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C1C2 Wiring and Posttraumatic Atlantoaxial Dislocation: An Effective and Cheap Surgical Procedure in a Developing Country

Ibrahim Dao[1,2,3*], Massimiliano Visocchi[4], Salah Sow[5], John Jabang[6], Ousmane Ouattara[1], Astride Somda[7], Abdoulaye Sanou[7,8], Elie Dibloni Nassoum[7,8], Arsène Tossou[7,8], Narcisse Ouedraogo[1], Frédéric Bako[1], Massadiami Soulama[2,3,4,5,6,7,8,9], Malick Diallo[2,3,4,5,6,7,8,9], Patrick Wendpouiré Hamed Dakouré[2,3,4,5,6,7,8,9]

[1]Department of Neurosurgery, University Hospital Souro Sanou, Nazi Boni University, Bobo Dioulasso, Burkina Faso
[2]High Institute of Health Sciences, Nazi Boni University, Bobo Dioulasso, Burkina Faso
[3]Military Hospital Colonel Major Tanguet Ouattara, Bobo Dioulasso, Burkina Faso
[4]Institute of Neurosurgery, Craniovertebral Junction Surgery Unit, School of Medicine, Catholic University, Rome, Italy
[5]Department of Radiology and Medical Imaging, University Hospital Yalgado Ouedraogo, Joseph Ki-Zerbo University, Ouagadougou, Burkina Faso
[6]Department of Neurosurgery (Unit), Edward Francis Small Teaching Hospital, Banjul, Gambia
[7]Department of Neurosurgery, University Hospital Yalgado Ouedraogo, Joseph Ki-Zerbo University, Ouagadougou, Burkina Faso
[8]Department of Neurosurgery, Military Hospital Capitaine Halassane Coulibaly, Ouagadougou, Burkina Faso
[9]Department of Orthopedic Surgery, University Hospital Souro Sanou, Nazi Boni University, Bobo Dioulasso, Burkina Faso
Email: *dao.ibrahim@gmail.com

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Abstract

Objectives: Atlantoaxial dislocation remains a rare and serious condition with a high preoperative and postoperative morbidity and mortality. Its successful surgical management is still challenging and gratifying for neurosurgeons. Several technics have been described such as wiring, trans articular screwing, C1C2 screwing with plate and screw introduced by Goel *et al.*, and modified by insertion of polyaxially screw and rod many years later by Harms. Unavailability and expensiveness of upper cervical spine instrumentation device led us to C1C2 Wiring resulting in a good outcome. Finally, a quadriplegic patient with a more comfortable financial condition had ordered devices from abroad and benefit for Goel and Harms screwing technique and improved dramatically from ASIA A to ASIA E. **Material and methods:** This is a retrospective study of patients managed in our department by a same neurosurgeon from January 2019 to April 2024. **Results:** We defined 6 men and 1 woman with an average age of 33 years. Unrestrained driver in a rollover motor vehicle accident was most common. Only one patient was neurologically intact on admission. Neurovegetative disorders were noticed in one patient. Dislocation was associated to a fracture of the dens in two pa-

tients. Three patients have been successfully operated with remarkable outcome, mostly from ASIA A to E. **Conclusion:** C1C2 dislocation is a serious condition and C1C2 Wiring represents an effective and cheaper technic. Therefore, this technic should deserve consideration above all in low incomes countries when screwing devices are not available. Seatbelt should be demanded for motor vehicle drivers and passengers.

Keywords

Superior Cervical Spine, Dislocation, Fracture, Wiring, Screwing, Neurovegetative Disorders

1. Introduction

The craniovertebral junction defined as the occiput, atlas (C1) and axis (C2) is a complex area that houses vital neural and vascular structures while achieving the most mobility of any segment within the spine [1] [2]. This craniovertebral junction is the most mobile and most stable region of the spine; the center of stability is C0-C1 joint, whereas the center of mobility is C1C2 joint [3]. Being a highly mobile functional unit at the junction of the skull and vertebral column, traumatic events in this area may produce devastating neurological complication and death [4]. Dislocations are more prone to compromise the integrity of the craniovertebral junction and lead to compression of vital structures through the foramen magnum resulting in lethal evolution. In case of instability without dislocation, patients are usually asymptomatic on admission. Therefore, craniovertebral junction trauma obeyed to the all-or-none law. However surgical complications are potentially lethal [1]. C1C2 wiring is among the pioneering technic reported by Mixter and Osgood in 1909 and by Gallie in 1939 using heavy stilk thread and steel respectively [5]. Since then, further technics using, clamps, screw and rod have been described and popularized, relegating wiring technic to the background so far. The most revolutionary and first instrumentation in modern neurosurgery was described by Goel *et al.* in 1994, using plate and screw method of fixation of the lateral mass of the atlas and the axis [6], and modified by Harms in 2021 using polyaxial screw and rod [5]. In Burkina Faso, instrumentation device above all screw and plate for Goel technic is still unavailable and expensive to afford it from abroad. Far from the all-or-none law; a patient with quadriplegia and neurovegetative disorders has been properly managed in our department through C1C2 wiring technic for posttraumatic C1C2 dislocation. A second one with quadriplegia ordered Screws and rod from abroad, and a Goel-Harms screwing achieved a rapid improvement from quadriplegia to an asymptomatic condition. Other patients with less serious condition received surgical or conservative treatment with good outcomes too. We report our short series of 7 patients.

2. Materials and Methods

This is a retrospective study about patients suffering from posttraumatic atlantoaxial dislocation, with or without associated C1 or odontoid fracture. Database was collected from January 2019 to April 2024 among patients admitted at the department of neurosurgery at the Military Hospital Capitaine Halassane Coulibaly and at the University Hospital Souro Sanou. Where included, patients operated or managed conservatively by the same surgeon, with at least 6 Months follow-up either post-operatively or after conservative treatment as well as the availability of medical records. Surgical or conservative management were based on symptoms, radiological findings, elapsed time from trauma to admission, patient's financial condition and the decision of the patient after preoperative counseling.

3. Results

There were 6 men and a woman with an average age of 33-year-old (Range from 22 to 40 years). Rollover motor vehicle accident in unrestrained driver in 2 cases and passenger in one case was reported, whereas 3 cases were motorcycle accidents and finally a fall of a heavy load on the head in one case. On admission, patients were suffering from cervicalgia in 3 cases, brachial monoplegia in two patients, isolated quadriplegia in two patients and quadriplegia with respiratory distress associated to neurovegetative disorders in one patient. Cervical computed tomography (CT) scan revealed associated fracture of odontoid in four cases; fracture of anterior arch of C1 in one case and transvers ligament rupture without any fracture in two cases. In one of these latter cases a magnetic resonance imaging (MRI) revealed a large upper spinal cord contusion with edema toward medulla oblongata in one case. C1C2 wiring was achieved in 2 patients, Goel-Harms screwing in one case, and conservative treatment was decided in 2 patients, whereas 2 patients with indication for surgical treatment refused surgery and were managed conservatively. A patient who refused surgery was lost to follow up after favorable outcome. Another with brachial monoplegia showed a partial improvement. The others five patients showed complete recovery (Table 1). Surgical or conservative management were based on symptoms, radiological findings, elapsed time from trauma to admission, patient's financial condition and the decision of the patient after preoperative counseling.

We give a detailed description of our case1, case 2 and case 7. The others are summarized on Table 1.

3.1. Case 1

This 33-year-old man without past medical history was admitted in our department for cervical spine trauma after receiving a heavy load on his head 5 days ago. He was out from the border of our country and was brought with an ambulance wearing a hard cervical collar. On examination He was quadriplegic ASIA A with respiratory distress and diaphragmatic breathing. Oxygen saturation varied from 85% to 87% under oxygen flow of 5 ml/min with a high fever of

Table 1. Summary of our cases.

	Sex/Age (Year)	Occurrence	Symptoms	Radiology	Treatment	Outcome
1	Man/40	Fall of heavy load on head	Tetraplegia (1/5), high fever of central origin, diaphragmatic breathing.	C1C2 dislocation, transverse ligament rupture and rostral spinal cord contusion with edema toward medulla oblongata	C1C2 Wiring	Complete recovery. Normal gait
2	Man/32	Rollover motor vehicle accident (Unrestrained passenger).	Left brachial deficit (2/5)	C1C2 dislocation with fracture of anterior arch of C1 left lateral process of C2 and rupture of transverse ligament.	C1C2 wiring	Complete recovery.
3	Man/28	Rollover motor vehicle accident (Unrestrained driver) Polytrauma	(After management of the polytrauma) right brachial monoplegia	C1C2 dislocation with odontoid fracture.	Conservative management (cervical collar)	Persistent right brachial monoplegia
4	Man/22	Road traffic accident (Motorcycle)	Absence of deficit then quadriplegia after 2 months (time of his admission on our department)	C1C2 dislocation with odontoid fracture (Anderson d'Alonzo type III) with huge displacement	Conservative management	Complete recovery despite a great compression of spinal cord on MRI
5	Man/33	Road traffic accident (Motorcycle)	Cervical pain	Odontoid fracture. (Anderson D'Alonzo type II) without displacement	Patient refused surgery: Conservative treatment (cervical collar: patient removed the collar)	Secondary dislocation (patient refused surgery)
6	Man/33	Road traffic accident (Motorcycle)	Cervical pain	C1C2 dislocation with odontoid fracture	Patient refused surgery. Conservative management (cervical collar)	Favorable outcome then lost to follow up.
7	Woman/33	Road traffic accident (Motorcycle)	Cervical pain with quadriplegia	C1C2 dislocation	C1C2 Screwing (Goel-Harms technique)	Complete recovery

40˚C. There was also an occipital compression sore. Computed Tomography (CT) scan revealed an atlantoaxial dislocation with transvers ligament rupture on MRI. There was also rostral spinal cord contusion with hyperintensity on T2 weighted images extended toward the medulla oblongata (Figure 1). White blood cells and procalcitonin were in normal range leading us to a conclusion of central fever. After a counseling with the patient and his family, a surgical decision was planned. However, the unavailability of proper devices for Goel or

Figure 1. Case 1 Preoperative images: Atlantoaxial dislocation with increased atlantodental interval ((a), (b), (c)), transverse ligament rupture ((b), (c)) associated to contusion of upper spinal cord and edema extended toward medulla oblongata (c).

Harms technic and the expensiveness to afford it abroad in addition to the patient condition made us chose a cheaper technic know as Gallie's technic or C1C2 Wiring.

Patient was place in prone position with the neck in neutral position. In the lack of Mayfield head holder, this neutral position of the neck was obtained by keeping the anterior part of the Philadelphia cervical collar whereas the head was on a horseshoe's head holder. A posterior cervical approach allowed a wide exposition of the posterior arch of C1 and the spinous process of C2. A reduction of the dislocation and C1C2 wiring using steel thread according to Gallie's technic was achieved under C arm control (**Figure 2**). The reduction was confirmed by a control CT scan (**Figure 3(a)**). Postoperatively the patient improved dramatically with normal temperature within two days and rapid improvement of his muscular strength to ASIA C on hospital day 8. At 45 postoperative days, the patient was ASIA E with a total independence (**Figure 3(b)**).

3.2. Case 2

This 32-year-old man without past medical history was an unrestrained passenger, admitted in our department for cervical spine trauma after a rollover motor vehicle accident. On examination there was only a left upper limb deficit with muscular strength about 2/5. Radiological investigations revealed on CT scan and MRI (**Figure 4**) an atlantoaxial dislocation, associated to a fracture of the anterior arch of C1 and the left lateral mass of C2; associated to an obvious rupture of the transverse ligament. After a counseling with the patient and his family, Gallie's technic was planned. The same surgical step was used like in case 1.

Due to the fractures on C1 anterior arch and C2 lateral process, the aim of the surgery was not to reach a genuine complete reduction of C1C2 dislocation. Since a moderate reduction was achieved, a fusion using bone graft and C1C2 wiring according to Gallie's technic was ensured under C arm fluoroscopy control (Figure 5). Postoperatively, the muscular strength of his left upper limb improved to the normal rang (5/5) within two months under physical therapy.

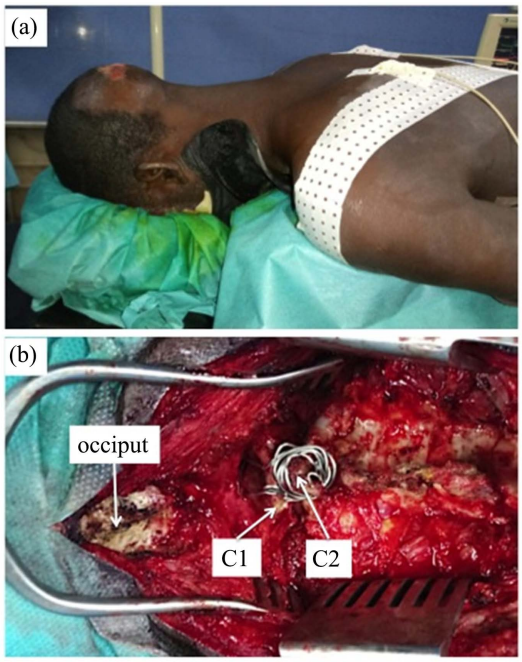

Figure 2. Case 1 Intraoperative images: patient position (a) and operative field after wiring (b).

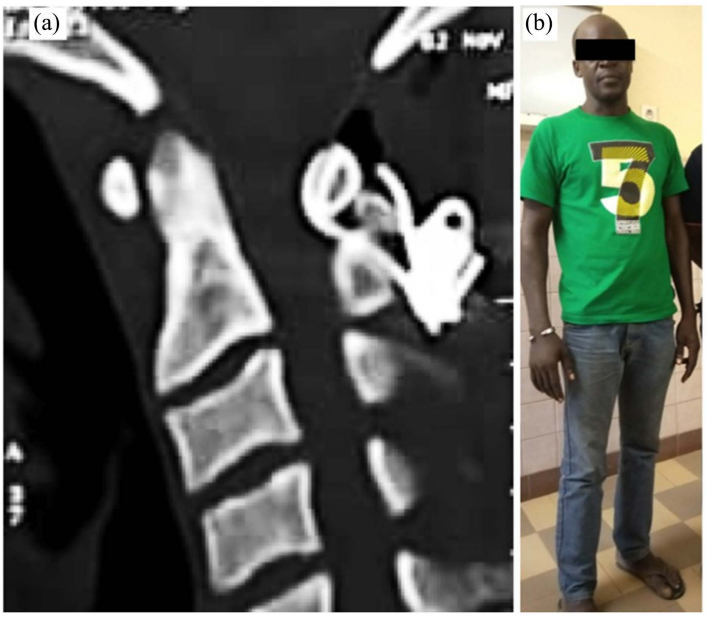

Figure 3. Case 1 Postoperative CT scan showing proper reduction of dislocation after wiring (a) and the patient at 45 postoperative days (b).

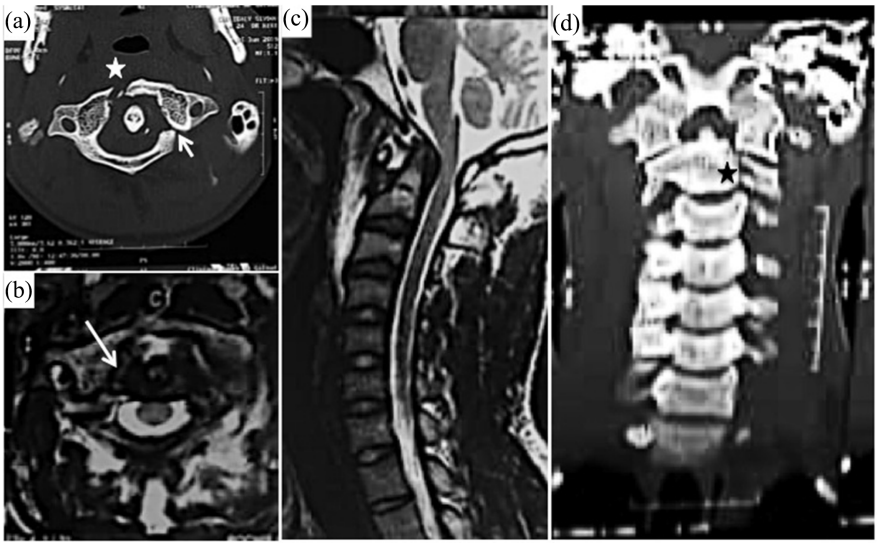

Figure 4. Case 2 preoperative images: Atlantoaxial dislocation ((a), (b), (c)) with fracture of C1 anterior arch ((a) white star), fracture of C2 lateral process (Black Star (d)). The white arrow on figure (a) indicates the left sulcus arteriosus, whereas it indicates a rupture of the transverse ligament on (b).

Figure 5. Case 2 Postoperative control X-ray (On C arm fluoroscopy).

3.3. Case 3 and 4

These patients had presented obviously odontoid fracture associated to atlantoaxial dislocation with secondary displacement (**Figure 6**). This highlight the instability of odontoid fracture located below the transverse band of the cruciform ligament above all the type II of Anderson d'Alonzo which may lead to dislocation, thus must be managed promptly and properly.

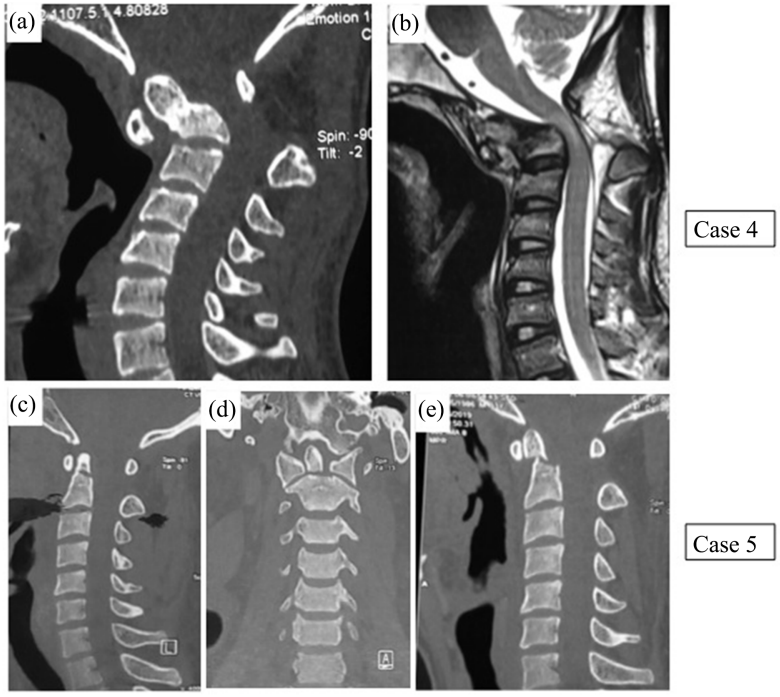

Figure 6. Case 4 on admission at 2 months after the trauma showing C1C2 dislocation with odontoid fracture displacement and consolidation in wrong position (a) associated to spinal cord compression and edema (b). Case 5 on admission revealing Anderson D'Alonzo type II odontoid fracture ((c), (d)) and secondary displacement after the removal of cervical collar by the patient (e).

3.4. Case 5

This 33-year-old woman without past medical history was admitted in our department for cervical spine trauma after road traffic accident (Motorcycle rider). On examination she was suffering from cervicalgia and isolated quadriplegic ASIA A. There was also an occipital wound. CT scan revealed an atlantoaxial dislocation with an atlantodental distance of 10 mm with a suspected rupture of transverse ligament (**Figure 7**). Unfortunately, MRI was unavailable. After a counseling with the patient and his family, a surgical decision was planned. The patient was able to pay for the screw and rod for posterior C1C2 Screwing, thus we ordered it from abroad for about one thousand dollar and the shipping times was five days.

Patient was place in prone position with the neck in neutral position. In the lack of Mayfield head holder, this neutral position of the neck was obtained by keeping the anterior part of the Philadelphia cervical collar whereas the head was on a horseshoe's head holder (**Figure 8(a)** and **Figure 8(b)**). A posterior cervical approach allowed a wide exposition of the posterior arch of C1 and the spinous process of C2 (**Figure 8(c)**). A Goel-Harms screwing technique was achieved with proper reduction under fluoroscopy (**Figure 8(d)**). Postoperative Xray showed a perfect reduction of the dislocation, the patient improved quickly and was discharged at hospital day 5 (**Figure 9(a)** and **Figure 9(b)**). She was ASIA E with a total independence at 45 days control (**Figure 9(c)**).

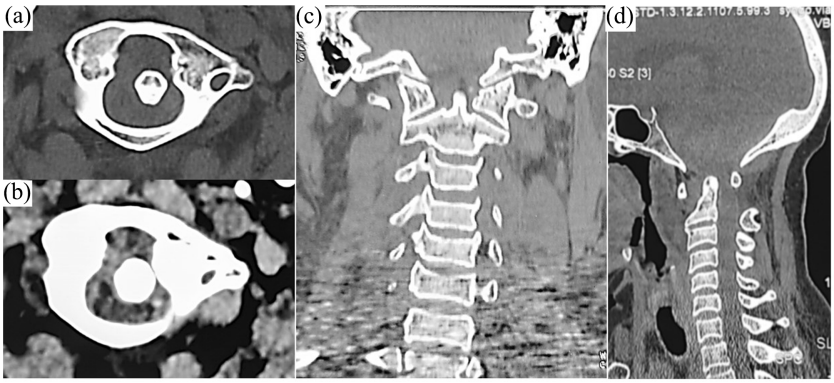

Figure 7. Case 7 Preoperative images: Atlantoaxial dislocation with increased atlanto-dental interval ((a)-(d)), and suspected transverse ligament rupture associated to compression of upper spinal cord (b).

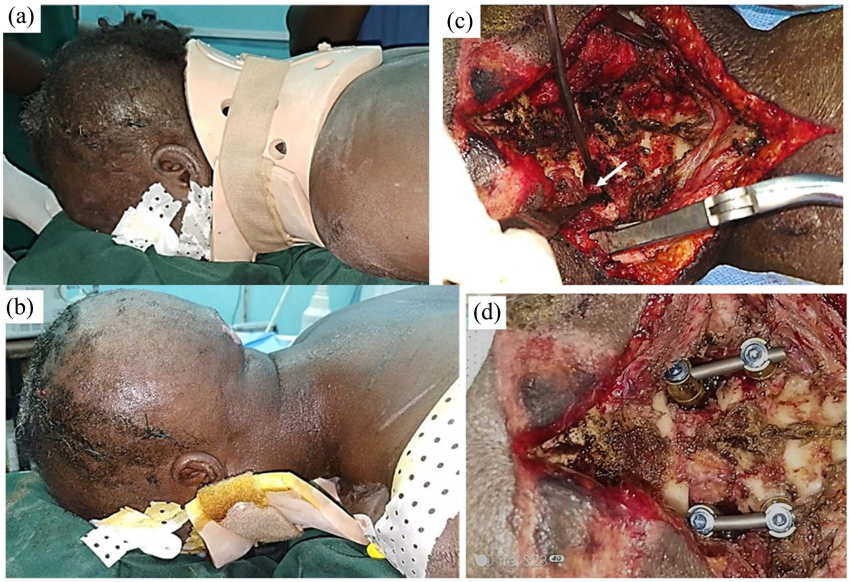

Figure 8. Case 7 Intraoperative images: patient position ((a), (b)), left C1 lateral masse exposure (arrow (c)) and C1C2 screwing with rod (d).

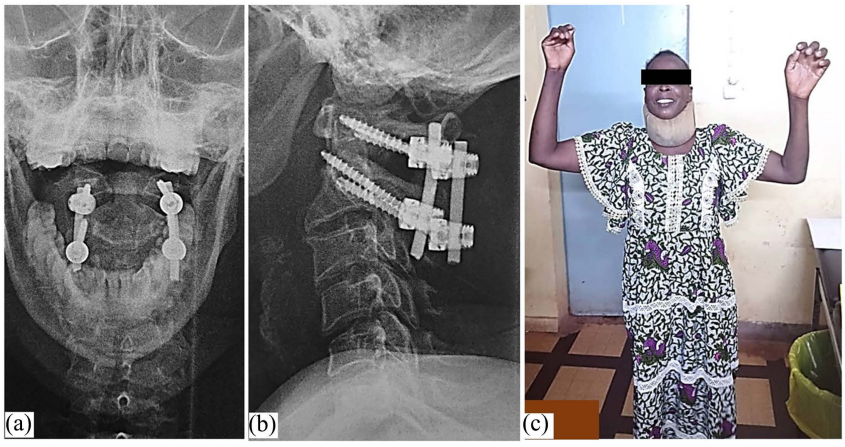

Figure 9. Case 1 Postoperative Xray showing proper reduction of dislocation after screwing ((a), (b)) and the patient at 45 postoperative days (c).

4. Discussion

Upper cervical spine injury is rare and result from high velocity trauma leading commonly to devastating complication [7]. In an autopsy series, 24.4% of patients whose death was attributable to traffic accidents had radiological lesions of upper cervical spine [8] [9]. Among all spinal injuries, atlantoaxial dislocation accounts for less than 1% [10] [11] [12]. This dislocation without fracture of the dens (odontoid process) is even more rare [10]. In our series, only two patients (Case 1 and 7) did not find bone fracture associated to atlantoaxial dislocation. The diagnosis of atlantoaxial dislocation can be defined on X-ray with the measurement of atlantodental interval. This distance is constant during head movement and should not exceed 3 mm in adult and 5 mm for children [13] [14] [15] [16]. In our case 1, this distance was 3.9 mm on admission CT scan and the condition of the patient impaired the day after. Thus, an MRI was realized and revealed an increased atlantodentral interval to 5 mm associated with spinal cord contusion despite a strict immobilization of the patient with hard cervical collar without an attempt of close reduction. For a better management of these atlantoaxial dislocations, several classifications were done and the more popular were Greenberg classification in 1968 as Well as Fielding and Hawkins classification; separating atlantoaxial dislocation in 2 subgroups (reducible and irreducible) and 4 subgroups (Anterior, posterior, lateral, rotatory) respectively [13] [16] [17]. The lack of therapeutic application of these latter classifications resulted in a new classification drew by Wang (**Table 2**). According to this classification, we achieved the reduction in our patients (case 1 and 7) with skeletal traction under general anesthesia, which was consistence with Wang's type II. Thus, a posterior stabilization was decided. Historically considered as a nobody's land, craniovertebral junction surgery or specialty recently gained high consideration as symbol of challenging surgery as well as selective top level qualifying surgery [18]. Over century, steady advances have been made in fixating unstable atlantoaxial complex. Current options for fixation of atlantoaxial complex including posterior

Table 2. Wang classification system of atlantoaxial dislocation [14].

Type	Description	Diagnosis	Incidences	Treatment
I	Instability	Reducible in dynamic X-rays	52.2	Posterior fusion procedure
II	Reducible	Reducible with skeletal traction under general anesthesia	17.7	Posterior fusion procedure
III	Irreducible	Irreducible with skeletal traction under general anesthesia	29.6	Transorally released anteriorly before posterior fusion
IV	Bony dislocations	Dislocation with bony anomalies that are visualized by reconstructive computed tomography scan	0.4	Transoral odontoidectomy

clamps, posterior wiring technics, C1 and C2 transarticular screw fixation, posterior C1 lateral mass screw with C2 pars or pedicle screw fixation, and anterior transoral C1 lateral mass to C2 vertebral body fixation [5]. As mentioned before, our case 1 and 7 was Wang's grade II and therefore, was consistence with posterior fixation. Unfortunately, device for screw-rod construction or other materials were unavailable, thus C1C2 wiring using steel wire was achieved according to Gallie's technic for case 1. This steel wire was cheaper for a cost about 3 to 4 dollars and a single wire was enough for this technic, in opposite to devices for Goel-Harms technique which have been ordered abroad for 1000 dollars. Although wiring technic was found to ensure a poor rotational stability with pseudoathrosis when odontoid fracture is associated, and requires the need of postoperative external hard cervical collar [19], it allowed an appropriated immobilization of the dislocation after skeletal reduction in our case 1. This was testified with a postoperative control CT scan showing an atlantodental interval within normal range and the good post operative outcome. However, Goel *et al.* reported 100% of union and stability in 1994 with his technique, without an occurrence of surgical adverse events [6]. We achieved a proper reduction in case 7 using C1 lateral mass and C2 pedicle screwing with rod, despite a huge preoperative dislocation. This screwing technique is very effective despite its expensiveness in our environment. Moreover, wiring is the alternative to lateral mass screw implants in patients with abnormal courses of the vertebral artery (15% - 20% of people), in osteopenic spines where screws may not hold, in scoliotic spines and in case of lateral mass asymmetry (Our Case 2) [20]. Wiring technic also shows a great importance in pediatric patients as well as in posttraumatic condition than in congenital instability of craniovertebral junction such as Morquio's or Down's syndrome [20]. In fact, craniovertebral region reaches adult size and configuration at approximatively 8 to 10 years of age, thus some authors support that lateral mass screw implants below this age can exert significant grow limitation [21] [22] [23]. In addition, some studies revealed the same 100% rate of fusion for both lateral mass screw implant and sublaminar instrumented wiring [24] [25]. However, in pediatric patients, complications such as 30% of screw pulling out in suboccipital area, 10.4% of other complications rate including vertebral artery injuries and mortality rate of up to 9% after complex spine decompression and fixation should be taken into consideration [20] [26] [27] [28] [29]. Abboud *et al.* reported worse Frankel grade (A or B) and neurovegetative disorders at presentation to be strongly statistically correlated with poor prognosis factor and higher mortality in 102 cases of cervical spine trauma over a study period of 11 years [4] [10] [30]. Despite the existence of those both latter factors in one of our patients (Case 1), his condition improved dramatically, moving from ASIA A with neurovegetative disorders preoperatively, to ASIA E postoperatively without any symptoms.

5. Conclusion

Atlantoaxial dislocation is a life-threatening condition with high mortality be-

fore surgery as well as postoperatively. Despite great progresses either in surgical technic or instrumentation devices, this surgery remains challenging and so gratifying so far, when a good postoperative outcome is achieved such in our described case 1 and 7. A lack of clamps, screw rod and other sophisticated devices in some developing countries, can be balanced with wiring technic using steel wire which is cheaper and available almost everywhere. Although it requires a more accurate preoperative neurosurgical setting, the screwing technique takes less time and is characterized by less blood loss and less postoperative discomfort than the wiring technique. However, the latter confirms the simplicity, safety (continuous fluoroscopic assistance is not necessary, and there is no risk of neurovascular injuries) and lower expense (neither complex hardware devices nor neuronavigation systems are required) than the screwing technique [31] [32]. When fever and neurovegetative disorders are seen at presentation, after ruling out an infectious disease, early reduction and immobilization may save the life of the patient as reported in our Case 1. However, an attempt should be made for the availability of atlantoaxial instrumentation devices above all the screw and plate use in Goel technic, which should be not beyond the financial possibility of the majority of the population.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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