The Use of Lateral Mass C1 and Pedicle C2 Screw for Fixation of Post Traumatic Upper cervical Instability: Surgical Technique and Operative Outcome

Ahmed Yehya, MD

Department of Neurosurgery, Faculty of Medicine, Alexandria University, Egypt.

Abstract

Background Data: The atlantoaxial segment of the cervical spine is a complex anatomic and functional structure. There are many diseases that can affect this segment and lead to instability as trauma, degenerative, inflammatory, neoplastic, or congenital diseases. It requires fusion for adequate immobilization and stabilization. Many surgical methods used for treatment of C1-C2 instability as posterior wiring techniques, C1–2 transarticular screws and lastly, C-1 lateral mass and C-2 pedicle screws fixation which has more advantages than other methods of C1–2 fixation.

Study Design: Retrospective clinical case review.

Purpose: The aim of this work is to evaluate the surgical technique and early outcome of C1 lateral mass and C2 pedicle screw fixation in post traumatic atlantoaxial instability.

Patients and Methods: The study was conducted on 12 patients admitted in the emergency department of the main Alexandria university hospital presented with post traumatic atlantoaxial instability started from January 2010 till January 2012. We did C1 lateral mass and C2 pedicle screws fixation using polyaxial screw system and rods. Ten patients (83.3%) were males and 2 females (16.7%) with age ranged from 21 to 48 years. Neck pain was the most common presentation in all the 12 patients (100%) followed by myelopathy in 6 patients (50%) and only 2 patients (16.7%) presented with sphincteric disturbance.

Results: The average time for surgery was 135min. Blood loss ranged from 250 to 900 ml with mean of 400ml. Dural tear occurred in only one patient (8.3%), with mild CSF leak postoperatively that stopped spontaneously. No vertebral artery injury was reported during surgery. The average hospital stay of the patients ranged from 2-10 days with a mean of 4 days. A total of 48 poly axial screws were inserted. We found that 40 screws (83.4%) were optimal in position, 8 screws (16.6%) were suboptimal including, 3 (6.2%) were medially directed, 2 (4.2%) were laterally directed, 2 (4.2%) were too long and only one screw (2%) was misplaced that needed to be reoperated for redirection. Neck pain improved in all the patients (100%) postoperatively, myelopathy improved in 5 patients (41.6%), and sphincteric disturbance improved in one patient (8.3%). Good fusion was achieved in 11 patients (91.7%) within 6 months.

Conclusion: Lateral mass C1 and pedicle screw C2 fixation offer an alternative means of achieving atlantoaxial fusion. The technique is safer with less complication. Laminectomy or fracture of the posterior elements does not prevent the use of this fixation procedure. (2012ESJ019)

Keywords: atlantoaxial stabilization, cervical spine, screw fixation, C1 lateral mass, C2 pedicle.

Introduction

Atlanoaxial segment of the spine is very unique segment and is considered as the most mobile part of the spine. It depends mainly on the ligamentous support and the integrity of the odontoid for its stability[13,17]. Trauma is the most common cause of C1-C2 instability leading to neck pain, headache and even quadeparesis or quadreplegia. Plain x-ray, multislice CT, and MRI cervical spine is mandatory for the diagnosis of post traumatic C1-C2 instability[7].

There are many techniques for treatment of atlantoaxial instability as posterior wiring techniques as Gallie[4], Brooks[2], and Sonntag fusions[14]. They reported atlantoaxial arthrodesis by using autologous bone graft with posterior wiring technique since 1939[4]. They achieved a fusion rate of 60%. Various modifications of these techniques had been reported as Gallie had used interlaminar clamps with the bony fusion[10] but this technique couldn't be used if the lamina or posterior neural arch are fractured. In 1979 Magrel and Seemann introduced new technique for atlantoaxial arthrodesis, using C1-C2 transarticular screw fixation guided by intraoperative radiological monitor to prevent vascular and neural injury[18]. This technique results in more rigid fixation with fusion rates of 87%. It requires a good knowledge of the course of the vertebral arteries, but it couldn't be used if there is abnormal anatomy of the cervical spine or if there is mal alignment of the C1-C2 segment after trauma[10].

The most recent technique of C1-C2 fixation is C1 lateral mass screw and C2 pedicle screw fixation which described originally by Jurgen Harms[6]. It has several advantages over the previously described posterior fixation techniques as it has minimal risk of VA and spinal cord injury[23], the integrity of the C1 or C2 posterior elements is not necessary for stable fixation and lastly this technique allows a reduction in any displacement of the elements of the atlantoaxial complex by repositioning the patient's head or directly manipulating the C1 or C2 screws[11,21]. The rod–polyaxial screw system has another advantages as it could be incorporated into other fusion constructs, such as occipito–cervico–thoracic systems[1,5], and also the C1–C2 facet joint is not damaged during the procedure so it could be used in patients requiring temporary fixation such as those with rotatory subluxation[3,8,10,12].

The aim of this work is to evaluate the surgical technique and early outcome of C1 lateral mass screw and C2 pedicle screw fixation in post traumatic atlantoaxial instability.

Patients and Methods

Twelve patients complaining of post traumatic atlantoaxial instability were operated in the Neurosurgery Department of Main Alexandria University Hospital. We did posterior C1 lateral mass screw and C2 pedicle screw fixation using polyaxial screw system and rods. A preoperative CT scan was mandatory in all patients to demarcate the length of the screws and the position of the vertebral arteries and if there was any other congenital anomalies before surgery.

All the patients were operated in prone position under general anesthesia. The head was maintained in neutral position with mild flexion using Mayfield holder. C-arm fluoroscopy was used to show the alignment of C1-C2 before surgery to adjust the position. Exposure of C1-C2 and the suboccipital region was performed, dissection of the C1-C2 laterally was done for exposure of the lateral mass of C1and the C2 nerve root, This step of the operation should be done cautiously to avoid injury of the vertebral artery which runs in a groove on the superior surface of the posterior arch of C1 and is protected by a thin rim of bone. The dissection was usually associated with venous bleeding that should be controlled with bipolar coagulation. Subperiosteal dissection was performed from the posterior aspect of the posterior arch of C1 anteriorly down to the lateral mass of C1, which appeared as a flat plateau. The medial wall of the lateral mass was identified using a small angled curette to identify the medial aspect of the mass for screw placement. The medial aspect of the transverse foramen was identified as the lateral limit for screw placement.

The entry point of the C1 lateral mass screw was indentified in the midpoint of the lateral mass immediately inferior to the posterior arch of C1with a trajectory ranged from 0 to 10 degrees medial in the AP plane. High speed drill was preferred than the traditional awl to start the pilot hole which was drilled with a 3 mm bit and directed toward the anterior tubercle of C1 guided by lateral fluoroscopy. A 25-30mm mini-polyaxial screw was placed with the head of the screw above the posterior arch of C1 (Figure 1).

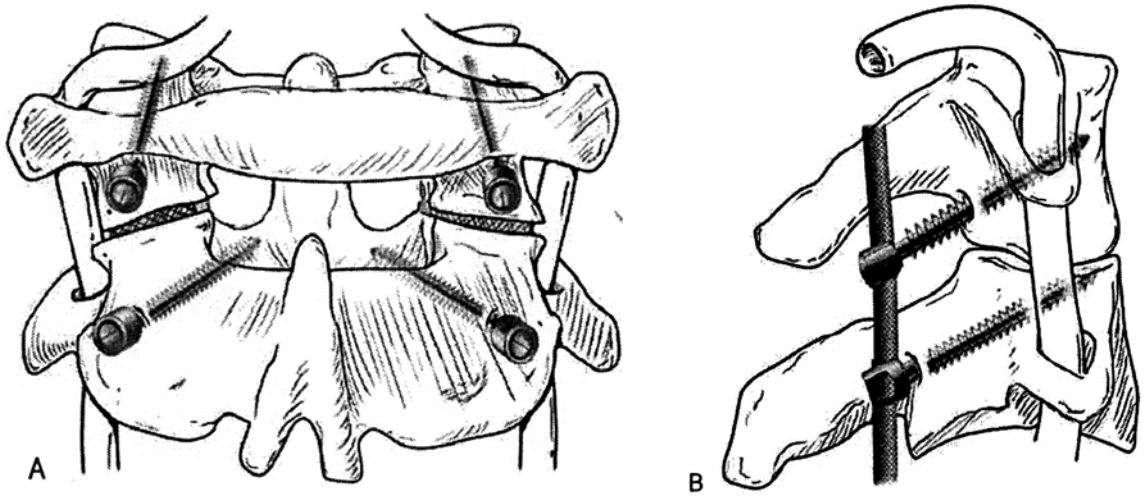

Figure 1. C1-C2 vertebrae showing the entery point for the C1 lateral mass and the C2 pedicle screw, demonestrated in A-P view and lateral view[20].

We expose the C1-C2 joint by elevating the C2 nerve root then we did decortications of the joint using small curette or high speed drill and packing of the joint with small bone fragments obtained from the adjacent lamina.

The C2 pedicle is the narrow portion of the C2 vertebra connecting the dorsal elements with the vertebral body with the pars interarticularis. The entry point of the C2 pedicle screw was identified in the midportion just inferior to the facet joint with a trajectory 15 to 25 degrees medial to the AP plane and 10 degrees cephalic angulation directed towards the base of the dens guided also by lateral fluoroscopy. We can remove part of the ligamentum flavum and feel the medial wall of the pedicle while inserting the screw to prevent medial breakdown of the pars. The length of the screw ranged from 14 to 18 mm. Finally 2 longitudinal rods were placed in the heads of the polyaxial screws and the nuts were used to secure the position after fixation (Figure 2).

The patients were followed up for at least 6 months. Plain x-ray cervical spine was done in AP and lateral study before discharge from the hospital and every 2 months interval latter on. The patients were recommended to wear philadelphia neck collar for at least 6 weeks postoperative, bony fusion occurs usually within this period of follow up.

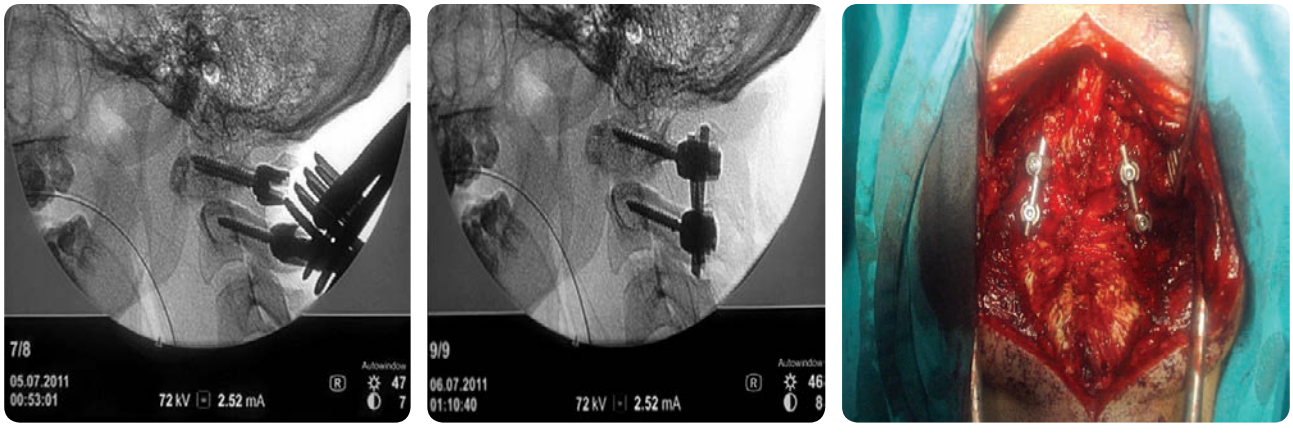

Figure 2. Shows fluoroscopic images and operative photo of C1 lateral mass and C2 pedicle screws of male patient presented with post traumatic C1-C2 instability (type II dens fracture).

Results

We have been operated on 12 patients admitted in the emergency department of the Main Alexandria University Hospital presented with post traumatic atlantoaxial instability. Ten patients (83.3%) were males and 2 patients (16.7%) were females with age ranged from 21 to 48 years. Neck pain was the most common presentation in all the 12 patients followed by myelopathy in 6 patients (50%) using the JOA-score, grade 1 myelopathy in 4 patients and grade 2 myelopathy in 2 patients (16.7%) and only 2 patients presented with sphincteric disturbance. No patients presented with brachialgia. The clinical data is shown in table 1.

Table 1. Shows the clinical data of the patients.

	No of patients n=12	%
Sex Males Females	 10 2	 83.3% 16.7%
Age Range Mean	 21-48ys 35.33 ± 7.24	
Neck pain	12	100%
Myelopathy (JOA-score)* Grade 1 Grade 2 Grade 3	6 4 2 0	50% 33.3% 16.7% 0%
Sphincteric disturbance	2	16.7%

NB*: The lower the score the more severe the deficits. Normal function; 16-17, grade 1: 12–15, grade 2: 8–11, grade 3: 0–7.

All the patients operated for posterior cervical lateral mass C1 and transpedicular C2 fixation using poly axial screws and rods, the average time for surgery ranged from 100 to 180 min average was 135min. Blood loss ranged from 250 to 900 ml with mean of 400ml. Dural tear occurred in only one patient (8.3%) intraoperatively, with mild CSF leak postoperatively that stopped spontaneously after 7 days of medical treatment. No vertebral artery injury reported during surgery. The average hospital stay of the patients ranged from 2-10 days with a mean of 4 days. Only 2 patients (16.6%) complained of mild superficial wound infection that treated medically with complete healing after 2 weeks. The operative data is shown in table 2. No postoperative deterioration of the neurological condition of the patients and no neural injury were reported.

Operative time; Range Average	 100-180min 135min
Blood loss; Range Mean	 250-900ml 400ml
Hospital stay; Range Mean	 2-10days 4 days

Table 2.
Shows the operative data of the patients.

Twelve patients had been operated using 48 poly axial screws. Follow up plain x-ray and multislice CT of the cervical spine were done to assess the position of the screws. We found that optimal position of the screws were present in 40 screws (83.4%) and 8 screws (16.6%) were suboptimal, 3 screws (6.2%) of them were medially directed and 2 screws (4.2%) were laterally directed, 2 screws (4.2%) were long and only one screw (2%) was misplaced in C2 that needed to be reoperated for redirection (Figure 3).

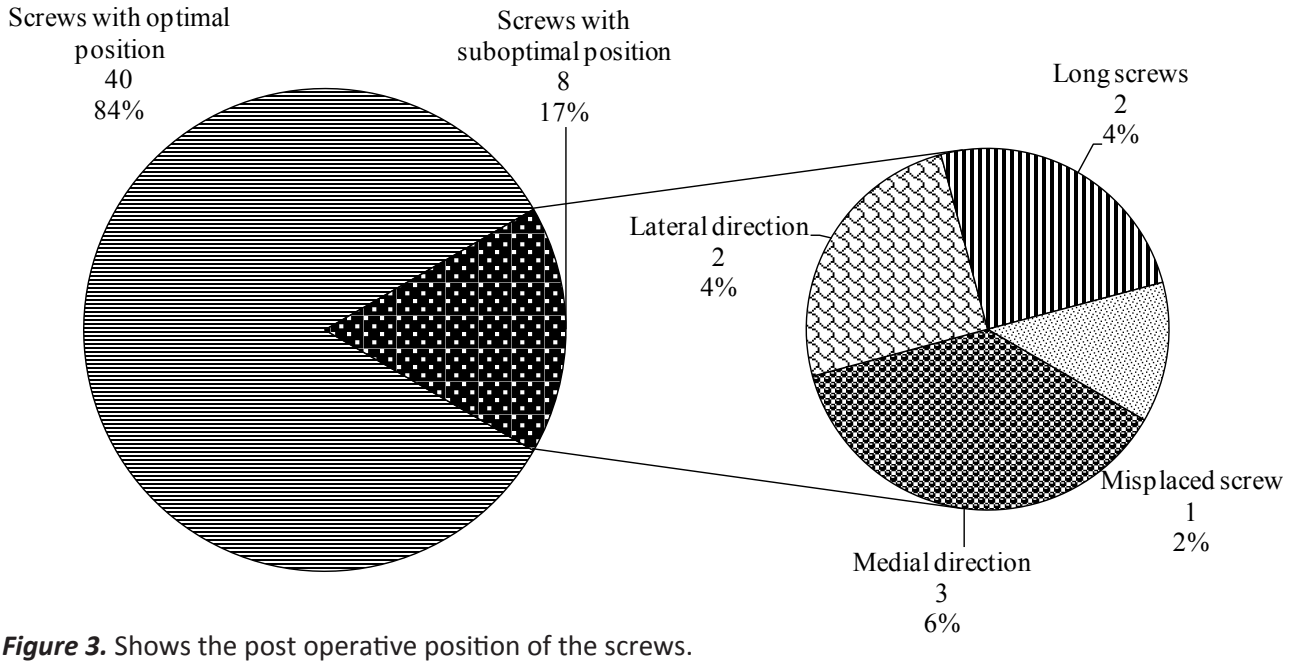

Figure 3. Shows the post operative position of the screws.

Follow up of the patients showed that neck pain was improved in all the patients (100%) postoperatively. Myelopathy improved in 5 patients (41.6%) including, 4 patients (33.3%) of grade 1 myelopathy and one (8.3%) of grade 2 myelopathy. The other grade 2 myelopathy patients (8.3%) remained stationary without improvement. The sphincteric disturbance improved in one patient of two. In postoperative x-ray follow up, good fusion was achieved in 11 patients (91.7%) within 6 months and only one patient (8.3%) showed no fusion but with no signs of instability present in flexion- extension dynamic x-ray of the patient postoperatively (Table 3).

Table 3. Shows the postoperative outcome of the patients.

	Improved	%	Not improved	%
Neck pain	12	100%	0	0%
Myelopathy Grade 1 Grade 2	5 4 1	41.6% 33.3% 8.3%	1 0 1	8.3% 0% 8.3%
Sphincteric disturbance	1	8.3%	1	8.3%
Bony fusion	11	91.7%	1	8.3%

Discussion

Many techniques are currently available for the C1-C2 fixation. However, in some instances, they cannot be applied. For example, in traumatic or neoplastic diseases where the posterior arch is disrupted, wires are not useful[9]. C1-C2 transarticular fixation is another important technique for stabilization of C1-C2 instability that can be used in cases where wires couldn't be used[18]. Biomechanically transarticular fixation provides a good stability mainly in rotation and lateral flexion[14], with fusion rate ranged from 85 to 100%[1,14]. The rare incidence of pseudarthrosis is usually considered to be a poor surgical outcome of this technique[14,18]. It couldn't be used in cases of a medially located vertebral artery, or cases were the vertebral artery anatomy will prevent the passage of screws bilaterally[23].

Twelve patients had been operated in this study. 10 patients (83.3%) were males and 2 patients were females (16.7%) as males were more liable to trauma[7], with age ranged from 21 to 48 years. Neck pain was the most common presentation in all patients (100%) followed by myelopathy in 6 patients (50%), grade 1 myelopathy in 4 patients (33.3%) and grade 2 myelopathy in 2 patients (16.7%) according to JOA-score. Only 2 patients (16.7%) presented with sphincteric disturbance, no patients presented with brachialgia.

All the patients operated for posterior cervical lateral mass C1 and transpedicular C2 fixation using poly axial screws and rods, the average time for surgery ranged from 100 to 180 min with a mean of 135min. blood loss was ranged from 250 to 900 ml with mean of 400ml. This is matched with other studies as Tan et al., in 2009 reported an operative time ranged from 90 to 176 minutes with a mean of 124 minutes. Intraoperative blood loss ranged from 270 to 1200 mL with a mean of 432 ml[19]. Stulik et al., also reported that operative time ranged from 35 to 155 min, with a mean of 81 min. Intra-operative blood loss ranged from 50 to 1500 ml, with a mean of 560 ml[15,16].

Dural tear occurred in only one patient (8.3%) intraoperatively, with mild CSF leak postoperatively that stopped spontaneously after 7 days of medical treatment. No vertebral artery injury during surgery. Kyung et al., reported one case of dural tear and one case of excessive blood loss from epidural venous plexus. These complications, however, did not cause any significant clinical consequences[7].

Twelve patients had been operated using 48 poly axial screws in this study. Follow up plain x-ray and multislice CT cervical spine was done to assess the position of the screws. We found that optimal position of the screws were present in 40 screws (83.4%) and 8 screws (16.6%) were suboptimal, 3 screws (6.2%) of them were medially directed and 2 screws (4.2%) were laterally directed, 2 screws (4.2%) were long and only one screw (2%) was misplaced that needed to be reoperated for redirection. Stulik et al.,[15] reported a total of 72 screws inserted, only three (4.2 %) were assessed as malpositioned related to the screws inserted in C2 which indicates that insertion of screws in C2 was more difficult. Xiao et al.,[22], reported 5 cases had failed placement of C1 lateral mass screw due to anatomic anomalies. Kyung et al.,[7], in a comparative study between C1-C2 transarticular fixation group 1 and lateral mass C1 and pedicle screw C2 fixation group 2. They found that in group 2, 54 screws were inserted in the atlas. All screws were positioned correctly in the C1 lateral mass. Another 54 screws were inserted in the axis. Fifty-three screws were applied correctly through the isthmus into the C2 anterior cortical bone. One was malpositioned and protruded into the artery canal, but without clinical consequences.

Follow up of the patients showed good fusion in 11 patients (91.7%) within 6 months and only one patient showed no fusion (8.3%) but no signs of instability were present in all the patients postoperatively even in the non fused patient. Harms and Melcher[6] reported that fusion rate was achieved in all the patients 100% within 4 to 12 months. Kyung et al.,[7] reported that the solid fusion rates was 96% at 12 months, and only one patient had a frank pseudoarthrodesis due to had hardware failure due to a screw malposition and non-union.

Neck pain was improved in all the patients (100%) postoperatively. Myelopathy improved in all 6 patients but one (41.6%). Mild superficial wound infection occurred in 2 patients (16.6%). No postoperative deterioration of the neurological condition of the patients and no neural or major vessels injury. Harms and Melcher[6], Tan et al.,[19].

and Stulik et al.,[15]. have reported no neurological deficits, vertebral artery related complications or other complications in all the patients. Yoshida et al.,[23] reported a case of vertebral artery rupture happened because of the use of electrocautery. The bleeding was stopped by hemostatic sponge and bone cement without causing cerebral hemodynamic deficit.

Conclusion

Lateral mass C1 and pedicle screw C2 fixation offer an alternative means for atlantoaxial fusion. The technique has minimal risk of vertebral artery and spinal cord injury. Laminectomy or fracture of the posterior arch of C1 or C2 does not prevent the use of this fixation procedure.

References

1. Ahmed R, Traynelis VC, Menezes AH: Fusions at the craniovertebral junction. Childs Nerv Syst 24(10):1209-24, 2008
2. Brooks AL, Jenkins EB: Atlanto-axial arthrodesis by the wedge compression method. J Bone Joint Surg Am 60:279–84, 1978
3. Chun HJ, Bak KH: Targeting a safe entry point for C2 pedicle screw fixation in patients with atlantoaxial instability. J Korean Neurosurg Soc 49(6):351-4, 2011
4. Gallie WE: Fractures and dislocations of the cervical spine. Am J Surg 46:495–9, 1939
5. Goel A, Desai K, Mazumdar D: Atlantoaxial fixation using plate and screw fixation for atlantoaxial subluxation. Acta Neurochir (Wien) 129:47–53, 1994
6. Harms J, Melcher RP: Posterior C1-C2 fusion with polyaxial screw and rod fixation. Spine 26(22): 2467-71, 2001
7. Kyung JS, Sun-Ho Lee, Kim, ES, Parkbal YM: Clinical and radiological Comparison of treatment of atlantoaxial instability by posterior C1–C2 transarticular screw fixation or C1 lateral mass-C2 pedicle screw fixation. J Clin Neuroscience 17: 886–92, 2010
8. Lee KH, Kang DH, Lee CH, Hwang SH, Park IS, Jung JM: Inferolateral entry point for C2 pedicle screw fixation in high cervical lesions. J Korean Neurosurg Soc 50(4):341-7, 2011
9. Li L, Zhou FH, Wang H, Cui SQ: Posterior fixation and fusion with atlas pedicle screw system for upper cervical diseases. Chin J Traumatol 11(6):323-8, 2008
10. Menendez JA, Wright NM: Review Techniques of posterior C1-C2 stabilization. Neurosurgery 60(1):S103-11, 2007
11. Nitising A, Jetjumnong C, Tisavipat N, Nantaarees: Posterior C1-C2 fusion using C1 lateral mass and C2 pars screw with rod fixation: techniques and outcomes. J Med Assoc Thai 94(7):794-800, 2011
12. Park YS, Kang DH, Park KB, Hwang SH: Posterior atlantoaxial screw-rod fixation in a case of aberrant vertebral artery course combined with bilateral high-riding vertebral artery. J Korean Neurosurg Soc 48(4):367-70, 2010
13. Resnick DK, Lapsiwala S, Trost GR: Anatomic suitability of the C1–C2 complex for pedicle screw fixation. Spine 27:1494–8, 2002
14. Sonntag VK, Dickman CA: Posterior C1–C2 transarticular screw fixation for atlantoaxial arthrodesis. Neurosurgery 43:275–80, 1998
15. Stulik J, Vyskocil T, Sebesta P, Kryl J: Atlantoaxial fixation using the polyaxial screw-rod system. Eur Spine 16(4):479-84, 2007
16. Stulik J, Vyskocil T, Sebesta P, Jan Kryl: Harms technique of C1-C2 fixation with polyaxial screws and rods. Acta Chir Orthop Traumatol Cech 72(1):22-7, 2005
17. Subach BR, Morone MA, Haid RW Jr, McLaughlin MR, Rodts GR, Comey CH: Review Management of acute odontoid fractures with single-screw anterior fixation. Neurosurgery 45(4):812-9, 1999
18. Suchomel P, Stulik J, Klezl Z, Chrobok J, Lukas R, Krebec M: Transarticular fixation of C1-C2: a multicenter retrospective study. Acta Chir Orthop Traumatol Cech 71(1):6-12, 2004
19. Tan J, Li L, Sun G, Qian L, Yang M, Zeng C, Teng H, Jia L: C1 lateral mass-C2 pedicle screws and crosslink compression fixation for unstable atlas fracture. Spine 34(23):2505-9, 2009
20. Thomas JE., Baron SL., Andrew WM: In Surgical management of spinal deformities. Saunders Elservier Inc, 2009, Chap 2:20-21
21. Wright NM: Translaminar rigid screw fixation of the axis. Technical note. J Neurosurg Spine 3:409–14, 2005
22. Xiao ZM, Zhan XL, Gong de F, Chen QF, Luo GB, Jiang H: 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(7):514-7, 2008
23. Yoshida M, Neo M, Fujibayashi S: Comparison of the anatomical risk for vertebral artery injury associated with the C2-pedicle screw and atlantoaxial transarticular screw. Spine 31:E513–7, 2006

Address reprint request to:

Ahmed Yehya, MD.
Department of Neurosurgery, Faculty of Medicine, Alexandria University, Egypt.
E-mail: ahmedyehyamd@yahoo.com

الملخص العربي

استخدام التثبيت الخلفي للفقرة الأولى والثانية العنقية في حالات إصابات الفقرات العنقية العليا الغير ثابتة: الطرق الجراحية والنتائج الأولية

مقدمة: تعتبر الفقرة العنقية الأولي والثانية من الفقرات المعقدة تشريحيا ووظيفيا. يوجد العديد من الأمراض التي قد تصيب هذه الفقرات وتؤدى إلي عدم ثبات الفقرات مثل الحوادث والالتهابات والخشونة والأورام والعيوب الخلقية. عدم ثبات الفقرات يتطلب التدخل الجراحي لتثبيت الفقرات والتحامها. يوجد العديد من الطرق الجراحية لتثبيت الفقرات العنقية الأولي والثانية منها استخدام السلك التيتانيوم أو استخدام التثبيت المفصلي أو استخدام الشرائح والمسامير والتي لها مميزات عديدة.

الهدف من البحث: صمم البحث الحالي بهدف تقييم الطرق الجراحية والنتائج الأولية لتثبيت الكتلة الجانبية للفقرة الأولى العنقية وعنق الفقرة العنقية الثانية بواسطة المسامير والشرائح في حالات إصابات الفقرات العنقية الأولى والثانية الغير ثابتة.

مواد وطرق البحث: تمت دراسة ١٢ مريض تم حجزهم بقسم الطوارئ بالمستشفى الرئيسي الجامعي وهم يعانون من إصابات الفقرات العنقية الأولى والثانية الغير ثابتة وتم عمل تثبيت الكتلة الجانبية للفقرة الأولى العنقية وعنق الفقرة العنقية الثانية بواسطة المسامير والشرائح.

النتائج: اشتمل البحث على ١٠ (٨٣,٣٪) ذكور و٢ (١٦,٧٪) إناث تتراوح أعمارهم من ٢١- ٤٨ سنة. آلام الرقبة هي اكثر الأعراض شيوعا بين المرضى بنسبة ١٠٠٪ ثم يليها أعراض ضغط النخاع الشوكي بنسبة ٥٠٪ وأخيرا إضرابات في البول أو البراز بنسبة ١٦,٧٪. متوسط وقت العملية حوالى ١٣٥ دقيقة ومتوسط كمية الدم المفقود أثناء الجراحة حوالى ٤٠٠ مل. تهتك الغشاء السحائي حدث بنسبة ٨,٣٪. متوسط إقامة المريض في المستشفى حوالى ٤ أيام. تم تركيب ٤٨ مسمار ٨٣,٤٪ كانوا في أماكنهم بالضبط و١٦,٦٪ كانوا في غير موضعهم الصحيح. تحسنت آلام الرقبة بنسبة ١٠٠٪ وأعراض الضغط على النخاع الشوكي تحسنت بنسبة ٤١,٦٪ وأخيرا إضرابات البول أو البراز تحسنت بنسبة ٨,٣٪. التحام العظام حدث بنسبة ٩١,٧٪ في خلال ٦ اشهر.

الخلاصة: تعتبر تثبيت الكتلة الجانبية للفقرة الأولى العنقية وعنق الفقرة العنقية الثانية بواسطة المسامير والشرائح في حالات إصابات الفقرات العنقية الأولى والثانية الغير ثابتة من الطرق الآمنة ومضاعفات قليلة. كسر الريشة الخلفية أو توسيع القناة الشوكية لا يمنع استخدام هذه الطريقة.