



Research Article

C1-C2 Posterior Segmental Fixation For Traumatic Atlantoaxial Instability

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Summary

Cervical spinal trauma is one of the most frequent causes of disability. Upper cervical spinal trauma, caused by more than one mechanism, is a complex injury which may show various neurological statements. Atlantoaxial fractures are seen frequently after motor vehicle accidents and falls from height. Various treatment modalities defined in the upper cervical spine trauma and surgical treatment technique, so there is still unclear. Seven patients, six male and one female, were surgically treated for symptomatic atlantoaxial instability. The major cause of instability was; motor vehicle accident in six patients and falling from height in one patient. C1-C2 posterior fixation and posterolateral fusion was performed in 7 cases. The fusion and C1-C2 stability were achieved in all cases after 6 months. C1-C2 posterior fixation and fusion technique is a reliable and safe method to treat atlantoaxial instability when followed the given instruction by spinal surgeons. But, further prospective clinical studies will be needed to determine the effectiveness of this technique.

Key words: Atlantoaxial instability, C1 lateral mass- C2 pedicle screw, instrumentation

Travmatik Atlantoaksiyel Instabilitede C1-C2 Posterior Segmental Fiksasyon Özet

Servikal travmalar sakat kalmanın en sık nedenlerinden biridir. Birden fazla mekanizmayla oluşan üst servikal travma değişik nörolojik bozukluklar gösterebilen kompleks bir yaralanmadır. Atlantoaksiyel kırıklar sıklıkla trafik kazalarından ve yüksekte düşmelerden sonra görülür. Üst servikal travmalarda değişik tedavi modaliteleri ve cerrahi tedavi teknikleri tanımlanmıştır fakat hala tedavi yöntemi karışıktır. Altı erkek bir bayan toplam 7 hasta semptomatik atlantoaksiyel instabilite nedeniyle cerrahi olarak tedavi edildi. Altı hastada atlantoaksiyel instabilite nedeni trafik kazası, bir hastada ise yüksekte düşmeydi. 7 hastada C1-C2 posterior fiksasyon ve posterolateral füzyon yapıldı. 6 ay sonra tüm hastalarda C1-C2 stabilizasyon ve füzyon sağlandı. C1-C2 posterior fiksasyon ve füzyon tekniği, spinal cerrahların verdiği açıklamalara uyulduğu sürece atlantoaksiyel instabiliteyi tedavi etmek için emniyetli ve güvenli bir metottur. Bu tedavinin etkinliğini belirlemek için daha fazla prospektif klinik çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Atlantoaksiyel instabilite, C1 lateral kitle-C2 pedikül vidası, enstrümantasyon

INTRODUCTION

Fracture of the cervical spine (C0-C1-C2) are frequent⁽¹⁷⁾. More than 60% of spinal injuries involve the cervical spine⁽²⁴⁾. Fracture of C1 account for approximately 2-15% of acute cervical fractures, while fractures of C2 account for approximately 17-25%⁽¹⁷⁾. Odontoid fractures are consisting of 10-15 % of all cervical spine fractures while 60 % of them are type-2 fractures. Also combined fractures of C1 and C2 constitute 3% of all cervical spine fractures⁽⁵⁾. Cervical spinal trauma is one of the most frequent causes of disability. Upper cervical spinal trauma, caused by more than one mechanism, is a complex injury which may show various neurological statements.

Atlantoaxial fractures are seen frequently after motor vehicle accidents and falls from height.

Various treatment modalities defined in the upper cervical spine trauma and surgical treatment technique, so there is still unclear. Modern sublaminar wiring technique which is first described by Brooks and Jenkins⁽¹⁾ in 1978 is easy to perform but non union is a well known complication⁽¹⁵⁾. Furthermore sublaminar wiring technique can not provide immediate stabilization⁽²⁾. Transarticular atlantoaxial fixation technique, described by Magerl in 1987, is another choice⁽²¹⁾. Disadvantages of this technique are; high risk of vertebral artery injury, screw malposition, instrumentation failure^(3,4) and the necessity of a complete reduction of the C1-C2 before stabilization procedure^(3,18,19,27). The technique described by Harms has been widely accepted because it minimizes the risk of injury to the vertebral artery, allows intraoperative reduction and achieve a good fusion rate⁽¹³⁾.

The present study describes our clinic's experience with posterior atlantoaxial stabilization using polyaxial screw-rod

system in traumatic patients. Also we investigated the clinical and radiological result of posterior atlantoaxial stabilization.

MATERIAL AND METHODS

Between May 2010 and June 2012, totally seven patients, six male and one female, were surgically treated for symptomatic atlantoaxial instability. In seven patients C1 lateral mass and C2 pedicle screw fixation was performed. Also in 4 patients, the screws were extended to subaxial cervical spine such as C3 and C4 (lateral mass) where necessary. Also in one patient, non-union of a dens fracture after anterior screw fixation was seen and posterior C1-C2 fixation was performed. The average age of the patients was 60 (range 25 to 79) years. The mean follow-up period was one year. The major cause of instability was; motor vehicle accident in six patients and falling from height in one patient. The complains of patients were persistence posterior cervical pain with radiation to the suboccipital area. Preoperative neurological examination was normal in all patients except one with left sided hemiplegia (Table 1). All patients' neutral plain cervical radiographs, Computed Tomographic (CT) scans and Magnetic Resonance Images (MRI) were obtained preoperatively. Preoperative CT scans used to perform the measurement of lateral mass and C2 pedicle screw. Also postoperative cervical plain radiographs and CT scans of the instrumented spinal levels were evaluated for correct screw position (Figure 1 and 2).

Surgical Techniques

The patient was placed in the prone position after the general anesthesia. The neck was held in neutral position by a three-pin head clamp. Reduction of C1-C2 facet joints were achieved with the aid of C-arm fluoroscopy intraoperatively. After preparing the surgical area in the usual fashion, a posterior paramedian incision, including C1 posterior arch and the upper edge of C4 or C5 lamina was made.

Atlantoaxial reduction was confirmed by lateral radiography. Exposure of lateral margins of the facet joints from C2 to C4 or C5 was provided with subperiosteal dissection of the cervical paraspinal muscles. The suboccipital bone and the lamina of C1 were identified. Dorsal root ganglion of C2 and venous plexus were dissected. The C1 lateral mass entry point, in the middle of the junction of the C1 posterior arch and the midpoint of the posterior inferior part of the C1 lateral mass, was marked just below the posterior arch by pushing the C2 root caudally with a hook. The sagittal cranio-caudal direction is determined by pointing to the C1 anterior tubercle on lateral C-arm view. The screw follows a posterior to anterior direction with 5° - 10° of convergence. Venous plexus bleeding was controlled by hemostatic sponge and cottonoids. Following drilling of the entry point of C1

lateral mass screw by high-speed drill and tapping through the entire vertebral body, polyaxial screw was inserted bicortically into the lateral mass of C1. C2 polyaxial pedicle screw was inserted through the cranial and medial quadrant of the isthmus surface of C2 by 20° to 30° with respect to the medial and cephalad directions. Posterolateral fusions were performed with using allograft.

Posterior cervical fusion was extended to C3 vertebra in two patients because of ligamentous injury such as interspinous and supraspinous ligaments. Also posterior cervical fusion was extended to C4 in one patient because of C3-C4 retrolisthesis and facet fracture.

All patients were mobilized on the first postoperative day with a Philadelphia collar.

Table 1: Data and characteristics of patients

Case	Age	Sex	Trauma	Pre-op Symptomos	Diagnosis	Surgery
1	38	M	Motor vehicle accident	Left Hemiplegia	Atlantoaxial rotator dislocation, transverse ligament injury	C1-C2 posterior fusion
2	60	M	Fall Down	Neck Pain	Tip 2 odontoid fracture	C1-C2 posterior fusion
3	65	F	Motor vehicle accident	Severe Neck Pain	Tip 2 odontoid fracture, atlantoaxial dislocation	C1-C2 posterior fusion
4	65	M	Motor vehicle accident	Neck Pain	Tip 3 odontoid fracture, transverse ligament injury	C1-C2 posterior fusion
5	79	M	Motor vehicle accident	Severe neck pain	Jefferson fracture, Tip 2 odontoid fracture	C1-C2-C3-C4 posterior fusion
6	75	M	Motor vehicle accident	Neck pain	Tip 3 odontoid fracture, C2 horizontal fracture and transverse ligament injury	C1-C2-C3 posterior fusion
7	75	M	Motor vehicle accident	Neck Pain	Tip 2 odontoid fracture, C1 posterior arch fracture	C1-C2-C3 Posterior fusion and anterior Odontoid fixation

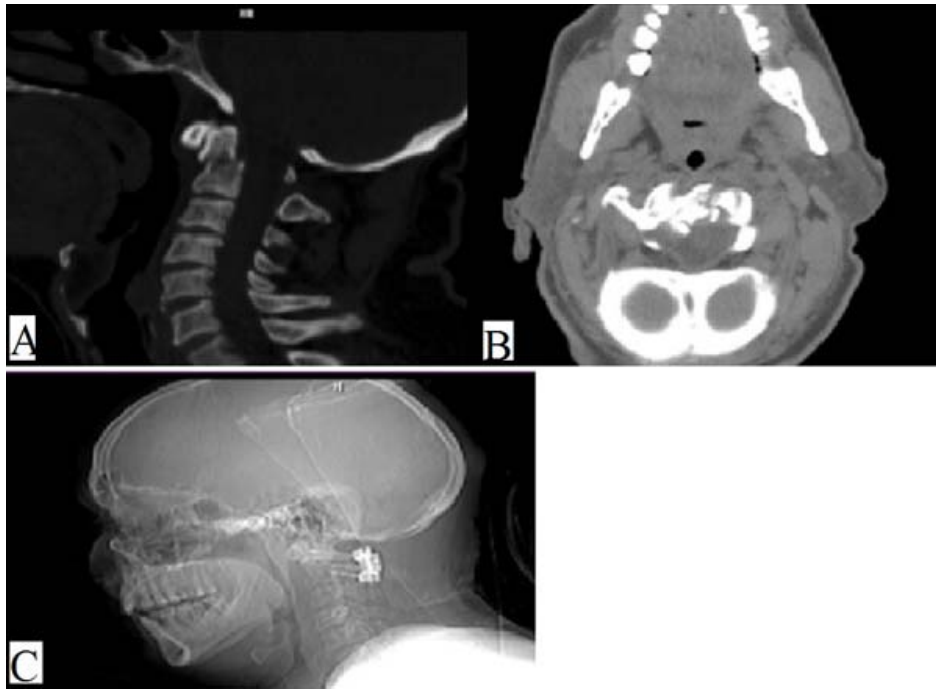


Figure 1: A-B Preoperative CT scan of case 4. C Post operative control cervical radiographs.

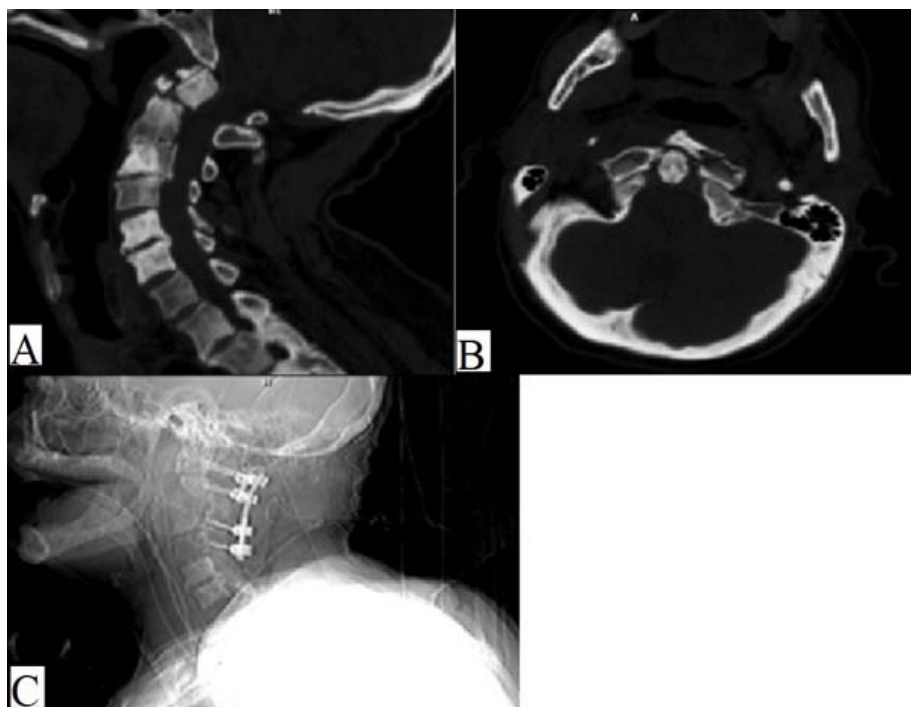


Figure 2: A-B Preoperative CT scan of case 5. C Post operative control cervical radiographs

RESULTS

All the patients were admitted to the hospital after the trauma and atlantoaxial instability was diagnosed before surgery by radiological investigations. 7 patients were treated with C1-C2 posterior fixation with posterolateral fusion. In one case, anterior odontoid screw fixation was performed previously. Because of non-union after 3 months, posterior C1-C2 fixation with posterolateral fusion was performed in this patient.

The mean operation time was 150 minutes (90-210 minutes); mean blood loss was 450 ml (180-820 ml).

All of the patients had been used Philadelphia collar after the operation for 6

weeks. There were no mortality and morbidity. There were no neurological or vascular complications associated with all surgical procedures. Also any postoperative complication such as wound infection was observed. All patients relieved from posterior cervical pain with suboccipital radiation. The neurologic sequela of one patient did not improve post operatively and the patient was transferred to rehabilitation unit. The patients were followed up with clinical and radiographic examination at 3, 6 and 12 months (Figure 3). Satisfactory screw positions were noted on postoperative CT scans. We did not perform any revision surgery. The fusion and C1-C2 stability were achieved in all cases after 6 months.

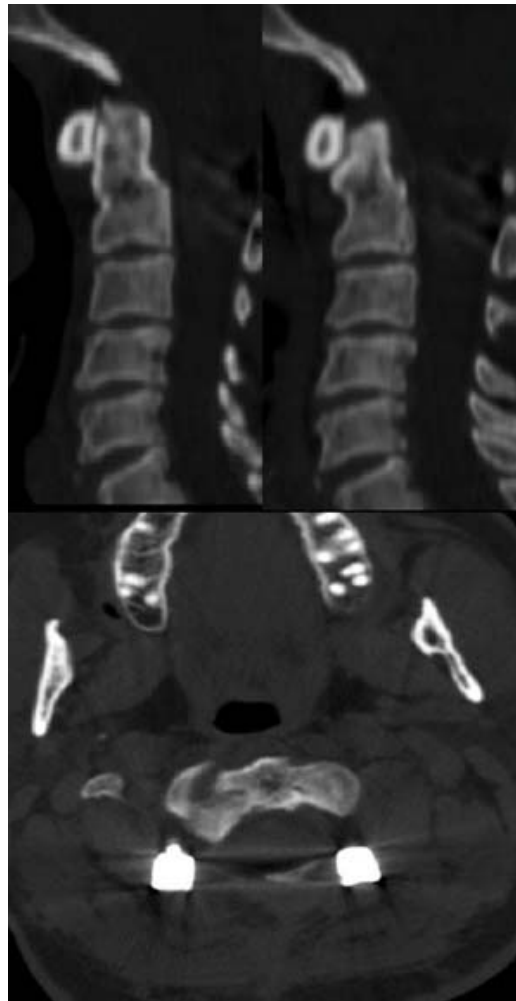


Figure 3: Post operative CT scan of case 4 at sixth month.

DISCUSSION

It is well known that the atlantoaxial segment is the most mobile region of the vertebral column. Approximately 50 % of the rotation of the cervical spine occurs at the C1-C2 joint. The stability of atlantoaxial joint is mainly provided by the ligamentous structures and dens. Various conditions such as trauma, inflammatory disease and congenital malformations implicated in the development of atlantoaxial instability. Instability of atlantoaxial joint can cause to pathologic motion with neurologic sequela. Atlantoaxial arthrodesis that reduces deformity and provides stability is a life saving procedure. Because instability of atlantoaxial joints cause sudden death due to compression over the spinal cord. Because of the clinical importance and complex anatomy, different fixation and fusion techniques have been reported in the literature for the treatment of atlantoaxial instability. Formerly, a posterior wire stabilization technique which was described by Brooks and Jenkins was used to treat atlantoaxial instability⁽¹⁶⁾. Although this technique is simple, safe and less dangerous to the nerve root and vertebral artery, it requires an intact C1 arch. Also it can not provide immediate stability, limits the flexion and extension of the cervical spine. Non-union rates is up to 30% even with halo vest immobilization and neurological injuries because of sublaminar passage of wires^(2-4,12-15-17,19-24,27). C1-C2 transarticular screw fixation techniques which was described by Magerl, requires reduction of C1-C2 before stabilization. Also prominent anatomy such as vertebral foramen precludes placement of the screws in approximately 20% of patients so it is important to evaluate preoperative CT scans before the screw placement⁽²²⁾. The probability of neurovascular compromise during implantation of transarticular screws is very high⁽¹²⁾. Also the risk of

vertebral artery injury is an incidence of 2.2% per transarticular screw and 4.1% per operated patient in Magerl technique^(3,13).

Recently, Goel et al. reported a new technique, involving C1 lateral mass and C2 pedicle screw which is popularized by Harms et al.^(9,10,13). The advantages of Harms technique are; a) minimal risk of vertebral artery and spinal cord injury b) it can be applied if C1-C2 is not reduced or posterior elements of C1-C2 are absent or present c) it is not required postoperative using of halovest. Also this technique can be incorporated with other cervical spine fusion constructs. The bony fusion rates range from 75% to 80% in posterior wire stabilization technique and 90% in Magerl technique while fusion rate is 100% in Harms technique. Also in our cases, we achieved the %100 C1-C2 bony fusion.

In all types of C1-C2 posterior stabilization, it is possible to damage the vertebral artery especially in patients with high-riding vertebral artery. In our series, there was no vertebral artery injury. Also either Harms or Goel did not reported vertebral artery or spinal cord injury after screw placement while individual authors reported vertebral artery injury using Magerl technique in 3,7-8,2% of patients^(11,14). The authors attribute this to better direct visualization of screw insertion than in the Magerl technique^(9,13).

It is important to know the anatomy and variations of C1-C2 complex prior to surgery. Preoperative CT scans, especially three-dimensional CT reconstruction is mandatory to evaluate venous and vertebral artery anatomy, bone structure and also for safe screw insertion in the C1-C2 complex^(23,28).

Recent years using the navigation system for the risk of vessel and spinal cord injuries in spinal surgery is much popular. But using navigation system in craniocervical junction surgery has some disadvantages because of high mobility of

this region. Also calibration errors of navigation system, bending of instruments and non-rigid connection between the reference base and the actual surgical site are other disadvantages of intraoperative navigation system in craniocervical junction surgery⁽²⁶⁾. Due to this advantages, most neurosurgeons use conventional intraoperative fluoroscopy. While Liu et al⁽¹⁸⁾. were reported that C1 lateral mass screws could be inserted without fluoroscopy with microscope assistance on a series of 24 consecutive patients, Simsek et al.⁽²⁵⁾ demonstrated that unicortical C1 lateral mass screws could be inserted safely and rapidly without fluoroscopy guidance in 17 consecutive patients.

Bleeding from the venous plexus around the greater occipital nerve may occur during the dissection of the C1-C2 inter-laminar space for C1 screw insertion. Bipolar coagulation in combination with tamponade is necessary to control bleeding. Also prompt insertion of screw into the C1 lateral mass is useful for stopping bleeding. Caudal retraction or sectioning of the C2 ganglion for C1 screw placement is controversial. The C2 ganglion occupies 76% of the foraminal height of the C2, between the arch of the atlas and the lamina of the axis so sectioning of the C2 ganglion and bipolar coagulation of the venous plexus provide wide exposure of the lateral mass entry point, thus, facilitating the placement of the C1 lateral mass screws⁽²⁵⁾. While Harms et al⁽¹³⁾. avoided leaving the nerve intact and retracting it caudally; Goel et al⁽¹⁰⁾. reported that patients tolerated the dissection of the nerve quite well. Harms et al.⁽¹³⁾ reported that the risk of injury or irritation of the C2 nerve root can be avoided by traction of the root inferiorly during screw insertion. However Goel et al⁽¹⁰⁾. reported no significant clinical symptoms with sectioning the C2 ganglion sharply to gain wide exposure of the C1 lateral mass entry point on 160 patients. We performed subperiosteal dissection

using a Penfield dissector and avoided the nerve intact in all cases.

CONCLUSION

C1-C2 posterior fixation and fusion technique is a reliable and safe method to treat atlantoaxial instability when followed the given instruction by spinal surgeons. This study has some limitations. First, in this study, the patients were not randomized and there were limited number of patients. Also all patients had trauma. There were no patients with inflammatory disease, cancer metastasis or congenital malformations. Also the relatively short follow-up time is the second study limitation. Therefore, further prospective clinical studies will be needed to determine the effectiveness of this technique.

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REFERENCES

1. Brooks AL, Jenkins EB. Atlanto-axial arthrodesis by the wedge compression method. *J Bone Joint Surg Am* 1978;60(3):279-84
2. Calsaneller T, Yılmaz C, Özdemir Ö, Caner H. Posterior atlantal lateral mass fixation technique with polyaxial screw and rod fixation system. *Turkish Neurosurgery* 2008;18(2): 142-148
3. Coric D, Branch CL Jr, Wilson JA, Robinson JC. Arteriovenous fistula as a complication of C1-2 transarticular screw fixation: Case report and review of the literature. *J Neurosurg* 1996;85:340-3.
4. Coyne TJ, Fehlings MG, Wallace MC, Bernstein M, Tator CH. C1-C2 posterior cervical fusion: Long-term evaluation of results and efficacy. *Neurosurgery* 1995;37:688-92; discussion 692
5. Dickman CA, Hadley MN, Browner C, Sonntag VK. Neurosurgical management of acute atlas-axis combination fractures. A review of 25 cases. *J Neurosurgery* 1989;70:45-49.
6. Dickman CA, Crawford NR, Paramore CG. Biomechanical characteristics of C1-2 cable fixations. *J Neurosurg* 1996;85:316-22.
7. Farey ID, Nadkarni S, Smith N. Modified Gallie technique versus transarticular screw fixation in C1-C2 fusion. *Clin Orthop* 1999;359:126-35.
8. Glaser JA, Whitehill R, Stamp WG, Jane JA. Complications associated with the halo-vest. A review of 245 cases. *J Neurosurg* 1986;65:762-9.
9. Goel A, Laheri V. Plate and screw fixation for atlantoaxial subluxation. *Acta Neurochir (Wien)* 1994;129:47-53.
10. Goel A, Desai K, Mazumdar D. Atlantoaxial fixation using plate and screw method: a report of 160 treated patients. *Neurosurgery* 2002;51:1351-6.
11. Haid Jr RW, Subach BR, McLaughlin MR, Rodts GE Jr, Wahliq Jb Jr. C1-C2 transarticular screw fixation for atlantoaxial instability: a 6-year experience. *Neurosurgery* 2001;4:65-8.
12. Hajek PD, Lipka J, Hartline P, Saha S, Albright JA. Biomechanical study of C1-C2 posterior arthrodesis techniques. *Spine (Phila Pa 1976)* 1993;18:173-7.
13. Harms J, Melcher PR. Posterior C1-C2 fusion with polyaxial screw and rod fixation. *Spine* 2001;26(22):2467-71.
14. Hott JS, Lynch JJ, Chamberlain RH, Sonntag VK, Crawford NR. Biomechanical comparison of C1-2 posterior fixation techniques. *J Neurosurg Spine* 2005; 2:175-81.
15. Jacobson ME, Khan NS, An HS. C1-C2 Posterior Fixation: Indications, Technique, and Results. *Orthop Clin N Am* 2012; 43: 11-18.
16. Jeon SW, Jeong JH, Choi GH, Moon SM, Hwang HS, Choi SK. Clinical outcome of posterior fixation of the C1 lateral mass and C2 pedicle by polyaxial screw and rod. *Clin Neurol Neurosurg*. 2012 Jul;114(6):539-44.
17. Longo UG, Denaro L, Campi S, Maffulli N, Denaro V. Upper cervical spine injuries: indications and limits of the conservative management in Halo vest. A systematic review of efficacy and safety. *Injury* 2010;41(11):1127-35.
18. Liu G, Buchowski JM, Shen H, Yeom JS, Riew KD. The feasibility of microscope-assisted 'free-hand' C1 lateral mass screw insertion without fluoroscopy. *Spine* 2008;33:1042-49.
19. Madawi AA, Casey AT, Solanki GA, Tuite G, Veres R, Crockard HA. Radiological and anatomical evaluation of the atlantoaxial transarticular screw fixation technique. *J Neurosurg* 1997; 86:961-968
20. Madawi AA, Solanki G, Casey AT, Crockard HA. Variation of the groove in the axis vertebra for the vertebral artery. Implications for instrumentation. *J Bone Joint Surg Br* 1997; 79:820-823.
21. Magerl F, Seemann PS. Stable posterior fusion of the atlas and axis by transarticular screw fixation. In: Kehr P, Weidner A, editors. *Cervical spine 1:Strasbourg* 1985. New York: Springer-Verlag; 1987. p. 322-7.
22. Paramore CG, Dickman CA, Sonntag VK. The anatomical suitability of the C1-2 complex for transarticular screw fixation. *J Neurosurg* 1996;85:221-4.
23. Resnick DK, Lapsiwala S, Trost GR. Anatomic suitability of the C1-C2 complex for pedicle screw fixation. *Spine* 2002;27:1494-8.
24. Shin JJ, Kim SJ, Kim TH, Shin HS, Hwang YS, Park SK. Optimal use of the halo- vest orthosis for upper cervical spine injuries. *Yonsei Med J*. 2010;51(5):648-52.
25. Simsek S, Yigitkanli K, Seckin H, Akyol C, Belen D, Bavbek M. Freehand C1 lateral mass screw fixation technique: our experience. *Syrigical Neurology* 2009;72:676-81.
26. Tessitore E, Bartoli A, Schaller K, Payer M. accuracy of the freehand fluoroscopy-guided placement of C1 lateral mass and C2 isthmic screws in atlanto-axial instability. *Acta Neurochir* 2011; 153:1417-25.
27. Wright NM, Laurysen C. 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* 1998; 88:634-640
28. Yoshida M, Neo M, Fujibayashi S, Nakamura T. Comparison of the anatomical risk for vertebral artery injury associated with the C2-pedicle screw and atlantoaxial transarticular screw. *Spine* 2006;31:E513-7.