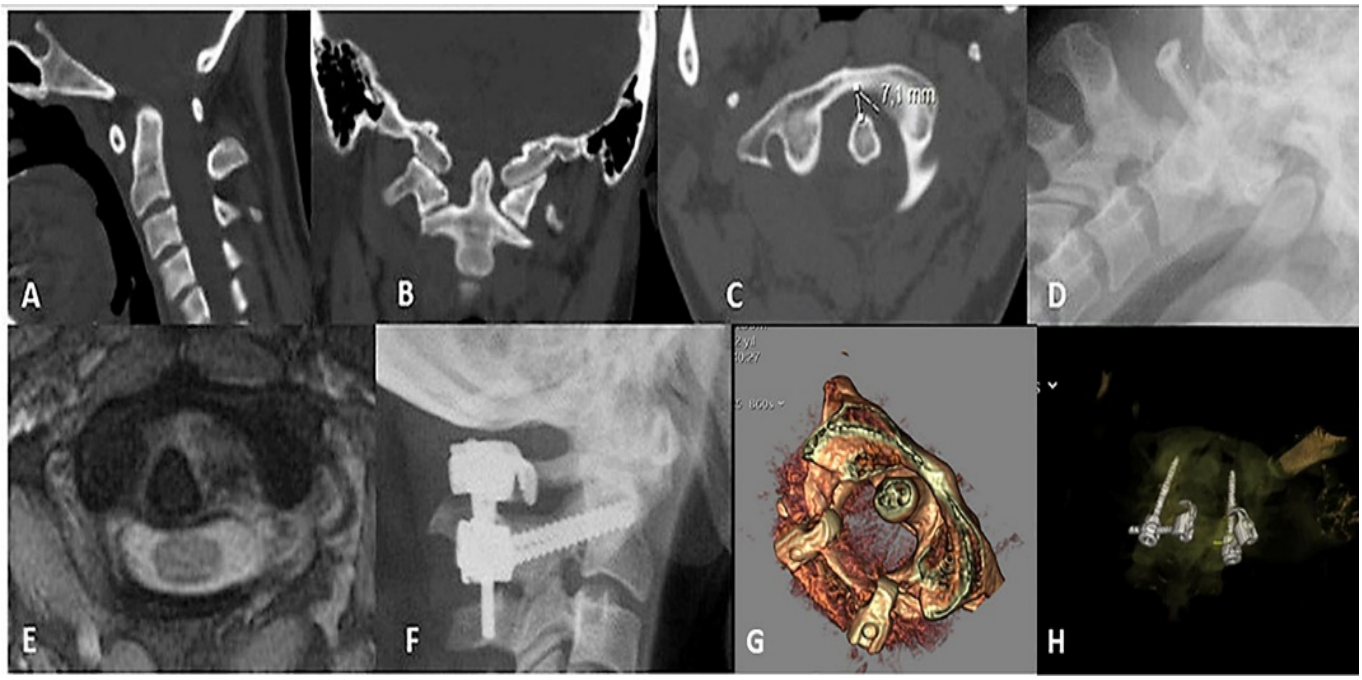

Fig. 1. 27/F, motor vehicle accident, neurological evaluation intact, Suboccipital and Neck pain: Preoperative sagittal axial coronal planes CT imaging (A, B, C), flexion lateral radiography (D), T2 axial MRI image (E) (Transverse ligament rupture) and postoperative lateral radiography (F) and 3D CT reconstruction images (G, H)

3. Results

Twelve patients were operated this procedure from March 2010 to December 2017. Four patients were female and eight patients were male. The average age was 36.53 years (range 18-65 years). The average follow-up duration was 23.7 months (range 15-36 months). The mean operating time was 81.9 min (70 to 90 min). The mean intraoperative blood loss was 114.28 mL (90 to 160 mL) (Table 2). There was no dangerous complication such as the spinal cord or vertebral artery injury. Patients are mobilized appropriately on the first day after the operation with a neck collar. All the patients were evaluated with flexion-extension cervical lateral x-rays at the end of the 3rd month. The posterior bony fusion formation was observed on imaging in all patients. Postoperative complications included two superficial wound infections. The complications were successfully treated by the surgical debridement and giving antibiotics.

Table 1. Clinical features of patients

Age	Gender	Causes of instability	Presenting Symptoms
19	Male	Odontoid fracture (motorcycle accidents)	Suboccipital and Neck pain
59	Male	C1 lateral mass fracture + anterior arch fracture (motor vehicle accident)	Suboccipital and Neck pain
27	Female	Transverse ligament rupture (motor vehicle accident)	Suboccipital and Neck pain
34	Male	Odontoid fracture (motor vehicle accident)	Neck pain
28	Male	Transverse ligament rupture	Suboccipital and Neck pain
46	Male	C1 fracture (fall)	Neck pain
56	Female	Transverse ligament rupture (motor vehicle accident)	Neck pain
23	Male	Odontoid fracture (motorcycle accidents)	Suboccipital and Neck pain
18	Male	Odontoid fracture (motorcycle accidents)	Suboccipital and Neck pain
24	Female	C1 fracture + Transverse ligament rupture (motor vehicle accident)	Suboccipital and Neck pain
65	Male	Odontoid fracture (fall)	Neck pain
48	Female	Transverse ligament rupture (vehicle accident)	Suboccipital and Neck pain

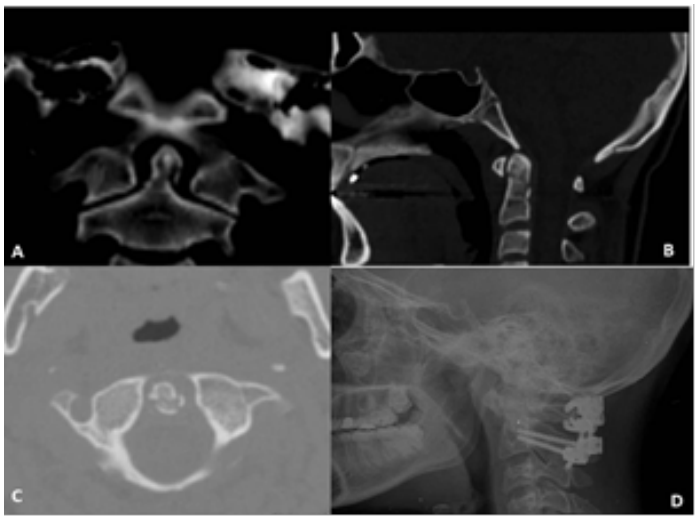

Fig. 2. 19/M motorcycle accident, neurological evaluation intact, Suboccipital and Neck pain, odontoid fracture (motorcycle accidents): preoperative coronal, sagittal and axial CT images (A, B, C) postoperative 12-month lateral radiography (D)

4. Discussion

The upper cervical region is the anatomical structure that be formed occipital bone, C1 and C2. Therefore, traumatic injuries are encountered in this region due to occipital condyles, atlantooccipital insertion, atlas, atlantoaxial joint, axis and especially odontoid. Especially the neck lateral bending and rotation movements take place mostly in this region. Presence of transverse ligament damage requires surgical treatment as an indicator of instability. The atlantoaxial joint neck movement is one of the most important regions where traumas causing excessive flexion, extension or rotation forces may cause severe dislocation and especially transverse ligament damage in the joint. Upper cervical injuries occur motor vehicle accidents sports injuries falling from height and due to high-intensity traumas. The most common symptoms seen in patients are neck pain, tenderness and limitation of movement in the neck, muscle spasm. Three-dimensional computed tomography (CT) is the gold standard imaging to diagnose atlantoaxial instability.

Table 2: Details of cases

Age & Gender	Operation Time (minute)	İntraoperative Blood Loss (cubic centimeter)	Complications
19/Male	90 min	110 cc	
59/Male	86 min	160 cc	
27/Female	70 min	125 cc	
34/Male	80 min	105 cc	Wound infection
28/Male	75 min	95 cc	
46/Male	84 min	115 cc	
56/Female	94 min	120 cc	
23/Male	76 min	100 cc	
18/Male	72 min	90 cc	
24/Female	75min	95 cc	
65/Male	94 min	115 cc	Wound infection
48/Female	87 min	120 cc	

Historically, this condition was generally treated with posterior cervical C1-2 fusion. Various surgical techniques were described by authors such as Brooks, Gallie, Dickmann, and Sonntag (Gallie, 1939; Brooks and Jenkins, 1978; Dickman and Sonntag, 1998). Although posterior binding techniques are less harmful for spinal cord roots and vertebral artery, they are technically easier to apply. Furthermore, it couldn't provide adequate stability and cause to restriction of neck movements. Magerl is the first surgeon to screw the C1-C2 complex transarticularly in 1986 (Magerl and Seemann, 1987). It provides stronger stabilization compared to the strapping technique and increases the chance of fusion. An important advantage of this method is that it does not require external immobilization (Guo et al., 2009) Although the method is safe, it has been reported that its applicability over time is technically difficult and causes various complication (Richter et al., 2002).The most important disadvantage in the posterior approaches is the loss of axial rotation but they have high fusion rate (Richter et al., 2002; Guo et al., 2009). Therefore, surgical techniques applied for this region have been developed from past to present and many techniques have been reported by some authors (Goel and Laheri, 1994; Goel et al., 2002; Xiao et al., 2008; Guo et al., 2009; Guo et al., 2014). Traditionally, posterior wire stabilization and structural bone grafting doesn't provide adequate immobilization of atlantoaxial complex. In addition,

this technique increases the risk of neural injury. Furthermore, the patients need to external support in the postoperative period, including the use of halo devices. In our study, C1 ring grapples assemble with axis transpedicular screw and bone graft and we didn't encounter any neural and vascular injury. Another surgical procedure is The Harms C1-2 Fixation method. Harm's technique is a highly effective and robust technique compared to wire fixation and interlaminar clamping techniques. There is no need to use halo in the postoperative period.

In addition, C1 and C2 vertebrae posterior structures, which must have a solid integrity in wire fixation technique, do not need to be solid in this technique. Furthermore, the risk of injury to the vertebral artery and its surrounding venous plexus has been reported for this technique. Because C1 lateral mass is surrounded by a venous plexus with rich anastomosis. So, C1 posterior ring grapple safer for venous injury than C1 lateral mass screw. With the trans-articular screw fixation technique, there has been a significant increase and improvement in bone fusion rates (Magerl and Seemann, 1987; Suchomel et al., 2004). But this technique can't be used with some conditions such as, cervicothoracic kyphosis, medially located vertebral artery (Paramore et al., 1996). However, researchers using this technique have reported that the risk of vertebral artery injury in 3.7–8.2 percent of cases (Grob et al., 1991; Wright and Lauryssen, 1998; Suchomel et al., 2004). In our study, we did not see any vertebral artery damage. However, there is a damage of vertebral artery when inserting the axis pedicle screw. In the previous study, it has been shown by authors that C1 laminar hooks fixation and C1-2 trans-articular screws have been shown to be biomechanically more stable and robust by the authors (Guo et al., 2009). In the other study, six different techniques were biomechanically compared invitro by non-destructive testing. In this biomechanical study, it has been emphasized that although the best technique for neck rotation and sideways movement is trans-articular screwing, this technique is not always possible for some cases (Richter et al., 2002). In the same study, the axis transpedicular screwing system combined with the atlas hook system was reported to be stable. In another study, it was mentioned that the trans-articular screw cannot be placed successfully in twenty percent of the cases (Paramore et al., 1996). However, the risk of damage to vascular and neural structures in the atlas hook and axis transpedicular screw technique is relatively lower (Ni et al., 2010). All the posterior cervical stabilization procedures provide a 74 to 100% fusion rate (Goel and Laheri, 1994; Julien et al., 2000; Huang et al., 2015). Similarly, the present study has a satisfactory fusion rate of about 100 percent.

Our limitations about this study are, since our study is retrospective, we couldn't have the long term follow up results and we could use only the flexion extension X-ray for control. Therefore, the atlas hook and axis transpedicular screw system should be included in our surgical options in appropriate cases. Because, this method is more reliable posterior atlantoaxial fusion technique. In this technique, the upper cervical spine area should be scanned certainly with preoperative CT. If the bone structure is normal, technique should be applied. Especially the atlas posterior ring must be intact

Conflict of interest

I declare that we have no conflicts of interest in the authorship or publication of this contribution.

Informed consent

This is a retrospective study and no new treatment was used. Ethics approval for the study was given by the local ethics committee (2020/10-15.01.2020).

References

1. Brooks, A.L., Jenkins, E.B., 1978. Atlanto-axial arthrodesis by the wedge compression method. J. Bone. Joint. Surg. Am. 60, 279-84Colledge WH. GPR54 and kisspeptins. Results Probl Cell Differ. 2008; 46:117-43.
2. Coyne, T.J., Fehlings, M.G., Wallace, M.C., Bernstein, M., Tator, C.H., 1995. C1-C2 posterior cervical fusion: long-term evaluation of results and efficacy. Neurosurgery. 37, 688-92; discussion 692-3.
3. Benny BV, Nagpal AS, Singh P, Smuck M. Vascular causes of radiculopathy: a literature review. Spine J. 2011 Jan;11(1):73-85. Dickman, C.A., Sonntag, V.K., 1998. Posterior C1-C2 transarticular screw fixation for atlantoaxial arthrodesis. Neurosurgery. 43, 275-80; discussion 280-1.
4. Gallie, W.E., 1939. Fractures and dislocations of the cervical spine. Am. J. Surg. 46, 495-499.
5. Goel, A., Desai, K.I., Muzumdar, D.P., 2002. Atlantoaxial fixation using plate and screw method: a report of 160 treated patients. Neurosurgery. 51, 1351-6; discussion 1356-7.
6. Goel, A., Laheri, V., 1994. Plate and screw fixation for atlanto-axial subluxation. Acta. Neurochir. (Wien). 129, 47-53.
7. Grob, D., Jeanneret, B., Aebi, M., Markwalder, T.M., 1991. Atlanto-axial fusion with transarticular screw fixation. J. Bone. Join. Surg Br. 73, 972-6
8. Guo, X., Ni, B., Zhao, W., Wang, M., Zhou, F., Li, S., Ren, Z., 2009. Biomechanical assessment of bilateral C1 laminar hook and C1-2 transarticular screws and bone graft for atlantoaxial instability. J. Spinal. Disord. Tech. 22, 578-85.
9. Huang, D.G., Hao, D.J., He, B.R., Wu, Q.N., Liu, T.J., Wang, X.D., Guo, H., Fang, X.Y., 2015. Posterior atlantoaxial fixation: a review of all techniques. Spine. J. 15, 2271-81.
10. Julien, T.D., Frankel, B., Traynelis, V.C., Ryken, T.C., 2000. Evidence-based analysis of odontoid fracture management. Neurosurg. Focus. 8, e1.
11. Magerl, F., Seemann, P.-S., 1987. Stable Posterior Fusion of the Atlas and Axis by Transarticular Screw Fixation. In Cervical Spine I: Strasbourg 1985. Vol., P. Kehr, A. Weidner, ed.^eds. Springer Vienna, Vienna, pp. 322-327.
12. Ni, B., Zhu, Z., Zhou, F., Guo, Q., Yang, J., Liu, J., Wang, F., 2010. Bilateral C1 laminar hooks combined with C2 pedicle screws fixation for treatment of C1–C2 instability not suitable for placement of transarticular screws. European. Spine. Journal. 19, 1378-1382.
13. Paramore, C.G., Dickman, C.A., Sonntag, V.K.H., 1996. The anatomical suitability of the C1–2 complex for transarticular screw fixation. Journal of Neurosurgery. 85, 221-224.
14. Richter, M., Schmidt, R., Claes, L., Puhl, W., Wilke, H.J., 2002. Posterior atlantoaxial fixation: biomechanical in vitro comparison

of six different techniques. Spine (Phila Pa 1976). 27, 1724-32.

15. Suchomel, P., Stulik, J., Klezl, Z., Chrobok, J., Lukas, R., Krbec, M., Magerl, F., 2004. [Transarticular fixation of C1-C2: a multicenter retrospective study]. Acta. Chir. Orthop. Traumato.l Cech. 71, 6-12.

16. Wright, N.M., Lauryssen, C., 1998. Vertebral artery injury in C1-2 transarticular screw fixation: results of a survey of the AANS/CNS section on disorders of the spine and peripheral nerves. American Association of Neurological Surgeons/Congress of Neurological Surgeons. J. Neurosurg. 88, 634-40.

17. Xiao, Z.M., Zhan, X.L., Gong, D.F., Chen, Q.F., Luo, G.B., Jiang, H., 2008. C2 pedicle screw and plate combined with C1 titanium cable fixation for the treatment of atlantoaxial instability not suitable for placement of C1 screw. J. Spinal. Disord. Tech. 21, 514-7.